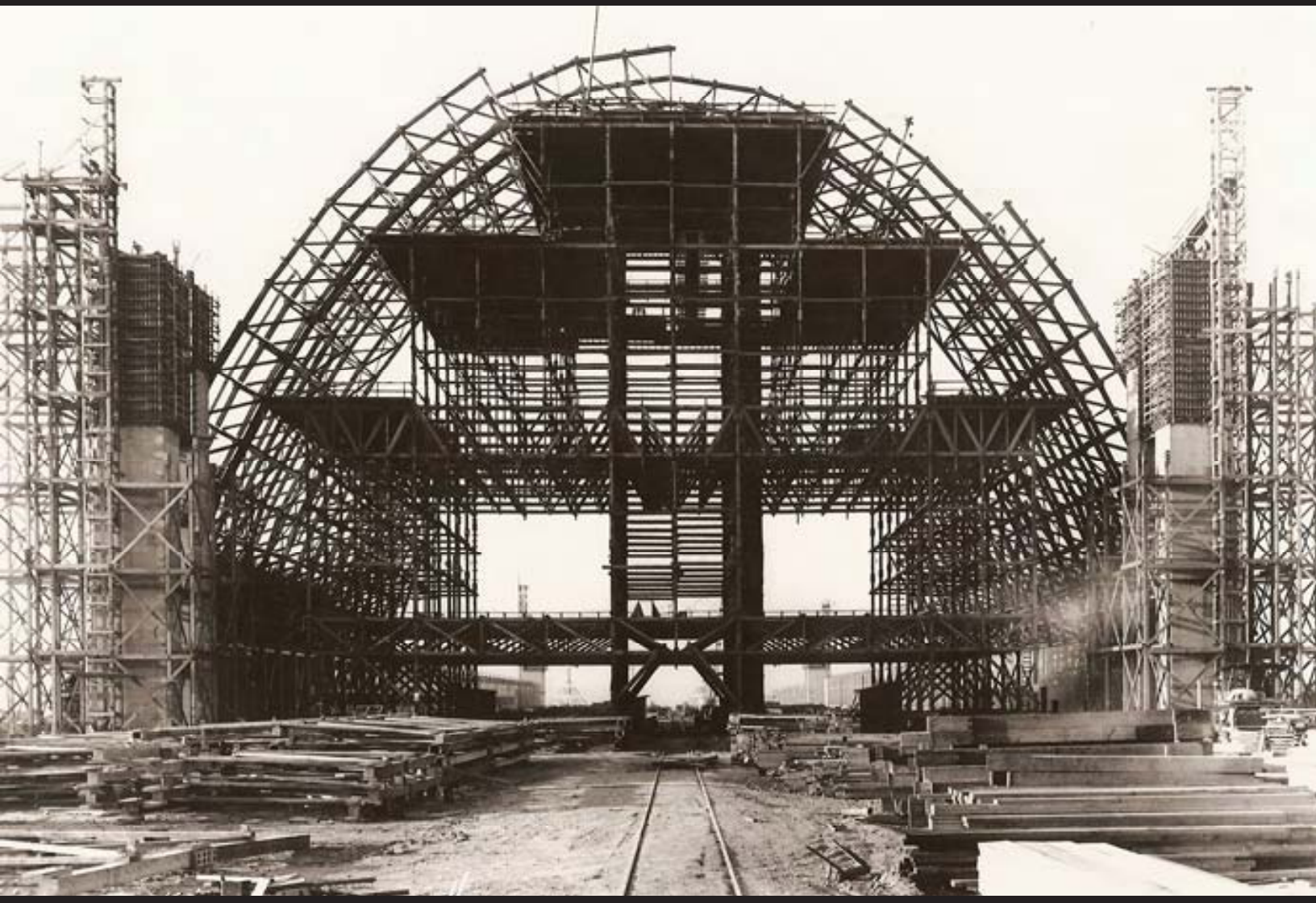

The Tustin Hangars: Titans of History

An historical account of the MCAS Tustin Hangars

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An historical account of the MCAS Tustin Hangars

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Building 28 (Hangar 1), south doors, 1999

MCAS Tustin aerial, c. 1960

TABLE OF CONTENTS

I. PREFACE

A. Introduction to the Tustin hangars and statement of purpose of written history

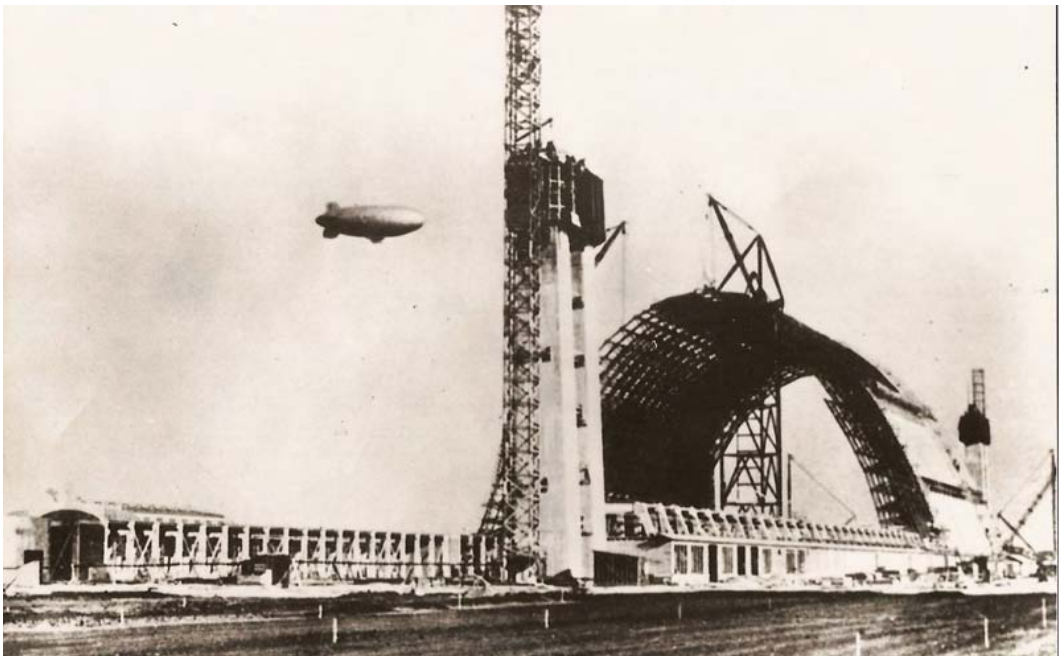
"The Tustin Hangars: Titans of History" is a comprehensive history of the two blimp hangars at the former U.S. Navy and Marine Corps air station in Tustin, California. The hangars were built early in World War II to house manned blimps or, in Navy terminology, non-rigid lighter-than-air (LTA) airships.

"The Tustin Hangars: Titans of History" examines the origin, construction and evolution of the hangars along with the support buildings around them and the Tustin air station itself, from its inception to the present.

The Tustin base, which was built in 1942 and most recently called Marine Corps Air Station (MCAS) Tustin, played a critical role in Navy and Marine aviation for over 50 years, first as an LTA airship base then as a helicopter facility and most recently as Marine Corps aviation's principal helicopter facility in the Pacific region.

According to the American Society of Civil Engineers, which named the hangars one of the "Historic Civil Engineering Landmarks" of the 20th Century, the Tustin hangars are two of the largest wooden structures ever built, and contain the largest covered, unobstructed open space of any structures in the world.

This history of the Tustin air station and its hangars is dedicated to the men and women who served there for more than six decades.



Hangar under construction, blimp overhead, c. 1942

"LTA has always been considered the 'pearl' of Marine Corps bases. In addition to its perfect location among the Southern California orange groves and proximity to all of the Southern California amenities, it also provides a nearly perfect environment for training helicopter pilots.

The nearby Saddleback mountains and adjacent foothills have 13 confined area mountain landing sites that every PUI (Pilot Under Instruction) has learned to hate and love."

– Thomas O'Hara
"Images of America: Marine Corps
Air Station El Toro"
p. 109, MCAS Tustin

B. Section 106 Mitigation Fulfillment

Pursuant to Section 106, the State Historic Preservation Office (SHPO), the Advisory Council on Historic Preservation, the Department of the

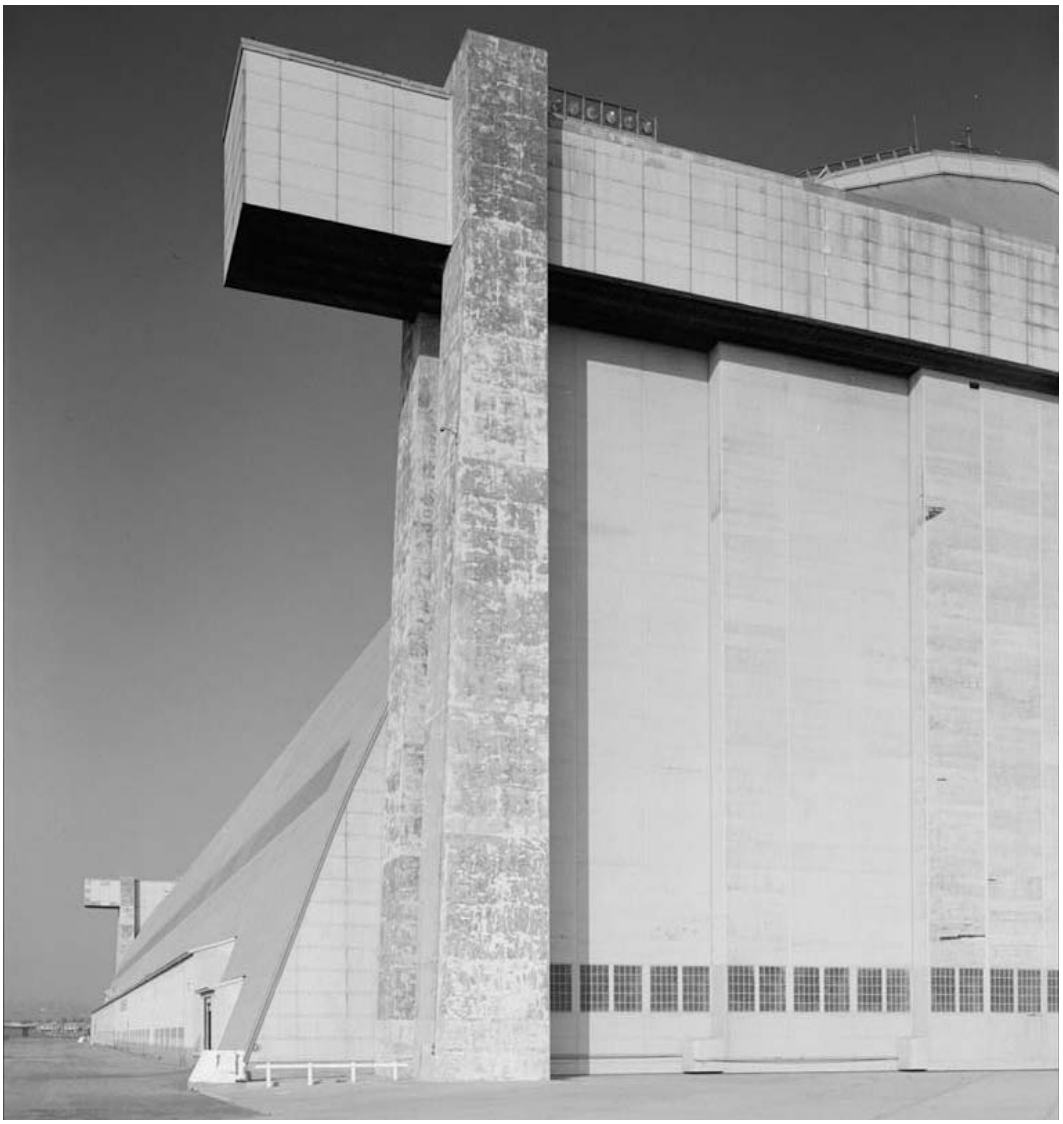
Navy (DoN), the City of Tustin, and the County of Orange executed a Memorandum of Agreement (MOA) that identified measures to mitigate the impacts of the destruction of portions of the eligible historic district, including the removal of Hangar 28 (northern hangar) and Hangar 29 (southern hangar.)

As required by the MOA, the County of Orange conducted a marketing study for Hangar 28 and reported to the DoN, SHPO, and the National Park Service that there is no economically viable reuse of the structure.

The City of Tustin, after completing a marketing study and requesting, receiving and evaluating expressions of interest and proposals for the Hangar 29 complex, has also reached the conclusion that there is no economically viable use for that hangar.

Stipulation III of the MOA includes mitigation measures if an economically viable adaptive reuse for the hangars is not identified, including a written history, documentary video, and exhibit. This written history is in satisfaction of a portion of this requirement.

Building 28 in foreground, Building 29 in background, 1999



Building 28, north doors, 1999

C. Acknowledgements

The authors would like to recognize and thank the City of Tustin, the County of Orange, the Department of the Navy, the State Historic Preservation Office (SHPO), the Advisory Council on Historic Preservation and the Tustin Historical Society for their contributions of data, graphics and photos that made this written history possible.

II. INTRODUCTION

Orange County, California is a vibrant collection of thirty-four cities some thirty-five miles south of Los Angeles. Home to just over 3,000,000 people, Orange County is an internationally recognized center for retail and hi-technology and one of the most desirable tourist destinations in the world.

In 1942, however, in the midst of World War II, Orange County was a dramatically different place. With just over 130,000 people, it was a sparsely populated rural area punctuated by endless orange groves and lima bean and sugar beet fields. The few people who lived there at the time were focused on the same issue as Americans everywhere – the war raging in Europe and the Pacific. The United States had entered World War II just

Tustin bean fields, circa 1930

Attack on Pearl Harbor, December 7, 1941

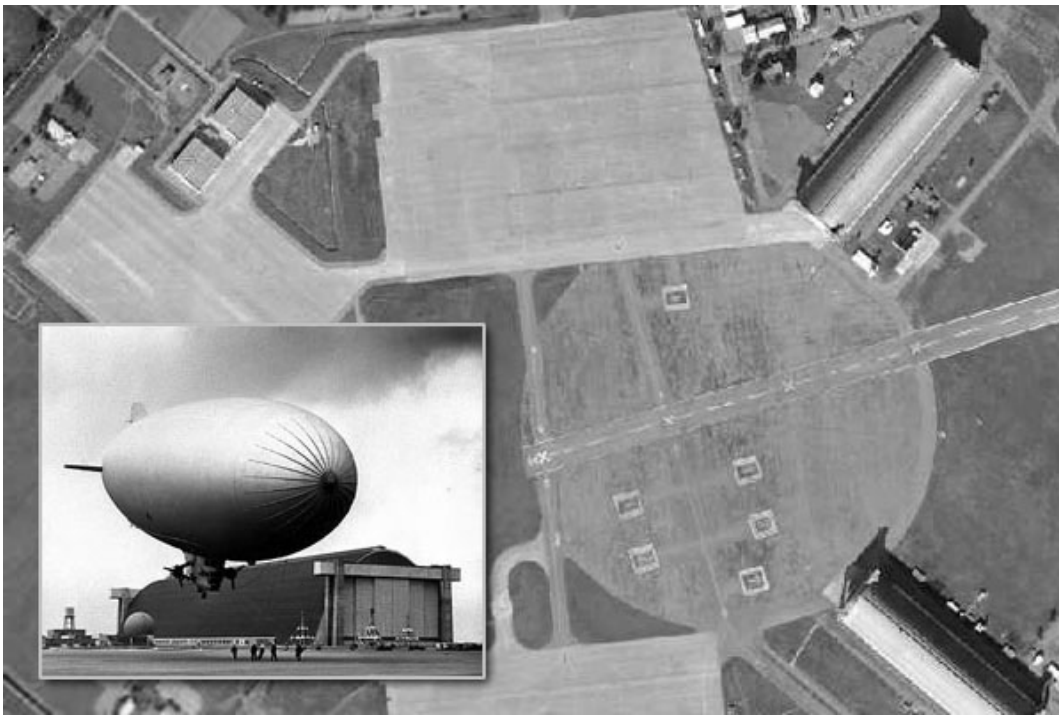
a few months earlier following the attack on Pearl Harbor by Japanese fighter-bombers on December 7, 1941.

The War Department, renamed the Department of Defense in 1949, selected 1,600 acres of farmland in central Orange County as the site of one of a number of manned blimp facilities to be built around the country. The airfields would house a number of LTA (Lighter-than-Air) squadrons around the country that would patrol the coastlines with manned blimps.

The proposed Orange County LTA site, which was being used to farm lima beans, was bordered by the City of Santa Ana on one side and the City of Tustin on the other.

The LTA facility was commissioned in 1942 as the Santa Ana Lighter-than-Air Base and eventually became Marine Corps Air Station (MCAS) Tustin. It would have a rich military history over those six decades, but would always be best known for its massive, iconic blimp hangars, which the Navy called Buildings 28 and 29.

Building 28, south doors, 1999



Tustin LTA base, as Naval Air Station Santa Ana, c. 1943

Seventeen stories high, over 1,000 feet long and 300 feet wide, the hangars were, and still are, two of the largest wooden structures ever built. They can be seen for miles from the ground, tens of miles from any nearby elevation and from as far away as visibility will allow from the air.

Long after the airship era was over, MCAS Tustin served as a major facility for Marine helicopter training and operations on the Pacific Coast and played a critical role in every major U.S. military operation from 1942 to 1992, including World War II, Korea, Vietnam and Operation Desert Storm, most of which were heavily dependent on helicopter operations.

The MCAS Tustin hangars were both landmarks for, and symbols of, the generations of local residents and the thousands of men and women who served at the Tustin facility.

III. HISTORICAL OVERVIEW

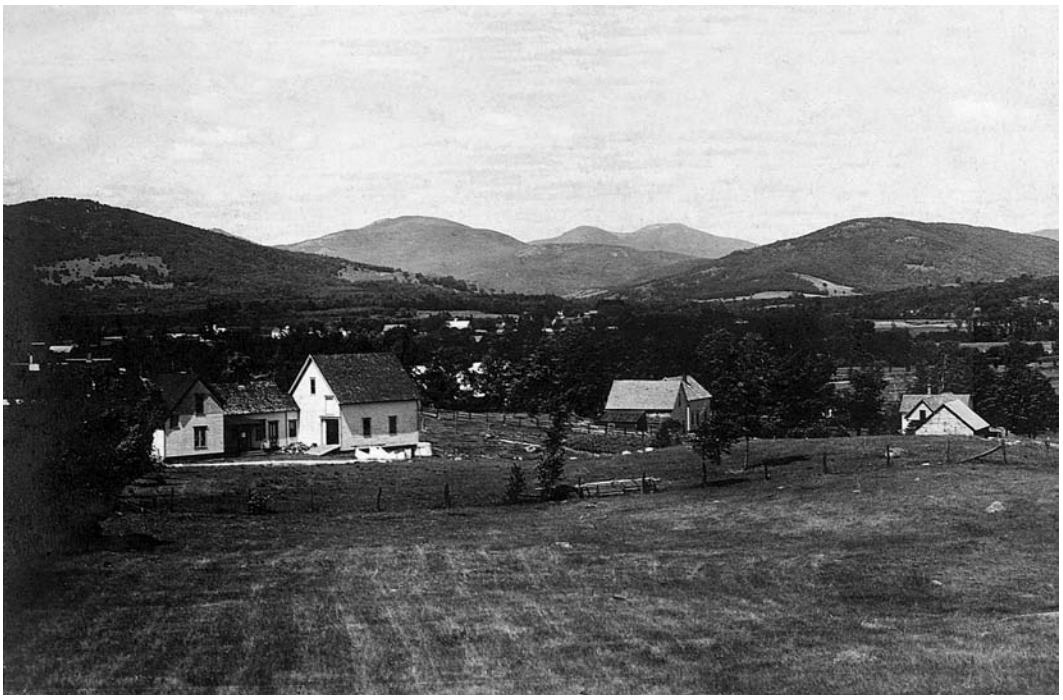
A. Land Acquisition and Base Design

In January 1942, just weeks after the attack on Pearl Harbor, the U.S. was on high alert for an attack from the air or sea by Japan on the Pacific Coast, or by Germany on the Atlantic Coast.

In Southern California, the Navy and the Army Air Corps identified what seemed to be an ideal location for aviation training and operations facilities – a sparsely populated agricultural area some 35 miles south of Los Angeles called Orange County, with acre after acre of orange groves and row after row of farm fields that seem to go on forever.

The War Department was especially interested in two large agricultural fields on the Irvine Ranch property. One area, at the mouth of a canyon called Canada del Toro, would become MCAS El Toro some 14 years later. The other was in a city called Tustin in central Orange County, and would become Naval Air Station Tustin and eventually, MCAS Tustin.

Tustin was a quiet agricultural community of about 900 people. The city had been incorporated in 1927 and was known for its wide, tree-lined streets – a trademark since 1870 when its founder, Columbus Tustin, started planting shade trees to mark the city's streets and walkways.



Tustin farm homes, viewed from Red Hill Avenue, c. 1920

Tustin, a Petaluma carriage maker, purchased 1,300 acres of Rancho Santiago de Santa Ana, one of the original Spanish land grant ranchos, in 1868.[1] Tustin made the building of "Tustin City" his life's work from that point on. He carefully laid out the new city's streets and paths, marking them with wild mustard and sycamore trees.

From the start, the city had been nicknamed "The City of Trees," a name that would come to have much more than an aesthetic meaning. The city's economy was largely based on trees well into the 20th century – trees by the thousands, laid out from horizon to horizon, bearing walnuts, avocados, lemons and oranges. But the War Department's interest in Orange County and Tustin had little to do with trees, and had been developing for quite some time.

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1 Carol Haugh Jordan, "Tustin: An Illustrated History," 2007 Tustin Area Historical Society

Naval Air Station Santa Ana, c. 1943

In 1928, Chief of Naval Aviation Rear Admiral W.A. Moffett arrived at Eddie Martin Airfield, now John Wayne Airport, to meet with James Irvine II, owner of the vast Irvine Ranch, to discuss the Tustin and the Canada del Toro sites.[2]

James Irvine was reluctant to sell either site. Both were productive and profitable as farm fields for the Irvine Ranch itself, or as lease land for other farming interests. Irvine was especially reluctant to sell the Tustin site, which had a very high water table that made it ideal for farming. Locals jokingly called the area that would become the Tustin base "La Cienega de Las Ranas" – "The Frog Swamp" – because the ground water was so high that the soil was almost always moist. Ironically, the same high water table would become a major challenge for any future construction on the site, including the hangars. Fortunately for Irvine, Moffett chose an alternate location in Northern California. But thirteen years later, just after the attack on Pearl Harbor, the War Department returned to Orange County to find a site, this time, with even more determination.

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2 Thomas O'Hara, "Images of America: Marine Corps Air Station El Toro" 1999, Arcadia Publishing

USN blimp over Tustin LTA base chapel, c. 1943

They reopened negotiations with James Irvine for what would become the Tustin base, some 1,600 acres of farm fields that seemed ideal for a Lighter-than-Air (LTA) facility, along with the larger site at Canyon del Toro, some 15 miles to the south, which would serve for fixed-wing aircraft.

A few miles to the north, in what would become the City of Costa Mesa in 1953, the Army Air Corps chose a site for a massive fixed-wing aviation training facility called the Santa Ana Army Air Base. Today, the site of the former base is the home of Orange Coast College, one of the largest community colleges in the country, and a few structures from the Santa Ana Army Air Base can still be seen around the OCC campus.

Under the extraordinary conditions that only war can produce, the Navy broke ground for the Santa Ana LTA facility on April 1, 1942, even though negotiations with James Irvine were still underway. In August 1942, with

NAS Santa Ana Commissioning Ceremony, October 1, 1942

negotiations still going on, the Navy began condemnation proceedings for the site. They took title to the land in January of 1943 – at which point negotiations were officially over.[3] James Irvine was offered, and accepted, $100,000 for both the Tustin and the El Toro sites, the equivalent of about $20 per acre.

B. Commissioning

On October 1, 1942, NAS Santa Ana (Naval Air Station Santa Ana) was commissioned – just 6 months after the April 1, 1942 groundbreaking. Airship operations began with a single blimp operating from a concrete mat and mooring mast until the hangars were completed in the following year.

Over the next 50 years, the Tustin base would remain an active and critical aviation installation for U.S. Navy and Marine Corps aviation. The Tustin base became the center of Marine helicopter aviation on the Pacific Coast.

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3 Dave Bryant, Tustin Area Historical Society

Its primary mission was to provide support services and materiel for the 3rd Marine Aircraft Wing and other units in the region. The Tustin base continued that role until the 1990's. At its high point, the base employed some 5,000 military and civilian personnel, about 4,500 of whom lived on the base.

It was re-designated Marine Corps Air Station (Helicopter), Santa Ana on September 1, 1969, was annexed by the City of Tustin on April 23, 1976, and became MCAS(H) Tustin on June 1, 1978.[4]

C. Base Closure

With the end of the Cold War and the break-up of the Soviet Union, the Federal government set out to streamline the armed forces and reduce the military budget by closing bases that were deemed to be no longer necessary for national defense. But the process of identifying which bases

Building 29, west doors, 1999

4 Thomas O'Hara, p. 109, "Images of America: Marine Corps Air Station El Toro" [Arcadia Press, 1999]

Warning sign, Building 28, March 2002

were going to be closed, and when, became so politically contentious that Congress enacted the Base Realignment and Closure Act, or BRAC, on October 24, 1988.

The act established the BRAC Commission – an independent, bi-partisan entity that would make recommendations to Congress and the Secretary of Defense on which installations were to close or be realigned, on what schedule. To minimize political interference and "horse trading" by members of Congress, lawmakers and the Secretary of Defense had to accept the closure list in its entirety.

The BRAC Commission issued its first closure list on December 28, 1988, recommending the closure of 86 installations, the partial closure of 5 installations and the realignment of 54 others. The Secretary of Defense approved the recommendations on January 5, 1989.

Two years later, in 1991, MCAS Tustin was selected for closure, and in late 1991, the City of Tustin was designated as the Lead Agency, or Local Redevelopment Authority (LRA), and was charged with preparing the required reuse planning documents.

On July 3, 1999, MCAS Tustin was officially closed, 57 years after the base and its iconic hangars arose from the farm fields of Orange County.[5]

D. National Register of Historic Places Listing

The Tustin blimp hangars were nominated for listing on the National Register of Historic Places by the Marine Corps in October 1974 in response to Executive Order 11593 of May 13, 1971.[6]

Building 29, left, Building 28 in background, 1999

5 Historic American Building Survey for the Marine Corps Air Station, Tustin Hangars (HABS NO. CA-2707), Prepared for U.S.N. by Karen Weitze, Ph.D., & Christy Dolan, KEA Environmental, Inc., January 2000.

6 Ibid

The hangars were entered into the National Register as a historic district on April 3, 1975, both for their historic connection with World War II and other conflicts and their status as two of the largest wooden structures in the world. The historic district consists of two elements:

Element A

LTA Ship Hangar 1 (Building 28); Helium Plant 28A; Mooring Mats 1, 2, 3; Connecting roads between the hangar and mooring mats.

Element B

LTA Ship Hangar 2 (Building 29); Helium Plant 29A; Mooring Mats 4, 5; Connecting roads between the hangar and mooring mats.

Building 29, right, Building 28 in background, 1999

E. Reuse Planning

The closure and reuse of a facility as large – over 1,500 acres – and as complex as the Tustin base is an enormous undertaking that requires years of intensive study, analysis and planning and must follow stringent requirements from a long list of federal, state and county agencies.

After being designated the Lead Agency or Local Redevelopment Authority (LRA) in 1991, The City of Tustin began preparing the required reuse planning documents and determined that the most appropriate tool to guide the conversion of the base was the preparation of a Specific Plan/ Reuse Plan.

The planning process also included an extensive public outreach effort over the years to include as many residents, businesses and stakeholders as possible in forging a community vision for the development of more than 1,000 acres of residential, commercial and retail uses along with new schools, parks and recreational facilities.

The result was the Specific Plan/Reuse Plan, which includes detailed planning standards, policies, regulations and implementation strategies to guide the reuse and development of the site into the next century, was adopted In October 2003 and amended in April 2006.

F. Cultural Aspects

In addition to being architectural and aviation icons, the mammoth hangars served as important cultural resources, both while the base was an active military installation and after it closed. Over the years, the hangars played host to air shows and community and charity events.

One hangar served as a staging facility for a number of Malcolm Forbes' record-setting hot air balloon flights, and both were used to test a variety of military and civilian experimental equipment, including a solar powered aircraft in the 1970's and a number of model aircraft prototypes. The world record for the longest flight by an ultra-light model aircraft was set in one of the hangars in the 1980's.

The hangars were, and still are, used as locations for numerous commercials and television programs, including "JAG" (CBS Television), "The X-Files" (Fox Television), and a number of feature films, including "Austin Powers" (1997), "Pearl Harbor" (2001), and various Hollywood depictions of the Hindenburg disaster.

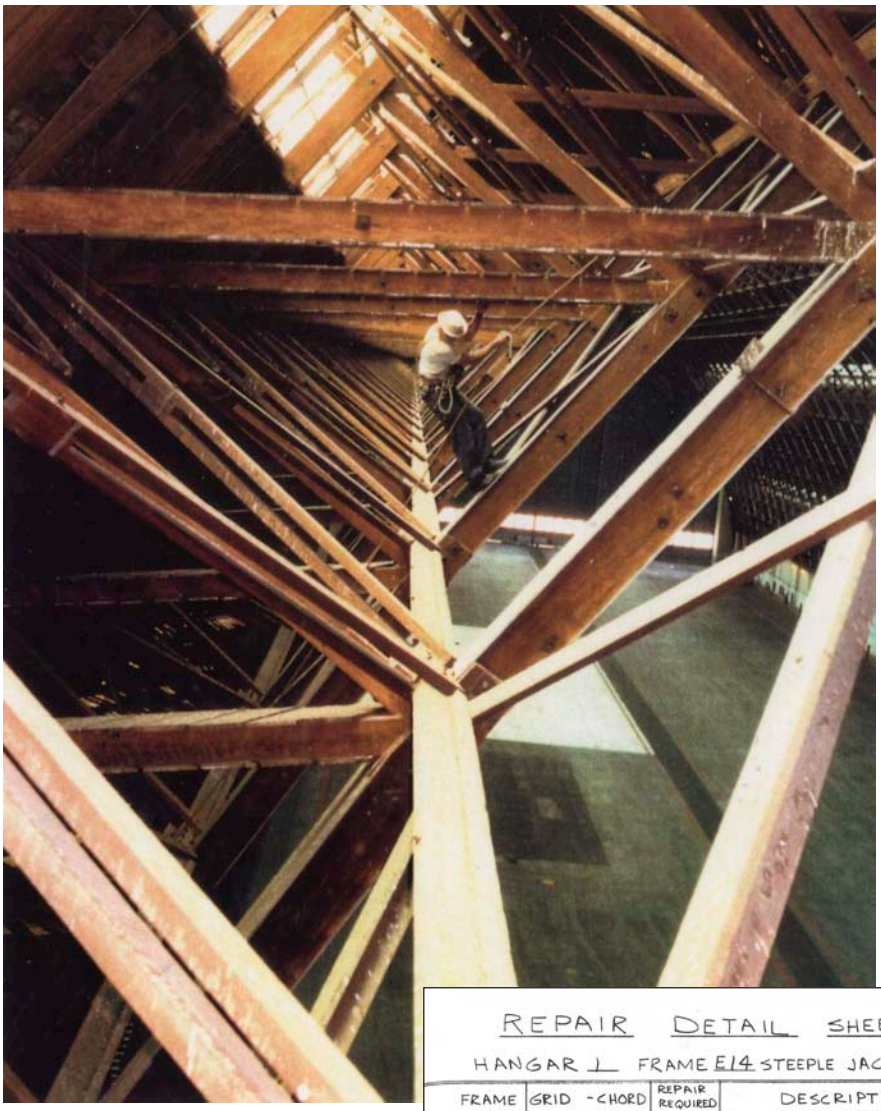
According to Col. William Hammerle, USMC (Ret.), commanding officer of MCAS Tustin from 1993 to 1996, the hangars have also been the source of a number of persistent urban myths over the years including, among others:

"An airplane (or helicopter) was flown through one door of a hangar and out the other for a film (or commercial.)"

Not true, according to Col. Hammerle.

"Tightening the thousands of bolts holding the hangars together was a never-ending task and a full-time job for a crew of military personnel. When the crew reached one end of a hangar, which took weeks (or months), it was time to start back at the other end."

Also not true. According to Col. Hammerle, whether it was to tighten bolts or any other task, climbing and hanging from the hangars' 170-foot high roof structures was done only by experienced civilian contractors, ususally as part of an inspection that took place every 5-10 years.



A civilian steeplejack inspects a portion of a roof truss, 1997.

REPAIR DETAIL SHEET

HANGAR 1 FRAME E14 STEEPLE JACK Dick Grambo

FRAME	GRID	-CHORD	REPAIR REQUIRED	DESCRIPTION
E 14	2	L.C.	Bolt	End of 6x14 Web V2
E14	13	L.C.	Clamp	3x12 L.C. member "6" at leaf facing E13 -- clamp close as possible below p.p. 13
E14	18	T.C.	Clamp	3x14 T.C. member "9" at leaf facing E13 -- clamp close as possible beTow p.p. 18
E14	16	T.C.	Bolt	3x12 T.C. member "8" at leaf facing E13 -- stitch between 2nd & 3rd thru bolts from end of chord
E14	16	T.C.	2 clamps	3x14 T.C. member "9" at leaf facing E13 -- place clamp 1 close as possible above p.p. 16 & clamp 2-30" above clamp 1

Typical Inspection Report

IV. THE TUSTIN HANGARS: DESIGN & CONSTRUCTION

A. Hangars (Buildings 28 and 29)

Designing and building two structures as massive as the Tustin hangars would be challenging enough today. But accomplishing it in 1942, in wartime, on a hyper-accelerated schedule and with a nearly all-wood design, is what earned the hangars their 1993 listing by the American Society of Civil Engineers as one of the "Historic Civil Engineering Landmarks" of the 20th Century.

Each hangar measures 1,088 feet in length and 297 feet in width, with timber arches set on 20-foot centers. The hangars are 178 feet or over 17 stories tall, with another 11 feet to the top of the wind indicators.

The two hangars were separated by a large circular landing mat that was about 2000 feet in diameter, with five smaller landing mats placed around the hangars in a cloverleaf pattern.

Then and now, the dimensions of the hangars are difficult for first-time visitors to grasp. The first and most lasting impression is the vastness of a covered space that is three football fields long, one football field wide and seventeen stories high – all enclosed in a single, self-supporting wood structure.

The amount of materials and supplies used to construct the hangars and support buildings was as impressive as the structures themselves: 2,719,000 board feet of lumber; 79 tons of bolts and washers; 30 tons of ring connectors.[7]

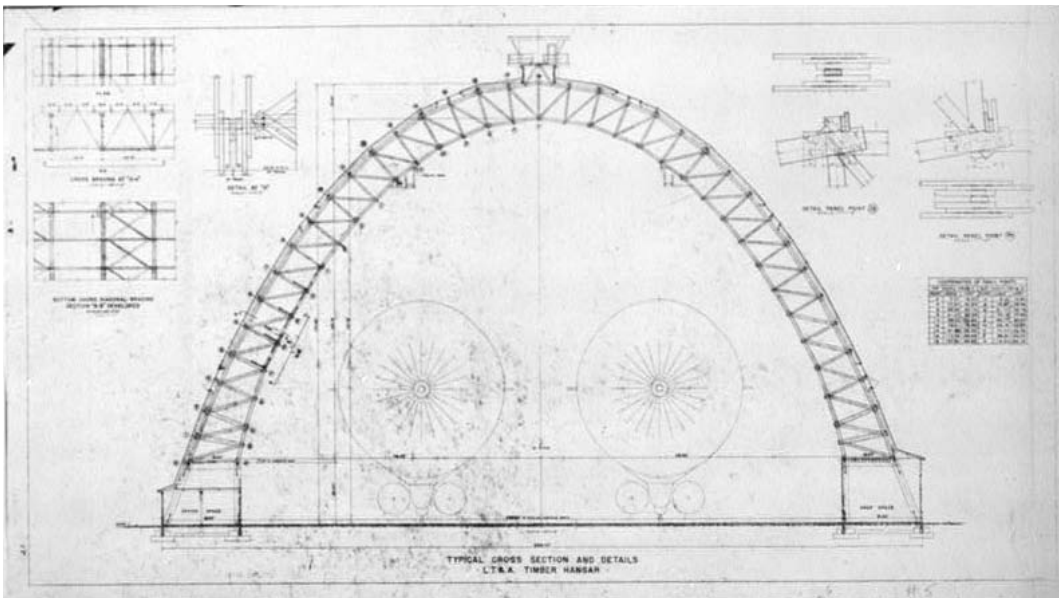
What the visitor can't see is just as impressive. The foundations for each hangar consist of some 1,600 poured-concrete piles, 48-feet deep for one hangar and 65-feet deep for the other.

The hangar floors consist of several un-reinforced concrete slabs, approximately five inches thick. Each slab is approximately 400 square feet and was poured in a checkerboard pattern. The overall floor area in each hangar is approximately 296,000 square feet, or 6.8 acres.

All the lumber used for the hangars was Oregon Douglas Fir. Because of the large amount of lumber, and the potential for fire damage, all the wood was heavily treated with metallic salts as a fire retardant.

The all-wood design was a direct result of the realities of war. While steel construction of large structures had been common practice since the early 20th century, wartime rationing meant that virtually all the steel produced in the country was earmarked for weapons and armored vehicles. Even passenger cars manufactured during the war were made with wooden bumpers, front and rear. While 33 tons of structural steel was used in building the hangars, traditional construction would have required over 4,000 tons of steel.

7 Carol Haugh Jordan, "Tustin: An Illustrated History," 2007 Tustin Area Historical Society



Construction plan, 1942, cross-section detail

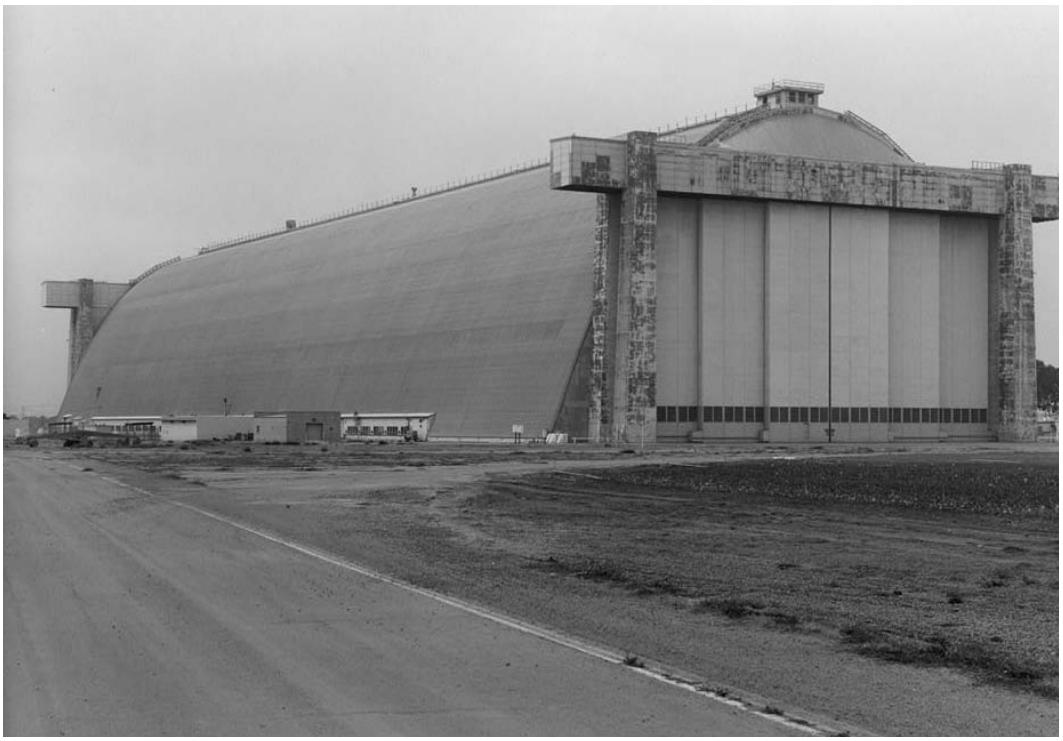
Building 28, 1999

Building 28, wall-roof detail, 1999

Building 28, south doors, control tower on right, 1999

Building 29, side view, 1999

Building 28, west side, 1999



Building 28, south doors, 1999

To meet the challenge of designing two of the largest structures ever built almost entirely of wood, the Navy chose a designer-engineer from within its own ranks, Arsham Amirikian, Principal Engineer of the Navy Bureau of Yards and Docks (BuDocks).

Arsham Amirikian (1899 - 1990)

A highly respected engineer, Amirikian was an Armenian immigrant who had studied in Europe and at Cornell University. More important, Amirikian had established a reputation for innovative designs for large structures using creative construction methods with timber, reinforced concrete, thin-shell pre cast reinforced concrete techniques and steel.[8]

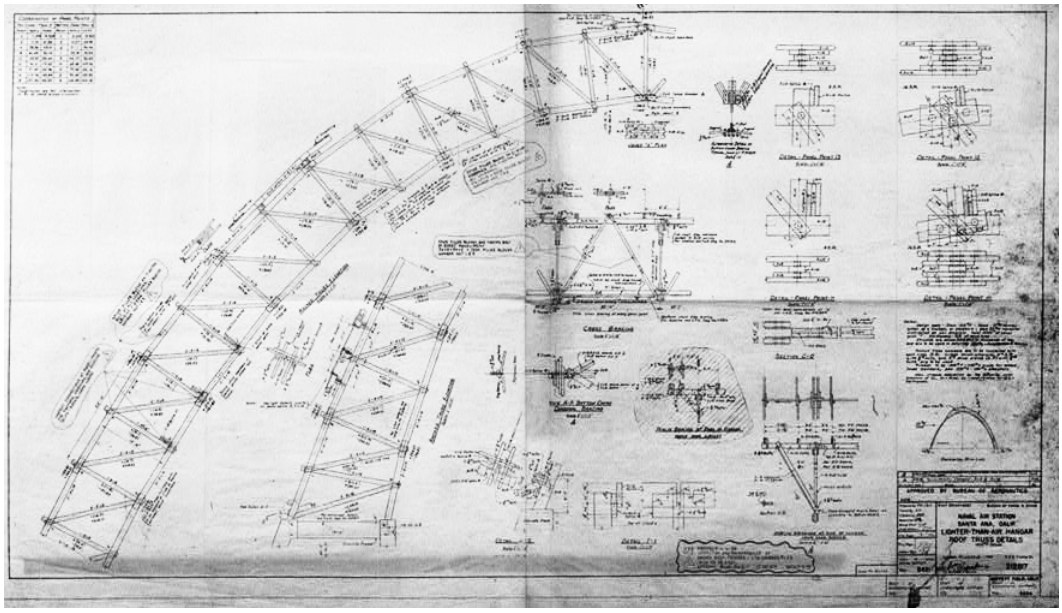
Amirikian's design was used to construct seventeen LTA hangars around the country. In later years, his designs for military structures and devices received international recognition and were used extensively in the Korean conflict and the Vietnam War.

8 American Welding Society, Arsham Amirikian Engineering Scholarship Description.

From an architectural standpoint, the defining features of the hangars' design were the:

- catenary form (a term in physics that describes the distinct "half-eggshell" shape of the hangars);
- nearly all-timber, partially prefabricated and fire-proofed construction;
- individual timber arches, with timber X-bracing and K-bracing;
- steel ring timber connectors;
- reinforced concrete A frame system supporting the arches;
- reinforced concrete bents devised for the end doors;
- rolling segmented timber doors;
- two distinct types of foundation systems;
- 2000-foot circular landing mat, with clusters of smaller, circular mooring pads.

In the October 1943 edition of ASCE Civil Engineering Magazine, Arsham Amirikian offered details about his innovative hangar design in his own words in an article entitled, "Navy Developed All-Timber Blimp Hangar" (see Appendix B.)



Hangar roof truss detail, 1942

In March 1942, the Navy Bureau of Yards and Docks contracted with Holmes & Narver Consulting Engineers of Los Angeles to design and engineer an LTA base in Orange County that would accommodate Arsham Amirikian's design for two airship hangars. One month later, BuDocks contracted with the James I. Barnes Construction Company to build the two hangars and the support facilities around them. The company was based in Logansport, Indiana but had offices in Santa Monica.

The final design for the hangars was completed in the fall of 1942. Construction began on Hangar 1, also called Building 28, in October 1942, under Navy contract No. 5421, and was completed in July 1943. Construction on Hangar 2, or Building 29 began in December 1942 and was completed in September 1943.

The Tustin LTA facility was the fourth in the Navy's sequence of seventeen timber hangars, after Lakehurst, New Jersey; Elizabeth, North Carolina and South Weymouth, Massachusetts.[9]

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9 James R. Shock, "American Airship Bases & Facilities," Atlantis Productions 1996

Barnes Construction faced some serious challenges at the Tustin site, such as the powerful Santa Ana winds and the porous soil conditions and high water table that made the area so desirable for farming. Those same conditions meant that the enormous foundations for the hangars had to be supported by concrete piles sunk as deep as 65 feet below grade – a step that only three of the seventeen hangars being built across the nation had to take.

The first phase of construction consisted of the hangars and several support structures for operations and personnel, including barracks, a mess hall, gatehouse, paint and oil storage building, administration building, fire station, garages, dispensary, bachelor officer's quarters, officer's houses, recreation building, radio tower and transmission building, storehouses, an incinerator and mooring masts.[10]

Like the other engineers and contractors across the country, Holmes and Narver and Barnes Construction developed their own technique for erecting the massive parabolic roof trusses – 51 of them in each hangar.

Hangar under construction, 1942

10 Historic American Building Survey for the Marine Corps Air Station, Tustin Hangars (HABS NO. CA-2707), Prepared for U.S.N. by Karen Weitze, Ph.D., & Christy Dolan, KEA Environmental, Inc., January 2000.

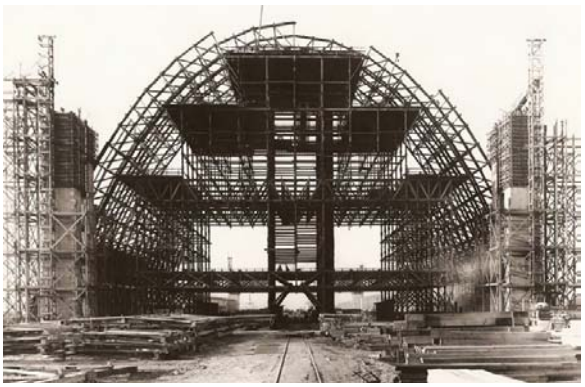
Hangar roof under construction, 1942, USN blimp in flight, upper left

Together, the trusses form a barrel-shaped roof some 1,000 feet long, 170 feet high and 296 feet wide. Barnes opted for a rolling scaffold, or false work, mounted on a traveler made up of 18 railroad flatcars coupled in six parallel units of three cars, each rolling beneath the false work.

Men worked in nine-hour shifts, moving the scaffolding two or three times a day as each truss was hoisted into place and secured. The winds determined how long it took to roll the scaffolding from one position to the next, which was about seven minutes when they were calm.

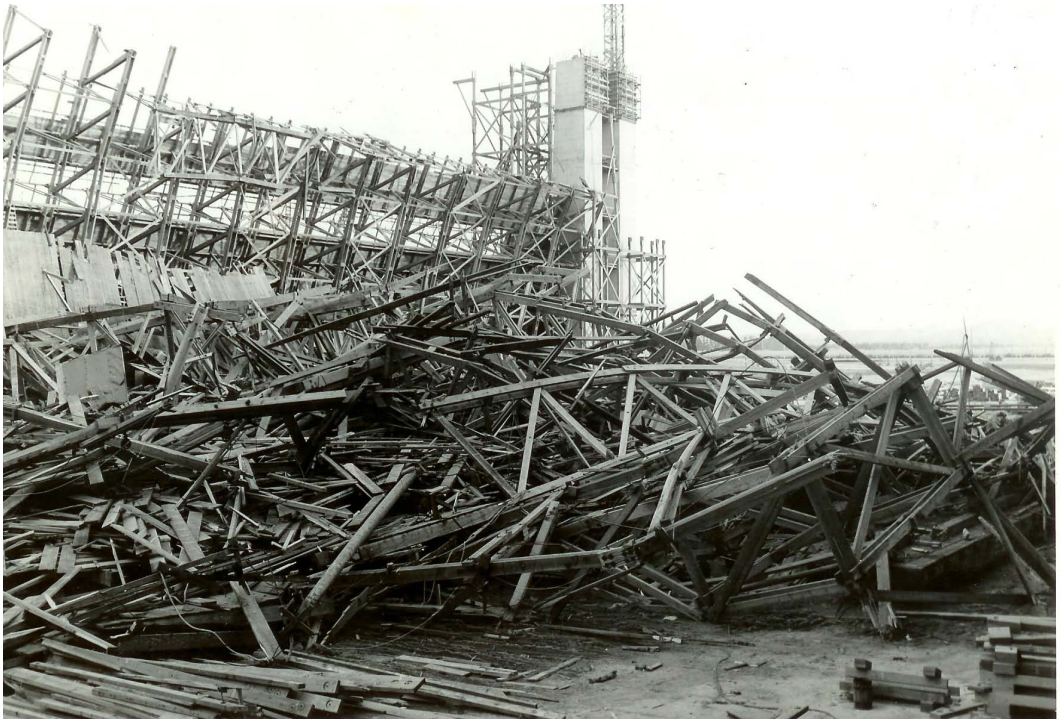
The accelerated construction schedule was typical of critical wartime projects. The two hangars and the support structures around them were completed in just over 6 months – from groundbreaking on April 1, 1942 to the start of flight operations on October 19, 1942 with a single blimp, then a full complement of 12 blimps by the end of that year.

As impressive as the construction schedule was, from dawn to dusk, seven days a week, it wasn't uneventful. There were two major collapses during construction…one caused by Mother Nature and the other by human error.



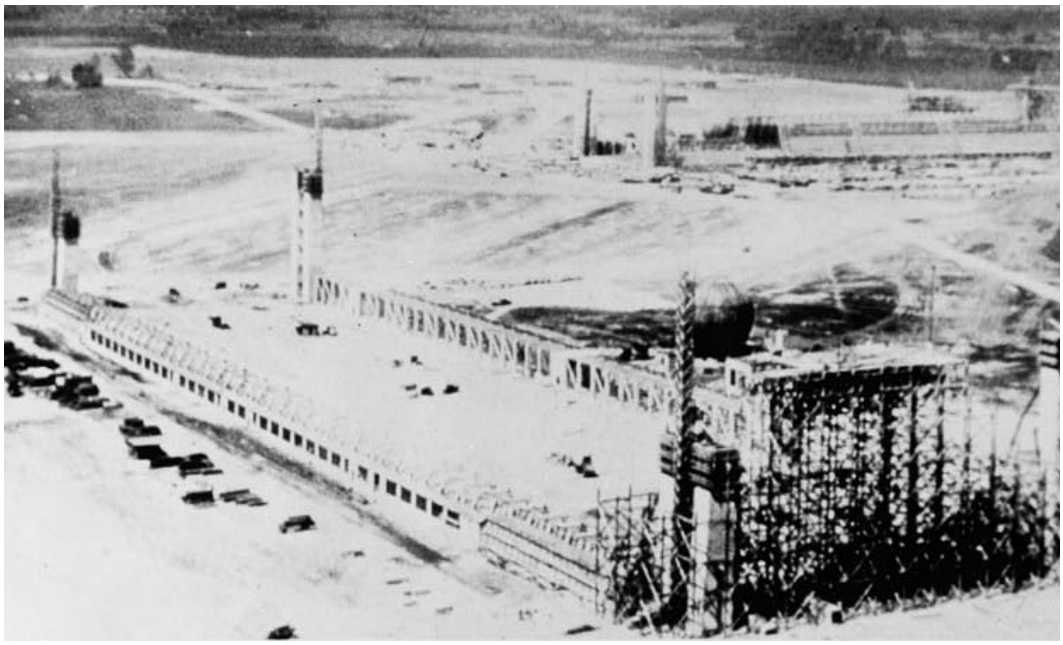
Hangar under construction, 1942

On January 23, 1943, a howling rainstorm and 80-mile-an-hour winds turned one of the partially built hangars into a pile of rubble, taking down a dozen completed and partially completed trusses.[11]



Building 29 following windstorm collapse, January 23, 1943

11 Carol Haugh Jordan, "Tustin: An Illustrated History," 2007 Tustin Area Historical Society



Hangars under construction, looking north, 1942

Less than a month later, on February 12, 1943, another collapse occurred. A mild Santa Ana wind sent a number of railroad cars, with trusses attached, crashing into the partially assembled hangar. But this time, Mother Nature was off the hook.

David Lee Narver, Jr. was the son of the founder of Holmes and Narver, the project engineer. When he passed away in May 2008, Mr. Narver was one of the last surviving members of the large team of engineers, designers and builders who worked on the hangars.

According to David Narver, the workmen responsible for the flatbed cars had forgotten to set the brakes on two of the cars at the end of the day. When the winds picked up during the night, they were strong enough to set the railroad cars and the trusses mounted on them in motion, and momentum took over from there.

The cost of the two collapses was significant, even in the dollar values of the time. The first collapse, which was deemed an act of nature, cost

$64,000, which the Navy paid. The second was ruled the fault of the contractor, who had to pay the additional $120,000 in costs caused by the collapse.

In November 1942, a P-38 fighter crashed into one of the unfinished hangars, killing the pilot and embedding the remains of the aircraft in the newly poured concrete of one of the doorway frames.

Despite the setbacks, the hangars and support buildings were completed in just one year, in October 1943, at a total cost of $10,062,482.08 – a remarkable figure when matched against the grueling construction schedule and the two collapses.

Even while they were being built, the Tustin hangars were attracting national attention. The two wooden behemoths rising from a California farm field were featured in newspaper and magazine articles across the country, including a number of articles in 1942 and 1943 in the leading engineering trade publication, the Engineering News Record.

Tustin hangars, c. 1943, livestock grazing in foreground

In more recent years, a large number of detailed studies of the history, design and construction of the hangars have been done for various state and federal agencies. Excerpts from two of those studies have been included as appendices:

Appendix C.
Historic American Building Survey for the Marine Corps Air Station, Tustin Lighter-Than-Air Ship Hangars

(HABS No. CA-2707, January 2000;
Karen Weitze, Ph.D, Christy Dolan,
KEA Environmental, San Diego, CA)

Appendix D.
Historic Blimp Hangars Analysis

(December 1994, Howard Needles Tammen and Bergendoff;
Leighton and Associates)

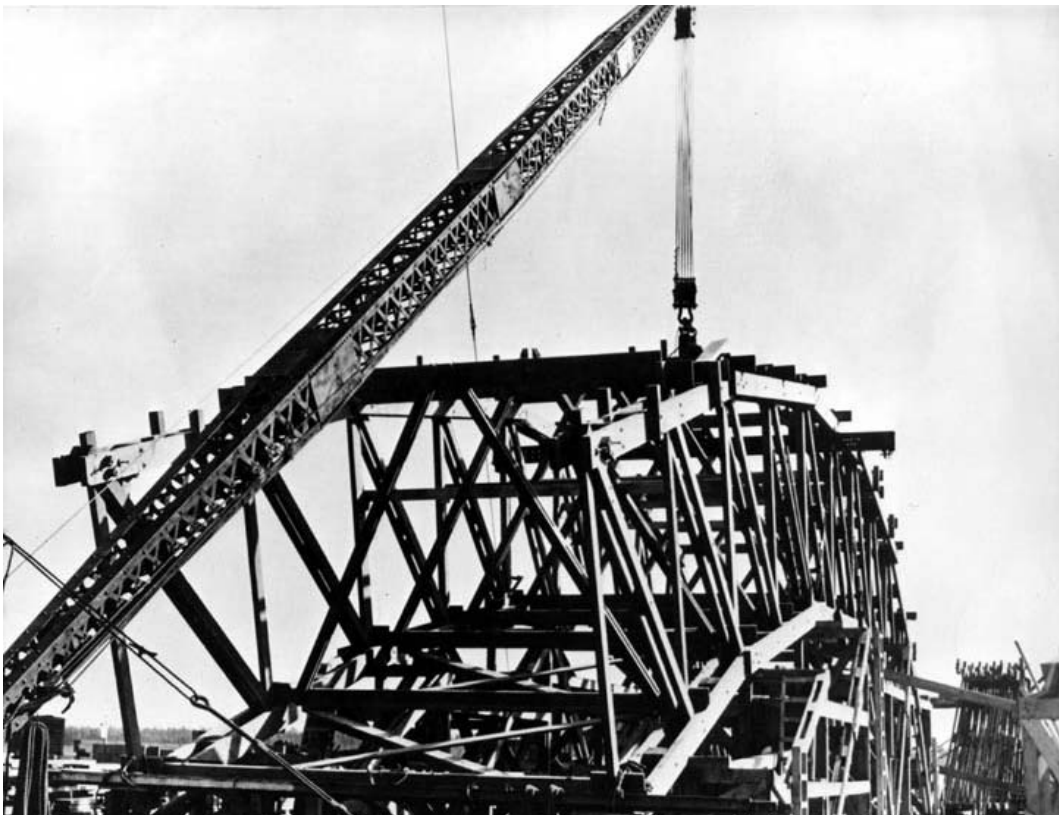
A recurring element in those studies and others is the diversity and quantity of materials needed to turn Amirikian's design into a reality at LTA bases across the country – especially the staggering amount of lumber needed. Each hangar required about three million board feet of wood, of which 750,000 board feet was needed for the 51 roof arches.

Almost all the hangars across the country were built from Oregon Douglas fir. The one exception was the hangar at the LTA field in Weeksville, North Carolina, which was allowed to use Southern white pine because of its availability.

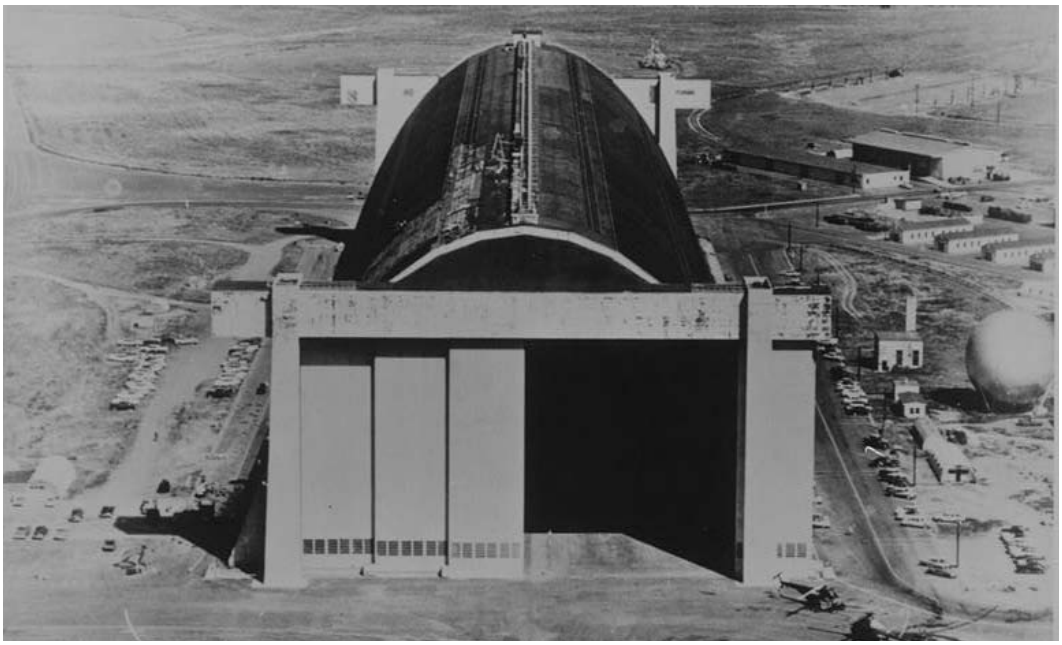
All the lumber for the Tustin hangars was milled, pre-cut, bored, grooved and beveled at Timber Structures, Inc. in Portland, Oregon. Timber Structures shipped the wood components in specially heated railroad cars to the individual hangar construction sites, where they were preassembled as "jigs," with all the pre-cut pieces lettered and numbered.

The lumber was heavily treated with salts both as a fire retardant and to prevent it from drying out completely, which would alter the dimensions of each piece. The timber was milled at about 25% moisture content, with the intent that each piece would be delivered and installed before the lumber dried out completely.

The Protexal Corporation of Kenilworth, New Jersey, provided the fire retardant and treated the lumber to withstand exposure to gas flames of



Hangar roof truss being set in place, 1943



Building 28, c. 1957

1,300 degrees, 1,550 degrees and 1,658 degrees for various intervals over a 45-minute period. Protexal's tests showed that the wood charred at those temperatures but didn't burn.

Over the years, however, fire from lightening strikes or accidents was a constant threat to wood LTA hangars across the country, bringing down three of them at Richmond, Florida in 1945, one of the two hangars at Tillamook, Oregon in 1992 and the hangar at Weeksville, North Carolina in 1995.

The Tustin hangars may have been spared serious problems with lightening strikes thanks to the Marine Corps, which took over the base in 1951. The Marines installed an aluminum-and-copper lightening rod system on each hangar made up of a series of sixteen-inch aluminum rods on swivel bases placed in double rows along the top of each hangar.

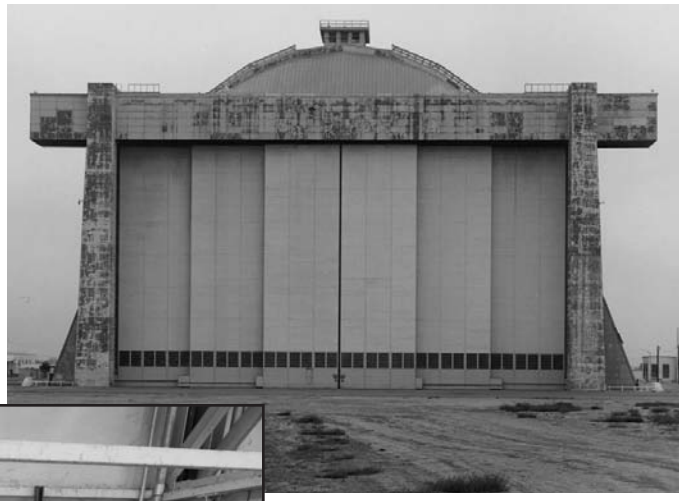
Seven of the seventeen Amirikian-designed hangars still exist today: two at Tustin, two at Lakehurst, New Jersey, two at Moffett field near Sunnyvale, CA and one at Tillamook, Oregon.

Hangar Doors

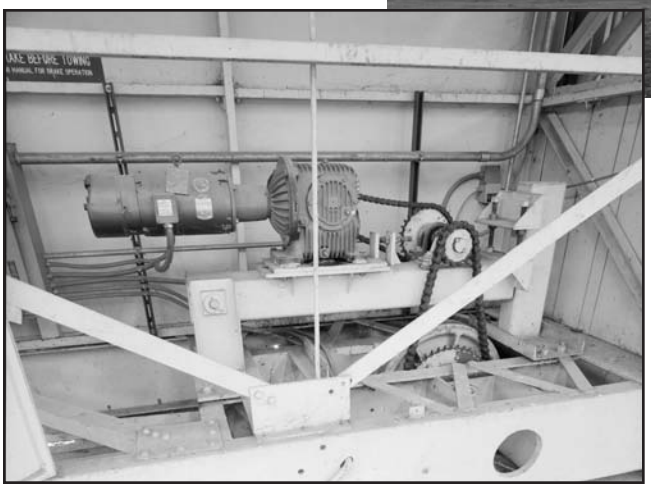
At each end of the hangars are a series of vertical flat-leaf, rolling doors. Each 120-foot high, 37-foot wide door leaf sits on a rolling carriage set on rails and operated by electric motors.

There are six door panels per opening. Each opening has a pair of reinforced concrete towers approximately 145 feet high which support the overhead box beam, which serves to guide the top of the door panels and provides part of the roof enclosure.

The door panels, which are stacked three deep at each concrete tower, open at the center. They were operated by motorized cables and took about two minutes to open or close.



Building 28, March 2002



Hangar door motor, mounted at bottom of one door panel. On each door, a motor with a chain drive mechanism drove the three sets of door panels.

Building 29, west doors, 1999

Building 29, west doors, on rails, 1999

Building 29 doors, with railroad wheel visible lower right, 1999

Building 28, south doors, control tower lower right, March 2002

Building 28 exterior, south door detail, March 2002

Floors & Foundations

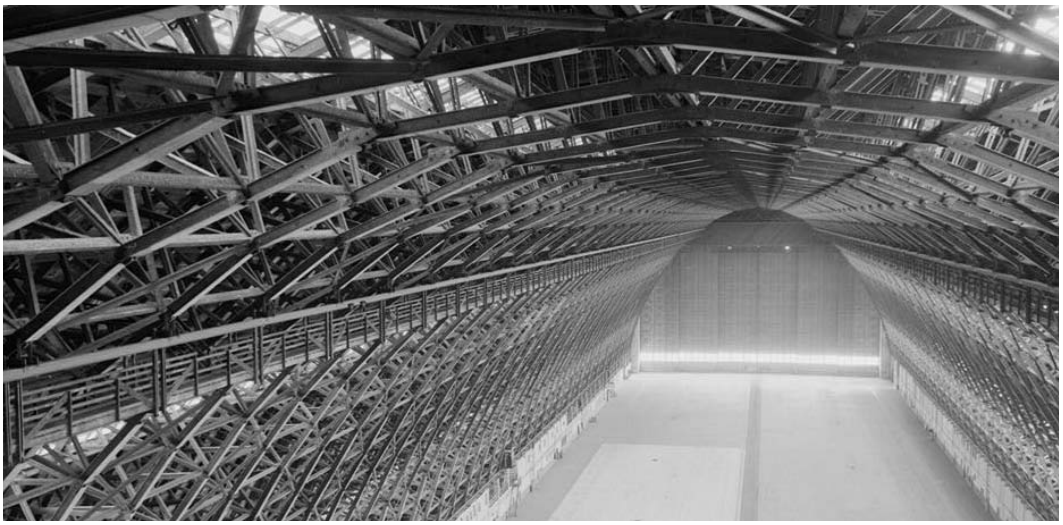
The hangar floors are 5-inch thick, un-reinforced concrete slabs. Each slab is approximately 400 square feet and was poured in a checkerboard pattern. The overall floor area is approximately 296,000 square feet per hangar.

The foundations for each hangar consist of approximately 1,600 Raymond piles sunk 48 feet deep for Hangar-1 and 65 feet deep for Hangar-2. Each pile was constructed using steel shells filled with un-reinforced concrete. The piles supporting trusses were designed for 30-ton capacity each, and the piles supporting the concrete towers were designed for 60-ton capacity each.

One of the 1,600 Raymond piles beneath the hangar foundations exposed during a 1997 inspection.

Electrical, Heating and Gas Systems

The hangar's electrical system, most of which has been disabled, was fed by buried underground cables leading to a series of transformer vaults in each hangar, from which power was distributed to various electrical panels. Each hangar had 480-volt electric service, which was reduced to 220 volt and 110 volt service for shops and offices.



Building 28, roof structure detail, 1999.

The original steam heating system, which served a series of steam radiators, has been completely disabled, along with the gas lines that serviced heaters and gas equipment in the hangars' maintenance shops.

The roof area can be reached, for those who dare, by a series of stairs leading to two catwalks suspended near the top of the roof trusses. The same area houses the steel trolley beams, which supported rolling winches that could lift up to 5,000 pounds at any point of the hangars' 1,000-foot length.

Helium Tank Buildings (Building 28A and Building 29A)

In addition to the hangars, there were a number of important support buildings and systems that were needed for flight operations, the most important being the helium production and purification system that provided the massive amounts of helium that the airships required.[12]

Helium was a critical commodity during the airship era of the early 20th Century. With extensive military and commercial use of airships, the federal government extablished the National Helium Reserve in 1925 at Amarillo, Texas to ensure a constant supply of helium.

12 Historic American Building Survey for the Marine Corps Air Station, Tustin Hangars (HABS NO. CA-2707), Prepared for U.S.N. by Karen Weitze, Ph.D., & Christy Dolan, KEA Environmental, Inc., January 2000.

Helium Tank Building No. 1 (Building 28A)

The point was well made when the U.S. embargo in the late 1930's against certain exports to Germany restricted helium shipments, which forced the Hindenburg and other airships to use hydrogen, which is much more volatile, as a lift gas.

For many years after World War II, the United States produced over 90% of the commercial helium in the world – first for airships before and during World War II, then as a coolant for rocket fuel during the Cold War and the Space Race of the 1950's and '60's. The National Helium Reserve was finally phased out in 1996, ironically, as a result of the efforts of then-Member of Congress Christopher Cox, whose district included Tustin and the LTA base. The helium tank buildings, also called Buildings 28A and 29A, produced helium that was delivered to the hangar beside it through a system of underground pipes. The helium tanks themselves were encased in heavy concrete liners to counteract the enormous upward force of the gas inside them.

Each helium tank building is a one story, 941-square foot concrete structure, 30 feet long, 30 feet wide and 30 feet high. The buildings are anchored on a concrete slab, with a flat roof, and a 6-foot by 6-foot concrete chimney that is some 46 feet tall. The chimneys are constructed of concrete on the outside and a single course of brick on the inside.

Metal ladders on the outside of the helium tank buildings reached to the top of the chimneys, which had openings for access from both inside and outside the chimneys.

Each building had two 12-foot metal roll doors on the wall nearest the hangar beside them – on the east wall of Building 28A and the south wall of Building 29A. Building 28A also had a concrete ramp leading up to these metal doors and an overhang above the doors.

C. Mooring Mats and Masts

The Tustin base was commissioned on October 1, 1942 and flight operations began on October 19, long before construction of the hangars was complete. Operations began with a single blimp then a fleet of 12 blimps by the end of the year, operating from circular concrete mats and mooring masts until the hangars were completed some 12 months later.

Each circular mooring mat was made of concrete and measured approximately 600 feet in diameter. Mooring Mats 1, 2 and 3, which were laid out to the northeast of the northern hangar in a cloverleaf pattern, were the first mats to be built and used for flight operations. Mooring Mats 4 and 5 were situated to the east of the southern hangar, Building 29.

Tustin LTA as NAS Santa Ana, c. 1945

V. MCAS TUSTIN: OPERATIONAL HISTORY

CHRONOLOGY

October 1, 1942
NAS Santa Ana (Naval Air Station Santa Ana) commissioned

1949
NAS Santa Ana (Naval Air Station Santa Ana) decommissioned

1949 – 1951
Used as civilian airfield, air museum and blimp storage

May 1, 1951
Re-commissioned MCAF Santa Ana (Marine Corps Air Facility Santa Ana)

September 1, 1969
Renamed MCAS(H) Santa Ana
(Marine Corps Air Station [Helicopter] Santa Ana)

April 3, 1975
Hangars entered into the National Register as a historic district

April 23, 1976
Base annexed by City of Tustin

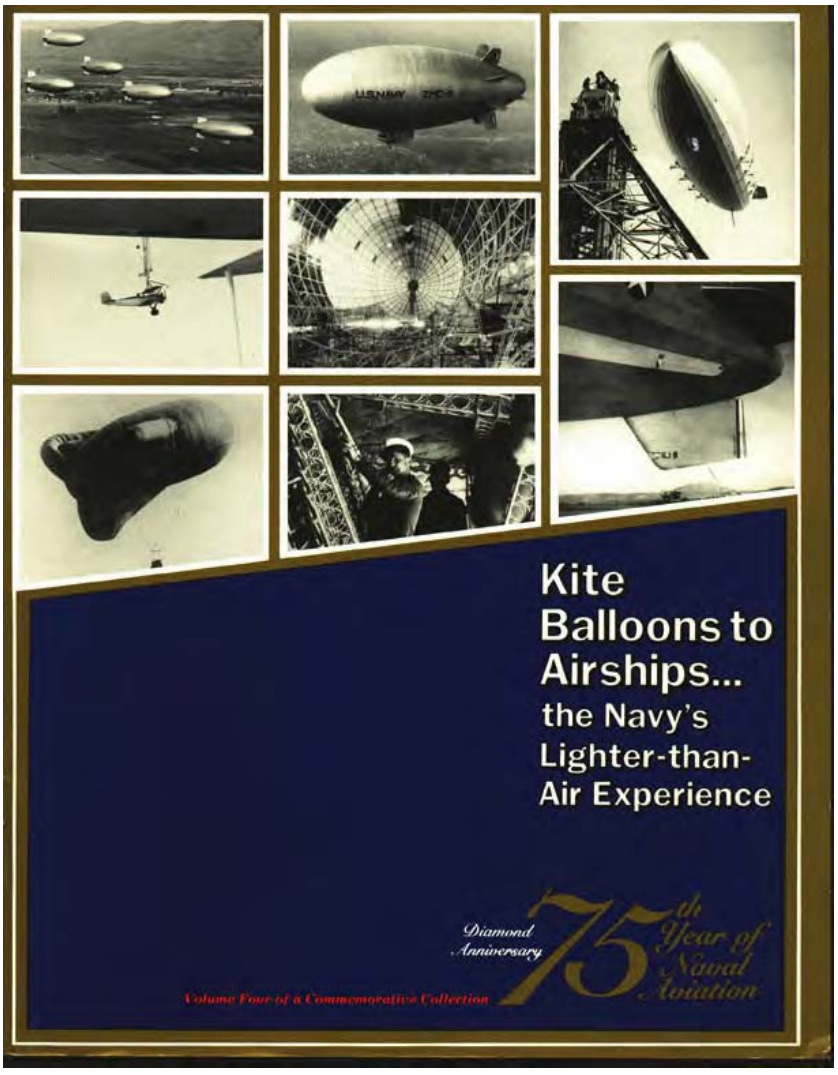
June 1, 1978
Renamed MCAS(H) Tustin (Marine Corps Air Station [Helicopter] Tustin)

1991
MCAS Tustin recommended for closure by Base Realignment and Closure (BRAC) Commission

July 3, 1999
Closed in accordance with Base Realignment and Closure Act

In 1987, the Department of the Navy published a pictorial history of the birth and evolution of the Navy's LTA program entitled "Kite Balloons to Airships: the Navy's Lighter-than-Air Experience." *(front cover below)*

The history was one volume in a commemorative collection honoring the 75th anniversary of naval aviation, excerpts of which have been included as Appendix E. Although no longer available in print, the entire document can be downloaded at: http://www.history.navy.mil/branches/lta-m.html



Building 28, south view, control tower on right, 1999

Building 28, south doors, 1999

VI. WORLD WAR II LTA OPERATIONS AND BEYOND

In the months following the United States' entry into World War II, the War Department's fears of attacks along the country's coasts were well founded. German submarines were active and deadly along the length of the Atlantic coast and the Caribbean, attacking and sinking 454 American and allied ships in 1942. Many of the attacks were within sight of land, sometimes during daylight hours while swimmers on nearby beaches watched in disbelief.[13]

The log of German submarine U-123, commanded by 28-year old Captain Reinhard Hardegen, provides a detailed record of how deadly the U-Boats could be. U-123 led a convoy of five submarines that sunk a total of 19 allied and American ships on two sorties in January and April of 1942.[14]

Though less intense, there were a number of attacks along the Pacific coast. On December 20, 1941, the S.S. Emidio, an American tanker, was sunk by a Japanese submarine 25 miles off the Mendocino coast.

In February 1942, Japanese submarines fired on oil derricks north of Santa Barbara and at least two locations on the Oregon coast, leaving the West Coast on constant alert for the possibility of a full-on Japanese assault by air and by sea.

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13 The Forgotten Blimps of World War II, CTC Edward E. Nugent, USN (Ret.), Foundation Magazine, Spring 1995, a publication of The Naval Aviation Museum Foundation.

14 IBID

Across the country, the war was the topic of every conversation and dominated everything, but nowhere more than along the coasts. Cars driving along Pacific Coast Highway at night had to have their headlights taped so that only a sliver of light shone through, supposedly making it harder for Japanese air or naval crews to locate and bomb key roads. The practice turned out to be so dangerous that Pacific Coast Highway was nicknamed "Blood Alley" for the rest of the war.

The City of Tustin was divided into 10 sections, with an Air Raid Warden and an emergency team assigned to each one. On December 12, 1941, just five days after Pearl Harbor, Tustin police and fire departments issued an air raid bulletin[15]:

POLICE AND FIRE
BULLETIN NO. 1

Tustin Police Dept. & Volunteer Fire Dept.

For Air Raids and Blackouts – Two blasts of fire siren at 30-second intervals. One blast, all clear signal.

IN CASE OF BLACKOUTS, all citizens are hereby requested to remain at home and TURN OUT ALL LIGHTS, and if any lights are burning in your community please request that lights be extinguished and REMAIN IN DARKNESS UNTIL THE CLEAR SIGNAL IS SOUNDED.

This Is For Your Protection – Please Cooperate.
All Firemen are Official Blackout Wardens
and have the authority to enforce same.

Signed: J. LeRoy Wilson, Mayor
John L. Stanton, Chief of Police
E.L. Kiser, Chief of Fire Department

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15 Carol Haugh Jordan, "Tustin: An Illustrated History," 2007 Tustin Area Historical Society

U.S. Army Air Corps crew securing a blimp, c, 1917

Developing a network to patrol both coastlines to detect and if possible attack hostile aircraft, ships and submarines became a top priority for the U.S. Navy. Reaching for a proven technology, the War Department decided to establish a number of LTA (Lighter-than-Air) squadrons around the country to patrol the coastlines using manned blimps. Military LTA airship operations had been commonplace since before World War I in France, Italy, Great Britain, and above all, Germany, where Count Von Zeppelin advanced the technology by a quantum leap.[16]

The Navy had been asking Congress for an expanded LTA airship fleet for years and finally got it in June 1940, when 48 airships were authorized as part of a major combat aircraft authorization bill called the "10,000 Plane Program." Now, with a war on, the blimps would not only conduct reconnaissance flights but carry machine guns and depth charges with which they could attack hostile ships and submarines.[17]

The military use of dirigibles got an added push in the early stages of the Battle of the Atlantic, an epic naval struggle between Nazi submarines and allied troop, passenger and cargo ships that often played out uncomfortably close to the Atlantic coast of the U.S.

Navy blimps, used to both patrol the coasts and attack enemy ships, had evolved a great deal since World War I. The new K-class dirigibles of the

16 Historic American Building Survey for the Marine Corps Air Station, Tustin Hangars (HABS NO. CA-2707), Prepared for U.S.N. by Karen Weitze, Ph.D., & Christy Dolan, KEA Environmental, Inc., January 2000.

17 The Forgotten Blimps of World War II, CTC Edward E. Nugent, USN (Ret.), Foundation Magazine, Spring 1995, a publication of The Naval Aviation Museum Foundation.

era, 246 feet long and some 54 feet wide, were built by Goodyear at its Ohio plant at a cost of about $300,000 each. They carried a crew of eight, had room for radio and navigation equipment, a galley and sleeping quarters. They reached speeds of more than 76 miles per hour, could cruise over 2000 miles and could be secured at outdoor mooring pads on masts, with or without hangars.

More importantly, they could take on fuel, supplies, and personnel from ships at sea, and they could stay beneath the clouds in low visibility, patrolling what was called the "100 fathom curve" – the stretch of coastal waters where shipping was most concentrated and where U-boats were most likely to be found.

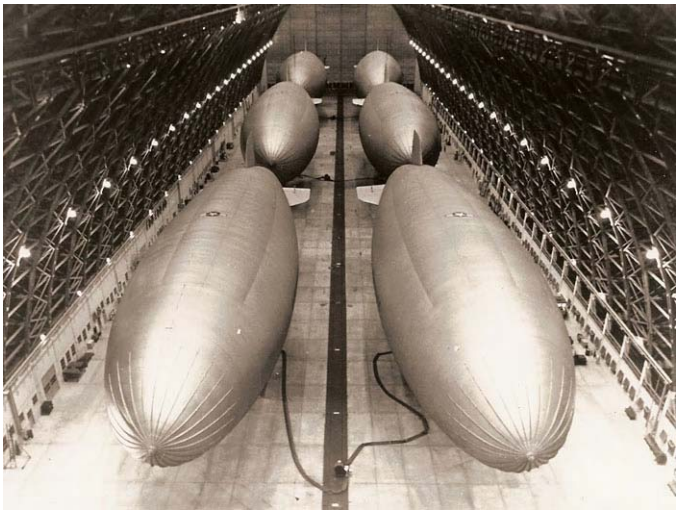
At the start of the war, the only fully operational LTA facility was the Naval Air Station at Lakehurst, New Jersey, already known around the world and destined to be remembered forever as the site of the 1937 Hindenburg disaster – the single, though catastrophic, failure of a Von Zeppelin design.

Building 29 on left, viewed from roof of Building 28, 1999

To jumpstart its LTA program with at least one facility on each coast, the Navy asked the War Department to reestablish a former LTA facility at Moffett Field, south of San Francisco. Moffett was established as a Naval Air Station in 1931 to house the 785-foot long dirigible USS Macon, the largest airship of the time, but was turned over to the Army Air Corps in 1935 when the Macon crashed off the coast of Monterey.

In addition to Lakehurst and Moffett, the Navy ordered a number of lighter-than-air (LTA) facilities to be built or upgraded around the country to house and operate blimps, including facilities in Maine, New Jersey, California, North Carolina, Georgia, Florida and Louisiana. Airship squadrons were also established in Brazil, Jamaica, Trinidad, French Morocco and Gibraltar.

Construction of the Tustin LTA facility, called NAS Santa Ana, began on April 1, 1942 and was operational in just over 6 months. The base was commissioned on October 1, 1942 and flight operations began on October 19 with a single blimp, an L-Class blimp on loan from Moffett Field in Northern California.



Hangar interior with 6 USN K-Class blimps, c. 1943

Ground crew securing blimp, c. 1943

MCAS Tustin, 1950's

By the end of 1942, there were 12 K-Class blimps operating from Tustin as Airship Patrol Squadron ZP-31, for Zeppelin Patrol 31. Until the hangars were completed in the fall of the following year the blimps operated from concrete pads and mooring masts beside each hangar. The Tustin facility also supported auxiliary detachments at Lompoc, California to the north and Del Mar to the south, along with a detachment at Ensenada, Mexico. Airship patrols along the California coast were conucted 24 hours a day from the LTA bases at Tustin and Moffett Field.

The airship fleet performed far beyond the War Department and the Navy's expectations in terms of both reliability and effectiveness – with a remarkable 87 percent "on-line and operational" rate, and 89,000 escort missions through submarine-infested waters for ships loaded with troops, equipment and supplies.

There were only two recorded incidents of airships being lost. The first, Naval airship K-74, was brought down by enemy fire in the Caribbean and the other, Naval airship L-8, was lost off the Pacific Coast near San Francisco, although exactly how and why it was lost remains a mystery to this day.

On the night of July 18, 1943, airship K-74 was on patrol in the Caribbean and engaged a German submarine on the surface in an exchange of gunfire. K-74 attempted a bombing run, but the airship's bombs failed to release, allowing the submarine's deck gun to bring it down. K-74 stayed afloat for hours and all but one crewmember were rescued up the next day.[18]

The second and perhaps the strangest loss was the case of airship L-8, which was patrolling the Pacific coast near San Francisco on August 16, 1942. L-8 took off with Ensign Charles Ellis Adams in command and Lt.JG Ernest Dewitt Cody, a qualified dirigible pilot, making his first flight in a blimp.

The flight was to start out over Treasure Island, go west about 25 miles to Farallon Island, then north to Point Reyes then land at Moffett Field. At 7:30AM, about an hour and a half into the flight, L-8 radioed that they had spotted a suspicious oil slick and were going to investigate. That was the last trace of L-8 ever seen or heard.

Some four hours later, a Navy shore patrol unit in San Francisco called Moffett Field and reported that a blimp had come down near a golf course, bounced off a hill then back into the air and came down a second time in downtown Daly City – all with no one on board.

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18 The Forgotten Blimps of World War II, CTC Edward E. Nugent, USN (Ret.), Foundation Magazine, Spring 1995, a publication of The Naval Aviation Museum Foundation.

The Navy incident report surmised that one of the two airmen may have crawled out of the cockpit to fix an issue of some kind, got into trouble and when the second airman tried to help him, both fell to their deaths, leaving the blimp in the air but without a crew. The report offered no evidence for that conclusion and made no mention of the radio transmission about going to investigate a suspicious oil slick. The mystery of airship L-8 was long forgotten until it was retold in an episode of the popular 1980's television series, "Unsolved Mysteries."

Ironically, the Navy's LTA program was so effective that it became a victim of its own success. By 1944, just two years after the Tustin hangars were completed, the need for blimp patrols and escort missions along both coasts was fading fast. In 1943 the number of sinkings dropped to 65 from the 1942 high of 454, then to just eight in 1944.

USN K-Class Blimps in Tustin hangar, c. 1942.

The Tustin facility continued to serve as an LTA base until 1949, when it was decommissioned as an active installation and designated an "outlying field" for military units in the area. Between 1949 and 1951, the base operated as a local airfield, museum and blimp storage facility for both the Mobil Oil "Red Horse" blimp and a number of Goodyear blimps that had been converted for wartime operations at the Tustin base.

A. Korean Conflict

The Korean conflict was the first war to extensively use jet aircraft in combat and to rely heavily on helicopters to transport troops and equipment, including the first Marine Corps assault helicopters, the Sikorsky HRS and H-19.

In 1951, in response to Korea, the Tustin base was reactivated as a Marine Corps aviation facility and became the country's first military airfield dedicated solely to helicopter operations – MCAF Santa Ana (Marine Corps Air Facility, Santa Ana.)

Initially, 19 USMC officers and 243 enlisted personnel were assigned to the base, with just one helicopter squadron, HMR-161, and one observation squadron, VMO-2. But by 1952, two Marine Air Groups, MAG-16 and MAG-36, and 13 squadrons were in place.

From that point on, the Tustin facility's reputation as the primary base of operations, training and maintenance for Marine Corps helicopter aviation in the Pacific region would advance quickly.

The now-obsolete blimp hangars proved to be ideal for large-scale helicopter operations, providing indoor storage and maintenance areas for huge numbers of helicopters, along with acres of ramp space for parking additional aircraft.

B. Vietnam Conflict

If Korea was the start of large-scale military helicopter operations, Vietnam was where they were perfected – transporting troops, attacking targets in the air and on the ground and moving supplies and equipment to and from every corner of the country.

In September 1961, President Kennedy sent retired Army General Maxwell Taylor to Vietnam to explore what could be done to save South Vietnam. One of Taylor's first recommendations was to dispatch three squadrons of helicopters to Vietnam to increase the mobility of the Republic of Vietnam's troops. Within a month, fifteen HU-1 "Huey" helicopter gunships were deployed to Vietnam.

By the late 1960's and early 1970's, Vietnam truly was a helicopter war. Pentagon estimates were that some one million American troops

Vietnam-era helicopter from MCAS Tustin on training flight over Orange County, c. 1965

Vietnam-era helicopter on ramp at MCAS Tustin, c. 1965

and support personnel were transported by helicopters during combat operations, and that by the end of the war, 4,857 helicopters had been lost due to combat activity or mechanical failures.

Throughout the Vietnam era, MCAS(H) Santa Ana remained the primary base for operations, training and maintenance of heavy and medium attack and transport helicopters for the 3rd Marine Air Wing. Squadrons based in Tustin included Marine Heavy Helicopter Squadron 361 (HMH-361,) HMH-462, HMH-465 and HMH-466.

HMH-361 took part in numerous major combat actions in Vietnam from August 1965 to May 1968, operating from Da Nang base, Marble Mountain, Ky Ha, Dong Ha and the USS Iwo Jima. HMH-361, which was initially established in Tustin in 1952 as Marine Helicopter Transport Squadron 361, also made history in 1962, as a front line unit during the Cuban missile crisis.

Senior USMC officers giving dignitaries a Vietnam-era tour of MCAS Tustin, c. 1965

Another Tustin-based squadron was the Marine Helicopter Training Squadron-301 (HMT-301), nicknamed the "Windwalkers," which was activated in Tustin on April 1, 1966. HMT-301 was an elite group of flight instructors and crew chiefs that trained the majority of Marine Corps pilots and support personnel bound for Vietnam and Southeast Asia.

Initially training pilots and crews for the UH-34 Sea Horse, the unit transitioned to the CH-53A Sea Stallion in January 1968 and was re-designated Marine Heavy Helicopter Training Squadron 301. In March 1972, HMHT-301 and HMHT-302 merged, which added the CH-46 Sea Knight to the squadron's inventory.

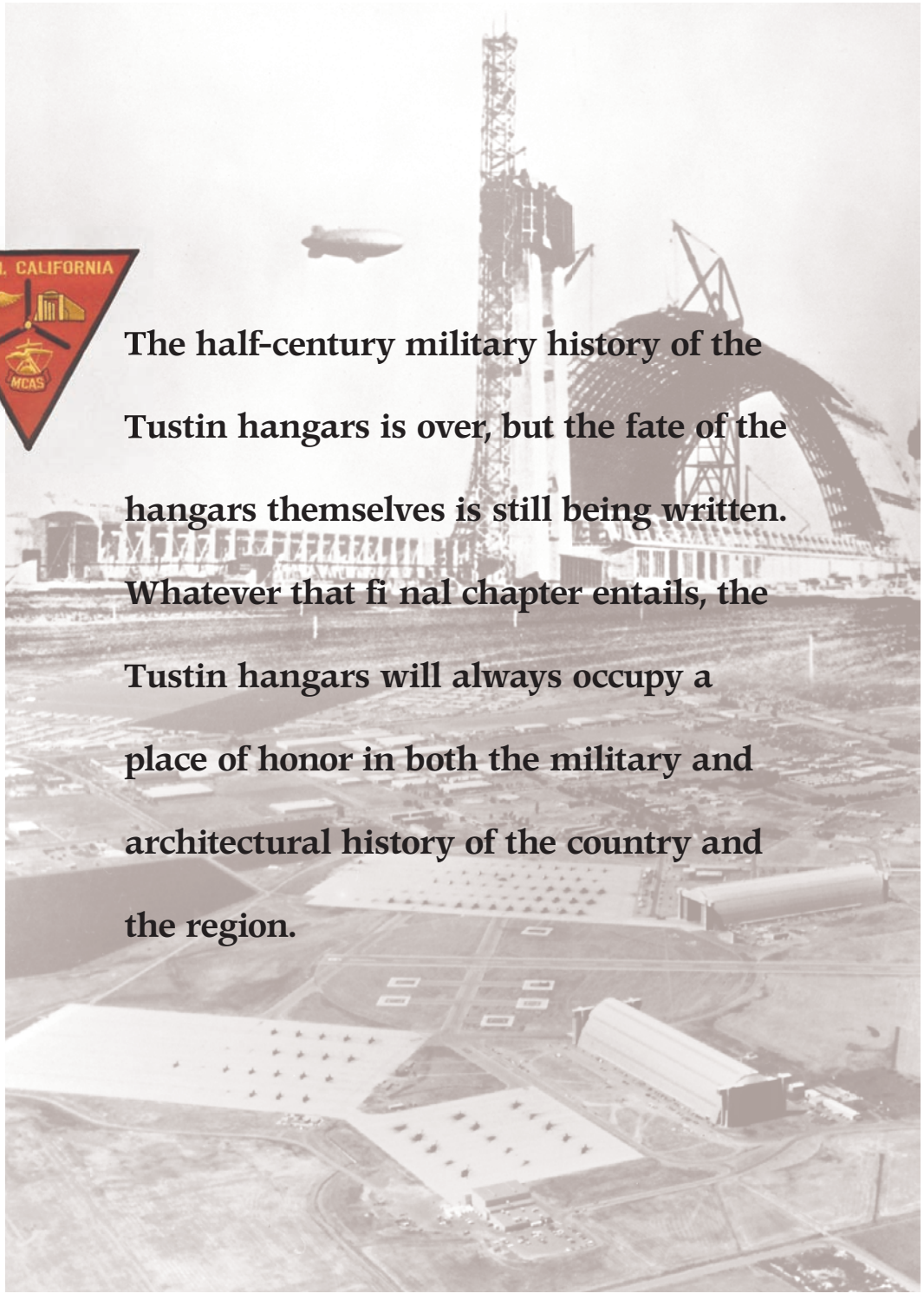
C. 1980'S Through Closure

In October 1983, the CH-53E Super Stallion was added, making HMT-301 the largest helicopter training squadron in the Marine Corps. The massive CH-53 Super Stallion – the second largest helicopter in the world after the Russian Mi-26 – became a familiar sight in the Orange County skies, slowing rising and descending to and from the Tustin base.

The last major combat operation in which MCAS Tustin played a critical role was during Operations Desert Shield and Desert Storm, which began on February 21, 1991, with the bombing and invasion of Iraq. HMH-466, nicknamed "The Wolfpack" was the first CH-53E Super Stallion unit to be deployed during Desert Shield, arriving in Saudi Arabia in August 1990. During Desert Shield and Desert Storm, HMH-466 recovered downed aircraft, conducted the first night vision goggle troop insertion and provided heavy lift support from port facilities to staging areas in preparation for the ground assault. After the war, the Wolfpack returned to MCAS Tustin having sustained no losses of personnel or aircraft.

In July 1993, 2nd Lieutenant Sarah Deal became the first woman Marine selected for pilot training and received her wings as a CH-53E pilot after undergoing training at MCAS Tustin.

Sarah Deal, 2nd Lt., USMC, first USMC CH-53E pilot, 1993



The half-century military history of the Tustin hangars is over, but the fate of the hangars themselves is still being written. Whatever that fi nal chapter entails, the Tustin hangars will always occupy a place of honor in both the military and architectural history of the country and the region.

APPENDICES

Appendix A

Photo Credits

Appendix B

Article by Arsham Amirikian,
ASCE Civil Engineering Magazine, October 1943

Appendix C

Historic American Building Survey (HABS No. CA-2707)
for MCAS Tustin LTA Hangars, January 2000

Appendix D

Historic Blimp Hangars Analysis, December 1994

Appendix E

"Kite Balloons to Airships…
the Navy's Lighter-than-Air Experience,"
Published by USN, Deputy Chief of Naval Operations
(Air Warfare), 1986

Appendix A

Photo Credits

PHOTO CREDITS

PAGE	*CREDIT*
(overleaf)	[Top: Building 28, exterior view, October 1999] Brian Grogan, Historic American Engineering Record; Historic American Building Survey (HABS No. CA-2707) Photo CA-2707-A-4
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p. 7	[Building 28, south doors, October 1999] Brian Grogan, Historic American Engineering Record, Historic American Building Survey (HABS No. CA-2707) Photo CA-2707-A-6
p. 8	[Tustin LTA aerial, blimp landing inset, circa 1943] Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780
p. 10	[Tustin farm homes, from Red Hill Avenue, circa 1920] First American Title, 2 First American Way, Santa Ana, CA 92707
p. 11	[Tustin LTA aerial, circa 1943] Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780
p. 12	[Tustin LTA chapel, blimp overhead, circa 1943] Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780
p. 13	[NAS Santa Ana Commissioning Ceremony, October 1, 1942] First American Title, 2 First American Way, Santa Ana, CA 92707
p. 14	[Building 29, west doors, October 1999] Brian Grogan, Historic American Engineering Record, Historic American Building Survey (HABS No. CA-2707) Photo CA-2707-B-3
p. 15	[Building 28, "Beware Rotor Blades" warning sign, March 2002] Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780; Kyle Oldoerp, Photographer

p. 16 [Building 29, left, Building 28 in background, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-10

p. 17 [Building 29, right, Building 28 in background, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-9

p. 20 Top: [Steeplejack inspects roof truss, November 1997]
Southwest Division, USN Naval Facilities Engineering Command,
Structural Evaluation & Report (A-E Contract No. N68711-96-D-2231),
by Becker & Pritchett, Structural Engineers, Inc.

Bottom: [Steeplejack's Repair Report, 1974]
Western Division, USN Naval Facilities Engineering Command,
FY 1974 ESR No. 412401P

p. 23 Top: [Construction plan, cross section detail]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-19

Bottom: [Building 28, interior, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-A-14

p. 24 [Hangar 28, interior, wall/roof detail, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-A-17

p. 25 Top: [Building 28, south doors, control tower on right, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-6

Bottom: [Building 29, side view, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-B-5

p. 26 Top: [Building 28, west side, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-5

Bottom: [Building 29, south doors, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-3

p. 27 [Photo portrait of Dr. Arsham Amirikian]
Memorial Tributes: National Academy of Engineering, Volume 5, 1992

p. 29 [Construction plan, hangar roof truss detail]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-15

p. 30 [Hangar under construction, circa 1942]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

p. 31 [Hangar roof under construction, blimp in flight, upper left, circa 1942]
First American Title, 2 First American Way, Santa Ana, CA 92707

p. 32 Top: [Hangar under construction, circa 1942]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

Bottom: [Hangar windstorm collapse, January 23, 1943]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

p. 33 [Aerial of hangars under construction, looking north, circa 1942]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-11

p. 34 [Tustin hangars, circa 1943, livestock grazing in foreground]
First American Title, 2 First American Way, Santa Ana, CA 92707

p. 36 [Hangar roof truss being set in place, circa 1943]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

p. 37 [Aerial view of Building 28, circa 1957]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-13

p. 38 Top: [Building 28, exterior view, March 2002]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780;
Kyle Oldoerp, Photographer

Bottom: [Hangar door motor, mounted on bottom of door panel, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-B-20

p. 39 [Building 29, west doors, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-B-9

p. 40 [Building 29, west doors, on rails, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-B-12

p. 41 [Building 29, interior doors, railroad wheel visible lower right, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-B-18

p. 42 Top: [Building 28, south doors, tower lower right, March 2002]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA
92780; Kyle Oldoerp, Photographer

Bottom: [Building 28, exterior, south door detail, March 2002]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA
92780; Kyle Oldoerp, Photographer

p. 43 [Raymond pile beneath foundation, November 1997]
Southwest Division, USN Naval Facilities Engineering Command,
Structural Evaluation & Report (A-E Contract No. N68711-96-D-2231),
by Becker & Pritchett, Structural Engineers, Inc.

p. 44 [Building 28, interior, roof structure detail, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-A-19

p. 45 [Helium Building No. 1, west and south sides, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-C-1

p. 46 [Aerial view, NAS Santa Ana LTA, circa 1945]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-12

p. 48 Publication Cover – "Kite Balloons to Airships…the Navy's Lighter-than-Air Experience,"
Publisher: Deputy Chief of Naval Operations (Air Warfare)
and the Commander, Naval Air Systems Command, Washington, D.C.; 1986;
Edited by Roy A. Grossnick, Designed by Charles Cooney

p. 47 Top: [Building 28, south view, control tower on right, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-6

Bottom: [Building 28, south doors, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-A-4

p. 52 [U.S. Army Air Corps crew securing blimp, circa 1917]
U.S. National Archives and Records Administration,
8601 Adelphi Road, College Park, MD 20740-6001

p. 53 [Building 29 on left, viewed from roof of Building 28, October 1999]
Brian Grogan, Historic American Engineering Record,
Historic American Building Survey (HABS No. CA-2707)
Photo CA-2707-8

p. 54 Left: [Hangar, interior, with 6 USN K-Class blimps, circa 1943]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

Right: [Ground crew securing blimp]
U.S. National Archives and Records Administration,
8601 Adelphi Road, College Park, MD 20740-6001

p. 55 [Aerial view, MCAS Tustin, 1950's]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

p. 57 [USN K-Class blimps in Tustin Hangar, c. 1942]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

p. 59 [Vietnam-era helicopter training over Orange County, circa 1965]
U.S. Navy Historical Center, 805 Kidder Breese S.E.,
Washington Navy Yard, Washington, D.C. 20374

p. 60 [Vietnam-era helicopter on ramp at MCAS Tustin, circa 1965]
U.S. Navy Historical Center, 805 Kidder Breese S.E.,
Washington Navy Yard, Washington, D.C. 20374

p. 61 [USMC officers and dignitaries, MCAS Tustin, circa 1965]
Tustin Area Historical Society, 395 El Camino Real, Tustin, CA 92780

p. 63 [Sarah Deal, 2nd Lt., USMC, first USMC CH-53E pilot, 1993]
U.S. Navy Historical Center, 805 Kidder Breese S.E.,
Washington Navy Yard, Washington, D.C. 20374

p. 64 [Tustin LTA under construction, blimp overhead, circa 1942]
First American Title, 2 First American Way, Santa Ana, CA 92707

Appendix B

Article by Arsham Amirikian,
ASCE Civil Engineering Magazine,
October 1943

Appendix C

Historic American Building Survey for the Marine Corps Air Station, Tustin Lighter-Than-Air Ship Hangars

[HABS No. CA-2707, January 2000;
Karen Weitze, Ph.D, Christy Dolan,
KEA Environmental, San Diego, California]

Appendix D

Historic Blimp Hangars Analysis (Excerpts)

[December 1994, Howard Needles Tammen and Bergendoff; Leighton and Associates]

Appendix E

"Kite Balloons to Airships: the Navy's Lighter-then-Air Experience" (Excerpts)

[1987, Department of the Navy;
Deputy Chief of Naval Operations (Air Warfare);
Naval Air Systems Command; U.S. GPO]