7 Conclusions and Recommendations

Conclusions

This study shows that military hangar construction, whether conducted in a piecemeal manner or in pre-planned, budgeted programs, was initiated in response to:

- air mission requirements
- increases in combat groups and aircraft inventory necessary to carry out mission requirements
- increases in corresponding ground facilities to house combat groups and aircraft.

Not surprisingly, all hangar construction and expansion ultimately was executed within the scope of the actual amount of funds appropriated to address the above requirements.

The study also documents the extensive use of standard plans in hangar construction. By WWII, not only was there a substantial amount of standardization across the entire Air Corps and Naval construction programs, but there was an appreciable amount of more precise standardization within particular building programs. (For example, Air Depot facilities can be distinguished from flying training field facilities, and these in turn can be distinguished from technical training facilities.) By World War II, the Navy had achieved similar standardization of their landplane and seaplane hangars.

The authors conclude that a facilities survey of national scope is invaluable in the local determination of a building's historical significance for purposes of Section 106 compliance. The national-scale survey provides a big-picture context for any local facility determined to be significant: the national significance is not "more important" than regional or local significance, but it provides a rich, DoD-specific context that may add meaning to regional or local building significance.

Because the significance of a hangar to DoD may rest on the fact that it is the earliest, best, or last existing example of a type, a national-level survey ultimately is necessary to identify structures of the greatest significance. In any

case, designating the “best” example of a building type is difficult because it relies to a large extent on an inspector's subjective judgment. If this subjectivity could be eliminated — and if local significance was not the deciding factor — it may be feasible and justifiable to use documentation of the nation's best example of a hangar type to represent the remaining examples for purposes of mitigation.

A number of statistical findings, as presented below, may help cultural resource managers develop more valid assessments of significance for local airfield construction.

Hangar Distribution

Excluding data for Reserve, Guard, and closure bases, national survey inventory data confirm that 55 percent of the DoD hangar inventory is under the stewardship of the Air Force. Approximately 20 percent of the inventory is under Army stewardship and another 20 percent is under Navy stewardship. The Marine Corps is responsible for the remaining 5 percent.

Listed below are the installations in each military service that host the most hangars. Not surprisingly, the listed bases are those with major aviation missions. It is important to note, however, that all of the hangars accounted for in the list (i.e., 222) represent only a small minority of total number of military hangars documented in the national survey responses. This observation has two obvious implications: (1) there may be a large number of hangars unaccounted for by the database due to a lack of response (or an incomplete response) from the surveyed installations, and (2) a substantial portion of the DoD hangar inventory is located on bases with minor air operations; each of these bases may have only a handful of hangars, but taken together these hangars probably account for a majority of the DoD inventory.

Installations hosting the most hangars are as follows:

Air Force

- Ellsworth AFB, SD (31)
- Fairchild AFB, WA (24)
- Andrews AFB, MD (24)

Army

- Fort Campbell, KY (20)
- Fort Stewart, GA (19)
- Fort Hood, TX (18)

Navy

- NAS North Island, CA (27)
- NAS Jacksonville, FL (20)
- NAS Pensacola, FL (17)

Marine Corps

- Quantico, VA (12)
- Cherry Point, NC (10)

Chronology and Construction Trends

With 86 percent of the respondents of the hangar survey providing the year of construction for their hangar entries, the data reveal an interesting chronology of military hangar construction. Only one existing hangar was identified as having been built in the Early Years era (pre-1917): Building No. 73 at NAS Pensacola, FL, constructed in 1916. It is a two-bay seaplane hangar with flat steel gabled trusses over each bay. This building is designated as permanent construction and encloses 15,511 sq ft of hangar space. There is no indication that this hangar was based on a standard design replicated at other bases.

Eleven hangars (approximately 1 percent) were built during the World War I era (1917–1918). Only two of the eleven were constructed in 1917. The first 1917 hangar is one of Albert Kahn's Signal Corps Mobilization Hangars at Brooks AFB, TX. It is of wooden temporary construction with a gambrel structural profile. While many of these hangars were constructed during World War I, Brooks AFB Building No. 671 appears to be the last standing example of its type. The second 1917 hangar is a U.S. All-Steel Hangar at Fort Sam Houston, TX (Building No. 1198). This hangar type, recognized by its standard 66-foot steel gambrel truss, was mass-produced during World War I, but many component parts did not reach their intended locations until after the Armistice. As a result, most U.S. All-Steel Hangars were not erected during the World War I era, but were assembled during the Interwar Years and often put to alternative uses as storage warehouses and maintenance shops. An additional World War I-era example of the U.S. All-Steel type was constructed at NAS North Island, CA. Erected in 1918, Building No. 830 appears to be a two-bay version of the standard design. Due to its modular design, it was not uncommon to erect the U.S. All-Steel hangars in multiple-bay configurations and with varying lengths.

Approximately 9 percent of the hangars from the survey were constructed in the Interwar Years (1919–1938). This may seem to be a staggering figure for an era during which the United States was not at war, but it is understandable when one considers both the long span of time that elapsed between the world wars

and the huge advances overall in the field of aviation during the period. Hangar construction during this period was dominated by a few standard designs, all of steel construction. These include the Standard 110'-0" Hangar All Steel 200-Feet Long; the Air Corps 110' x 240' 1929-B Design; the Air Corps 1930-A Design, -B Design, -D Design, and -E Design; the Air Corps Double Hangar Type H; the Air Corps Type A-A Hangar Steel Two-Bay; and, again, the U.S. All-Steel Hangar.

Approximately 16 percent of the hangars documented in the survey were constructed during the World War II era. Hangar construction in this period was dominated by several standard types, including the 120-Foot Temporary Hangar; the 184-Foot Demountable Type DH-1 Hangar; the Air Corps Technical School Types TUH-1 (Steel) Hangar and TUH-2 (Wood) Hangar; the Air Depot A/C Repair Hangar in single, double, triple, and quad configurations; the Heavy Bombardment Type HANG-R-A Hangar; the Squadron OBH-1 (Steel) Hangar and OBH-2 (Wood) Hangar; and the Transport Squadron Type HANG-E-A Hangar. The Navy hangar construction program was dominated by the Type B-M Landplane and Type B-M Seaplane Hangars, both of which have a distinctive sawtooth monitor roof. The B-M Hangar was constructed in half and full configurations as budgets allowed. Regional standard hangar designs evolved to make use of readily available construction materials. In the northwestern continental United States and Alaska (and nearby islands), for example, the wooden Birchwood, Kodiak, Kotzebue, and Yakutat Hangars were erected in large numbers, each being named after the Alaskan towns that had first received these hangars.

Virtually all wooden hangar construction occurred during the World War II period, and no evidence was found to suggest that wooden hangar construction occurred after this period. Many of these wooden hangars have been demolished or dismantled, making them relatively rare. Despite some permanent designations today, it is likely that all wooden hangars were originally considered temporary or semi-permanent construction. However, it is important to understand that not all temporary hangars are of wooden construction. In fact, only a quarter of the temporary hangars in the survey were timber structures. The Air Corps implemented policy during World War II to allow for the use of steel in technical construction, explaining the large number of steel temporary hangars in DoD's inventory today. Approximately half of the temporary and semi-permanent hangars in the survey were constructed during the World War II period, with most of the remainder constructed during the Cold War era.

Most hangars standing today — a full 55 percent of the DoD inventory — were constructed during the Cold War period. Approximately 5 percent documented in the survey were constructed during the Korean War era; about 36 percent

were constructed during the Vietnam conflict, and approximately 14 percent were built after Vietnam. Most Cold War-era hangars were constructed from standard designs. Two standards are Army-specific: the Army Air Field 12,000 Square-Foot (20,000 With Shops) Hangar and 20,000 Square-Foot (35,000 With Shops) Hangar. Other standard designs include the Double Cantilever Hangars, which feature unique flat exterior forms with arched interior structures; design variations of these were created for Fighter A/C, Medium Bombers, and Heavy Bombers. The Very Heavy Bombardment Type HANG-T-A Hangar, the Liaison Type Plane Hangar, the Organizational Maintenance Hangar and Organizational Pull-through Hangar; the Alert Fighter A/C Hangar and prefabricated Butler Type Alert Hangar; and the Readiness Hangar and Ready Fighter Hangar are other standards. Some standard Cold War-era plans accommodated specific aircraft. These include the B-36 Maintenance Hangar; the Type MB-2A Hangar for B-29, B-50, and DC-97 aircraft; and the Type MB-3A Hangar for KC-135R and B-52 aircraft. Other period standard plans were created for specialized equipment, including Fuel Cell Hangars and Weapons Calibration Hangars. During the Cold War, the Navy construction program became increasingly more standardized. Their standard designs included the arched concrete Denver Type Reserve Hangar; the Naval Weapons Shore Facility Module E Hangar, with its distinctive external structural support; and the Maintenance Type I and Type II Hangars, which also feature the external support. The latter two types can be differentiated by their height, Type I being 28 feet high and Type II 35 feet high.

Five percent of the hangars in the DoD inventory were constructed after the Cold War. The Navy continued to utilize its Maintenance Type I and Type II standard plans. Little survey data for the post-Cold War era was returned, prohibiting any substantial analysis of Air Force and Army standard design use during the period.

Other Findings

The survey data indicate that hangar distribution in terms of temporary, semi-permanent, and permanent construction is 5 percent, 5 percent, and 68 percent, respectively. No construction designation was provided for 22 percent of the survey entries. In several cases the construction type was upgraded or downgraded, perhaps to project the future life of the structures or influence their future O&M funding. In the former, it is important to understand that temporary hangars were designed for a service life of only 5 years. Once the hangars outlived their service life, and based on their current condition and projected durability, they were frequently upgraded to semi-permanent or permanent construction.

According to the survey, the percentages of hangar construction by material is as follows: 1 percent of the DoD hangar inventory is concrete, 2 percent are wood, 50 percent are steel (including both truss and girder construction), and 47 percent had no entries for structural materials. Most of the hangars with no structural information given are most likely steel hangars, as this was the material of choice for these technical structures. The above figures help emphasize the rarity of both concrete and wood hangars. As could be expected, all of the concrete hangars were of an open arch configuration, and all were designated permanent construction.

Without tracking specific space utilization within each of the hangar entries, the survey did inquire as to whether the hangars were in traditional use, meaning they continued to house aircraft and aircraft maintenance; were in non-traditional use, meaning they housed no aircraft or aircraft maintenance; or were mothballed and not in use at all. Attributed to the highly technical nature of aircraft maintenance, a full 70 percent of the DoD military hangar inventory continues in its traditional use. Nineteen percent of the hangars had been converted to new uses. Two percent had been mothballed, and 9 percent of the entries had no use designation at all.

The above survey results, combined with the historical context and building typology presented earlier in this document, should provide cultural resource managers, historians, architects, and engineers a sound basis from which to evaluate their military aircraft hangars. The broader perspective presented here will certainly influence national-level significance assessments, as well as provide the basis for more meaningful regional and local significance determinations.

Recommendations

It is recommended that the best surviving example of each major aircraft hangar type on U.S. military installations be identified through a coordinated effort according to the most objective criteria that can be developed, and that these prime examples then be documented according to the Level II protocols specified by the Historic American Buildings Survey (HABS). Some hangar types have already been documented according to Level II protocols, but installations with the same kinds of hangars are not likely to be aware of this documentation or the fact that their hangars are of the same type. HABS Level II recordation, in combination with the preliminary thematic overview, can act as a basis for a Memorandum of Agreement between installations, major commands, services, or DoD and concerned parties. A Programmatic Agreement of this kind is desirable so that Sec-

tion 106 review for a multitude of aircraft hangars of the same type can be accomplished by documenting the single best example of that type. The creation of HABS documentation, housed at the Library of Congress, satisfies environmental compliance requirements, provides wide public access to the records, and saves considerable costs compared to alternative piecemeal documentation approaches.

It is recommended that a follow-on study be conducted to cover Reserve, National Guard, and overseas DoD properties not addressed in the current work. Such a study should describe the principal types of aircraft hangars, document their approximate numbers and locations, and provide a historical context to support future assessment of the architecture's historical significance.

Because of their size, many aircraft hangars have already undergone modifications to accommodate new uses such as offices and recreation facilities. This study addresses the requirements for Section 106 compliance prior to these modifications. It does not address standards and guidelines for the design of future modifications, which may have an impact on the historic integrity of the hangars. A study and guide of successful adaptive reuse solutions of various hangar types would be beneficial for those executing future adaptive reuse of their hangars.

It is recommended that DoD consider developing a new category of definitive designs that would appropriately and cost-effectively address the physical limitations, as well as the range of design possibilities, of retrofitting existing hangars to accommodate new missions. The time and cost benefits of using standard plans and definitive designs to expedite construction are well known to DoD. It seems reasonable to apply the same fundamentals to the adaptive reuse of existing hangars — in other words, to create a new set of *retro-definitive designs* based on the original hangar design. These retro-definitive designs would address regulatory compliance issues up-front, thus eliminating time-consuming mitigation processes commonly encountered during the modification of historic aircraft hangars. Installations would be empowered to choose from a set of standardized adaptive reuse plans. Multiple scenarios for different reuse options also could be offered, as one solution may not be suitable for all installations.