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BREAKING THE CODE ON MILITARY CONSTRUCTION: EDWARDS AIR FORCE BASE'S RESPONSE TO EMERGING FACILITY REQUIREMENTS

MICHELLE R. PERRY

AIR FORCE TEST CENTER
EDWARDS AFB, CA

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As the global arms race intensifies, it becomes increasingly important for the U.S. to become more agile and efficient in developing and modernizing military capabilities. Improving the U.S. military's acquisition processes, specifically for critical new facilities, enables greater competition with the People's Republic of China in global power competition. The U.S. needs to overcome antiquated standards that are not responsive to today's global environment. Utilizing the problem-solution framework, this paper explores Edwards Air Force Base's (Edwards) rapid response to a lack of purpose-built facilities when the DoD Military Construction process takes too long to meet the emerging needs of today's warfighter. Over the past six-years, Edwards has used relocatable facilities procured as equipment, to support the quick-turn support for emerging test programs. Rapid acquisition of relocatable facilities has proven successful to expeditiously provide structures (hangars, SCIF, SAPF, office, etc.) for emerging test programs to conduct research, development, test and evaluation for the warfighter, which is absolutely critical to keeping the U.S. agile and responsive to China's assertions. This paper provides additional information on Edwards' successes, as well as lessons learned for other installations.

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BREAKING THE CODE ON MILITARY CONSTRUCTION:

EDWARDS AIR FORCE BASE'S RESPONSE TO EMERGING FACILITY REQUIREMENTS

by

Michelle Perry, Civilian, DAF

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements for the Degree of

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PREFACE

I started my civilian career in working for the Air Force Materiel Command (AFMC), Air Force Test Center (AFTC), 412th Test Wing (412 TW), Civil Engineer Group (previously known as 95th Air Base Wing), located at Edwards Air Force Base, CA back in 2001. Over 17 years in Civil Engineering (CE), I held several different positions. I started as a project programmer overseeing programming functions for Operations and Maintenance (O&M) projects, Military Construction (MILCON) projects, and Military Family Housing projects. In 2004, I assumed the position of Base Community Planner where I was responsible for overseeing the Installations future development of over 308,000 acres of military land. I also served as the Pacific region Subject Matter Expert (SME) for area development planning. In 2018, I took a different position in the 412th Test Wing Plans and Programs Office as the senior test and evaluation installation planner.

Throughout my tenure in CE, I learned programming rules, project development, price estimating, project prioritization, facility siting, installation planning, and developed and authored the installation design standards. These design standards are currently still in use for all contracted project efforts. Relocatable Facilities (RLFs) were highly frowned upon because there always seemed to be a vacant building somewhere that could be used as swing space, or extra unused space that an inbound program could use. In the 2007 timeframe, the CE field had to adhere to the "20/20 by 2020" initiative[1] to reduce facilities and infrastructure by 20 percent by 2020 which demolished all excess facility space the installation had at the time. Fast forward a few years, and new missions and customer testing are more than plentiful at Edwards. However, there are no longer vacant facility spaces available to accommodate those needs.

Working in the Plans and Programs Office, I had to change my way of thinking, to better support the warfighter and customer needs regarding facility space. My supervisor introduced me to the relocatable facility construct. At first, I still had my 'CE hat' on and had a difficult time grasping the legality of the process. After site visits to the manufacturing plants (Modular Management Group (MMG), Rubb, and Cocoon), both my supervisor and I could better understand what products we were purchasing, but also, a sigh of relief to see the superior construction of the RLFs. Seeing is believing! Another thing that hit me hard, was the very first MILCON project I had programmed in 2001still had barely gained any traction in over 20 years. The MILCON project was to replace several antiquated munitions bunkers from the 1940's and 1950's within the munitions compound. Additionally, the door openings are not wide enough to accommodate the larger size of today's munitions. In my new role in XP, we had programs looking for munitions storage, but no storage bunkers were available. Today we are late to need; that requirement was identified in 2001! I'm happy to say we have had some munitions storage constructed at Edwards (by specific test programs), however, more than one of those facilities are RLFs.

I chose the topic of RLFs for this research elective because I have witnessed the difference this process has made not only for Air Force (AF) missions and customers, but also for the increased capability of the installation. There have been great victories in the RLF endeavor, along with some woes. Recently, Edwards has had many Distinguished Visitors (DVs) to the base for site visits to see and to talk through our procurement processes. It is without a doubt, RLFs are the way of the future to meet the emerging test and customer requirements of today, tomorrow, and into the future. The AF can no longer wait for those MILCONs of the early 2000s to bubble up to the top to be funded. We no longer can afford another 10 or even 5 years.

We need facilities to field future weapons platforms to keep our warfighters relevant and ready. I look forward to sharing the experiences and lessons learned thus far with other installations.

I'd like to thank my supervisors and co-workers for their continued support and suggestions for my research; my husband for putting up with all the late hours on the computer; course instructors, peers, and mentors for all the critiques and recommendations for making this a solid, relevant, and informational paper.

ABSTRACT

As the global arms race intensifies, it becomes increasingly important for the U.S. to become more agile and efficient in developing and modernizing military capabilities. Improving the U.S. military's acquisition processes, specifically for critical new facilities, enables greater competition with the People's Republic of China in global power competition. The U.S. needs to overcome antiquated standards that are not responsive to today's global environment. Utilizing the problem-solution framework, this paper explores Edwards Air Force Base's (Edwards) rapid response to a lack of purpose-built facilities when the Department of Defense Military Construction process takes too long to meet the emerging needs of today's warfighter. Over the past six-years, Edwards has used relocatable facilities procured as equipment, to support the quick-turn support for emerging test programs. Rapid acquisition of relocatable facilities has proven successful to expeditiously provide structures (hangars, Secret Compartmentalized Information Facilities, Secure Access Program Facilities, offices, etc.) for emerging test programs to conduct research, development, test and evaluation for the warfighter, which is absolutely critical to keeping the U.S. agile and responsive to China's assertions. This paper provides additional information on Edwards' successes, as well as lessons learned for other installations.

1. INTRODUCTION

As the global arms race intensifies, it becomes increasingly important for the U.S. to become more agile and efficient in developing and modernizing military capabilities. The People's Republic of China (PRC) delivers a major weapons system in roughly seven years, while the typical timeline for the United States (U.S.) is sixteen years; giving the PRC a nine-year advantage over the U.S. for production and modernization, along with the perfection of tactics, procedures, techniques, and proficiency.[2] According to the 2020 Government Accountability Office (GAO) Defense Acquisitions Annual Assessment, some major defense acquisition programs have suffered delays of more than a decade; in fact, the Navy's V-22 Osprey Vertical Lift Aircraft experienced a delay of fifteen years.[3] The U.S. needs to overcome antiquated standards that are not responsive to today's global environment. For the U.S. to maintain the status of a superpower, change is needed, "or the U.S. will lose".[4]

To overcome the PRC's lead time of nine years, change within AFMC will come in many forms including Digital Materiel Management[5] and seven operational imperatives.[6,7] Digital Materiel Management applies to every step of a program's lifecycle, and to every organization and Airman and Guardian under the AFMC umbrella to achieve an aligned, capable program delivery.[8] It is crucial to address facility requirements to ensure a seamless and expeditious transition between the Special Program Office and the selected supporting installation. The facilities necessary to support research, development, test, and evaluation (RDT&E) of new military acquisitions (such as aircraft and weapons), Department of Defense (DoD) customers, and new test programs could be met with improved facility management processes allowing for relocatable facilities.

Edwards Air Force Base is locally referred to as "the Center of the Aerospace Testing Universe."[9] "The 412th Test Wing plans, conducts and analyzes test missions and reports on flight and ground testing of aircraft, weapons systems, software, components, and modeling simulation for the U.S. Air Force. There are three components for this mission – engineering, maintenance and flight operations."[10] Essentially every aircraft the Air Force has fielded was tested at Edwards Air Force Base (Edwards). As aircraft have evolved over the past, so have the supporting infrastructure requirements, especially facilities.

While Edwards is home to a large land mass, the flightline area is limited, as are the available facilities to support their ever-evolving test mission. Edwards has experienced an influx of test programs over the past several years, with more on the horizon. The lack of availability of facilities is partially due to the continued test and evaluation of some legacy airframes, (B-52 and F-22), as well as new missions.[11] Across the Air Force and Department of Defense, other agencies have experienced the same facility shortcomings as Edwards.

Edwards has broken the code for military construction! What can other military installations learn from temporary construction methods at Edwards Air Force Base to meet their own emerging facility requirements? Military installations can support quick-turn facility requirements by adopting Edwards Air Force Base's system of purchasing relocatable facilities as equipment. What is a relocatable facility? DoDI 4165.56, *Relocatable Facilities,* defines a relocatable facility as "A facility that is specially designed and constructed to be readily erected, disassembled, transported, stored, and re-used."[12] Relocatable Facilities (RLF) are purchased as equipment to meet emerging program or mission requirements, because the military construction process (traditional brick and stick, or brick and mortar construction) is not agile or flexible enough to meet emerging facility needs in a timely manner. The military construction timeline is

between five to seven years.[13,14] Seven years is too long to support short timelines dictated by new test programs. As stated by former Secretary of Defense, Jim Mattis, in *Summary of the 2018 National Defense Strategy of the United States of America,* "current processes are not responsive to need."[15]

When RLFs are talked about, the first thought that comes about is a single-wide mobile home from the 1950's, 60's and 70's. Visions of run-down structures, with roof panels and doors swinging in the wind. It is for this reason, RLFs have a connotation of perhaps, inferior[16] construction and a short lifespan, as depicted in the photo to the right.[17] Today's modulars are not those of the past. Modulars today are constructed to industry standards, and comply with the national, state, and local building standards, such as the Unified Facilities Criteria (UFC). The UFC defines the design and construction for all DoD facility construction.[18]

Photo Credit: Getty Images

The Civil Engineering community does not fully endorse the use of RLFs to support "enduring" mission needs.[19] RLFs are not considered real property, do not come with base operating support, such as manning or sustainment dollars; facility maintenance must be funded by the program requesting the facility.[20] Relocatable construction meets the requirements set forth by the Unified Facilities Criteria to include fire, safety, and seismic codes, local Base Design Standards, and depending on the use of the facility, additional requirements can be included in the equipment purchase. For instance, cranes or hoists in relocatable hangars and administrative relocatables meeting Special Access Program Facility (SAPF) or Secret Compartmentalized Information Facility (SCIF) security standards. Installations must be

flexible and able to rapidly react to emergent test mission facility demands in support of the warfighter; purchasing RLFs to satisfy requirements has proven a timely and cost-effective way to provide facilities to the warfighter while being good stewards of the American tax dollars. Experience at Edwards AFB has shown that purpose-built RLFs can be purchased at a fraction of the cost of a military construction project. Facility concept to construction completion is much more expeditious than military construction; hangar timelines are less than three years and roughly 18 months for office-type facilities. Relocatable construction in other parts of the world yields the same cost and time savings over conventional construction.[21]

What can other military installations learn from temporary construction methods at Edwards Air Force Base to meet their own emerging facility requirements? This research will use the problem-solution research framework to discuss the purchase of RLFs as equipment in response to emerging facility requirements to support new test programs and where the military construction program falls short. The military construction program approval and appropriation processes take a long time (upwards of 5-7 years) and are not flexible enough to meet the facility demands of rapidly developing technological test programs fielded at Edwards. New program demands, short timelines, and limited funding have forced Edwards to think outside the box. Utilizing tools available to the Joint Forces at forward-deployed locations, Edwards was able to find a viable solution to support rapid acquisition within the test community. The problem-solution framework is a perfect fit as Edwards has experienced first-hand the push for the test of new technologies with no available facilities to house the program. This coupled with the military construction approval and appropriation processes equaled a big problem. Edwards needed to find viable, cost-effective facility solutions to accommodate new test capabilities in

short periods of 30 months or less. Types of RLFs procured by Edwards include hangars, office modules, a munitions bunker, laboratories, and warehouse space.

Five criteria will be used to quantitatively measure the RLFs against brick-and-mortar real property facilities. The first criterion is the timeline for design, award, construction, and occupancy. Essentially this will measure the overall time needed for the construction of each type of facility to the beneficial occupancy date. The RLFs purchased by Edwards will be compared with real property facility's construction timeline. The second criterion is cost. Unspecified Minor Military Construction (UMMC) is a program for smaller-scaled construction projects. UMMC projects range from $750K to not to exceed $6M. In December 2022, the cost limit for a UMMC project was temporarily increased from $6M to $9M from December 2022 through 1 December 2025 as stated in 10 U.S.C. S2805.[22,23] Military construction projects typically start at the upper end of UMMC, and do not have a limit. Most new construction projects fall into this category.

Given the rising costs of construction and supporting materials, most of today's facility construction exceeds $9M, thus generating higher headquarters approval for the local funding (installation-level) threshold. This is important to track as some programs have limited funding availability or may not have longevity whereby it would not be cost-effective to construct a multi-million-dollar facility. For example, the construction of a hangar through the MILCON process was estimated at $54M (in Fiscal Year (FY) 18 dollars) while the purchase of that same hangar as equipment was under $15M (including supporting infrastructure).[24] The third criterion is the overall construction method and materials of the facilities. Comparing the construction technique and materials will provide an overview of whether the facility types are comparable to one another. This would include adherence to international, national, and local building codes;

UFCs[25], seismic, fire suppression, installation design standards, and includes supporting infrastructure such as electricity, water, sewer, gas, and wastewater. The fourth criterion is the proposed lifespan of both types of facility construction, for instance, the lifespan of the hangar as a MILCON effort has a 40-to-50-year lifespan, while the relocatable hangar has a +25-year life span (due to the Polyvinyl Chloride (PVC) skin needing replacement after 25-years; the steel frame has an indefinite lifespan). The fifth criterion is maintenance and sustainment costs for both types of facility construction. Essentially, the annual maintenance and repair costs for both types of facilities over time.

The research will begin by exploring the military construction program processes and procedures and looking at the procurement processes of Edwards's base-contracting office and Defense Logistics Agency. Focus will be placed on facilities procured by Edwards over the last six years, and a look to the relocatable construction industry for trends at other military installations.

Data analysis using the identified criteria will be used to compare the alternatives which will result in a recommendation or a solution to the overall problem. Finally, conclusions and an overview of Edwards's RLFs will be discussed. Photo on the bottom left depicts a relocatable office, and the photo on the bottom right shows relocatable hangars.

Photo Credit: Modular Vendor

Photo Credit: Scott Baker, Edwards

2. BACKGROUND AND SIGNIFICANCE

2.1. AFMC STRATEGY

2.1.1. ACCELERATE CHANGE

"The U.S. Air Force is accelerating change on many fronts" in response to the growing multi-domain threat of the PRC.[26] In 2023, AFMC Commander General Duke Richardson released the *2023 AFMC Strategic Plan* which provides a strategic map outlining AFMC's strategy (see Figure 1 below). The Strategy consists of the AFMC mission, vision, and four lines of effort, and relates them to all Airmen; What, Who, How and Why. As seen in Figure 1, the How speaks to revolutionizing AFMCs existing processes through the implementation of solutions across the AFMC enterprise.[27] The "How" Line of Effort 3, states "Inculcate internal processes that activate innovation, speed, strength, endurance, balance, flexibility, and coordination in AFMC's ability to deliver capabilities on relevant timelines in spite of fluid threat environments."[28]

AFMC released a white paper "An Accelerated Future State" earlier this year that stated the PRC is nine years ahead of the U.S. with their ability to deliver an integrated warfighting capability.[29] The U.S. needs to identify and do away with "antiquated serial processes, inadequate teaming, or lifecycle and functional stovepipes".[30] Essentially, if the U.S. does not figure out a way to accelerate change, the PRC wins.

Figure 1. AFMC Strategy Map[31]

Reprinted from *Air Force Materiel Command Strategic Plan* (2023)

2.1.2. PRC BUILD-UP

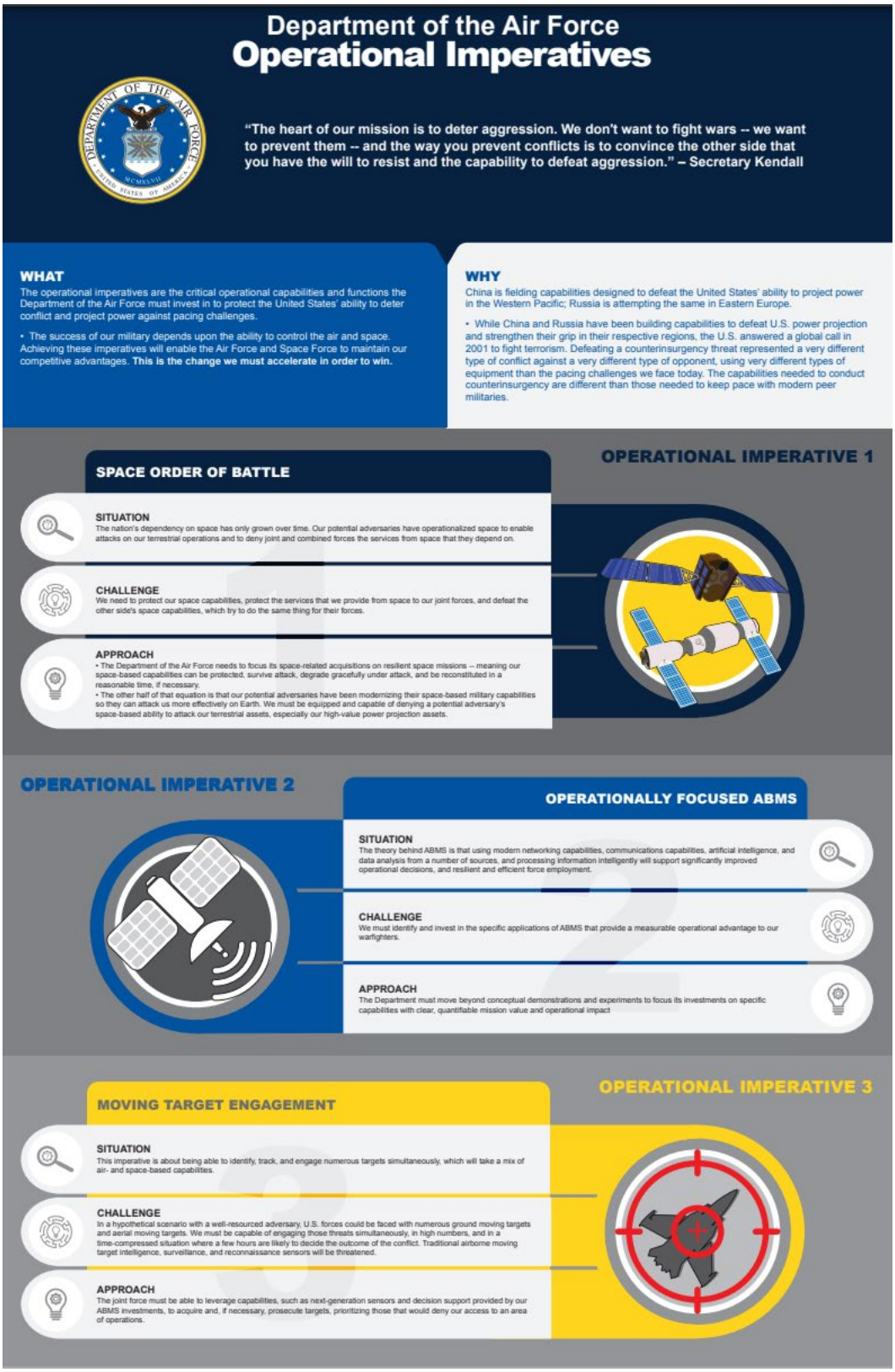
Over the last 20 years, the PRC has built up the shoals or coral reefs in the South China Sea to create stand-alone islands; not only do these islands include all supporting infrastructure such as roads, electricity, water, trees, facilities, recreation areas, etc., but they are also heavily fortified and militarized.[32] Meanwhile, back in the U.S., it takes the military nearly a decade just to garner approvals, appropriations, and if lucky, the start of construction for a single project/facility; not an entire island or complete military build-up. The U.S. must be able to innovate, embrace change, and accelerate that change to win.[33]

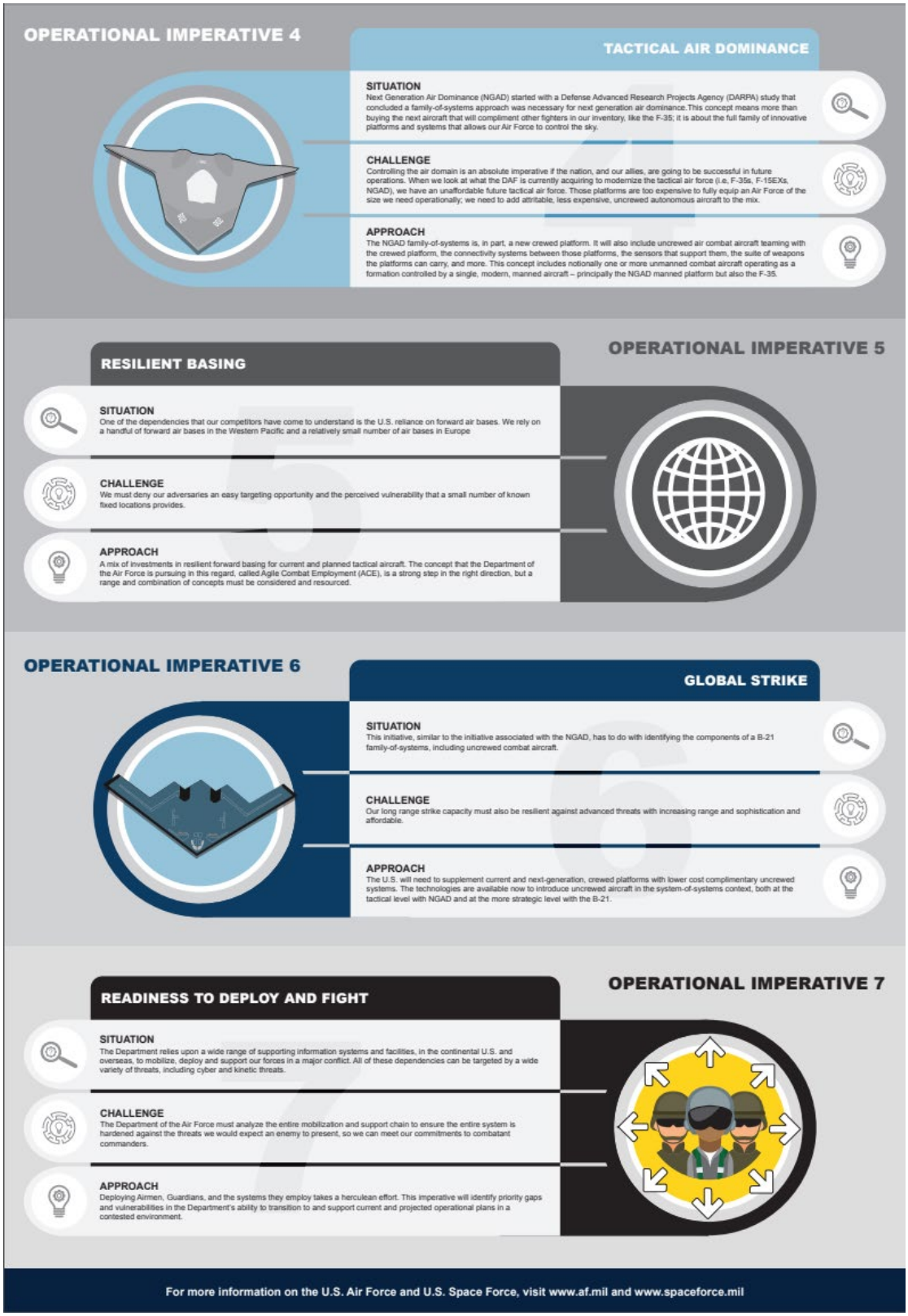
2.2. OPERATIONAL IMPERATIVES

In early 2022, the Department of the Air Force released seven "Operational Imperatives" (Figure 2) which outline the crucial functions and operational capabilities the U.S. must take to maintain a competitive edge over the PRC and Russia by discouraging conflict, and projecting power.[34] The seven OIs collectively support the Air Force and Space Force, to maintain superiority, and competitive advantages over the PRC.[35,36] Each of the OIs in some form or fashion relies on supporting infrastructure and facilities to house the operational capabilities. The OIs are broken down to describe the situation at hand, the present challenge, and an approach to successful achievement of each respective imperative. The OIs provide[37] "space order of battle, operationally focused Advanced Battle Management System, moving target engagement, tactical air dominance, resilient basing, global strike, and readiness to deploy and fight". The OIs can be accessed at the link provided after Figure 2 below, where they are explained in greater detail.

It is imperative that the U.S. changes its way of thinking. The PRC is now a near-peer competitor in the Great Power Competition (GPC) with the U.S. In order for the U.S. to keep its competitive edge, antiquated, stovepipe processes, and ways of thinking need to adapt to change and consider the innovative ways private industry utilizes for success. In part, consideration for code-compliant facilities that are engineered to be permanent yet designed to be relocatable.[38]

Figure 2. Department of the Air Force, Operational Imperatives[39]





Reprinted from Department of the Air Force, Secretary of Defense Frank Kendall, *Operational Imperatives* (2023)

2.3 THE DIFFERENCE BETWEEN RELOCATABLE FACILITY AND STANDARD CONSTRUCTION (MILCON)

As previously mentioned, DoDI 4165.56, *Relocatable Facilities,* defines a relocatable facility as "A facility that is specially designed and constructed to be readily erected, disassembled, transported, stored, and re-used.[40] DAFI 32-9005, *Real Property Accountability,* defines the same as a "habitable, prefabricated structure that is designed and constructed to be readily moveable (transported over public roads), erected, disassembled, stored and reused", this includes "tension fabric structures assembled from modular components…".[41] Relocatable facilities are essentially prefabricated structures constructed off-site utilizing lean manufacturing (less waste) techniques.[42] These structures are built in full compliance with standard building codes which include fire safety, seismic, and wind, to include local installation design standards. Local design standards include base-specific details that are to be included in construction. For instance, Edwards' design standards dictate the standards specific to Edwards. Standards include items like exterior facility color, doors, lock types, design criteria, wind loads (withstand 115 mph wind gusts), seismic loads, snow loads, specific type of fire alarm notifiers, and intrusion detection systems.[43] Additionally, all relocatable facilities are sited to align with the base installation development plan and in accordance with the fire and antiterrorism standards.[44]

RLFs are durable enough to sustain initial transport to the base as well as possible relocations or re-installations and have comparable life spans to standard/traditional construction.[45] Most of the relocatable facilities procured by Edwards were constructed with steel and wood and are purpose-built or tailored to meet the needs of a customer or specific program.[46]

As discussed in a recent research proposal submitted on this topic,[47] most of today's military installations do not have the excess facility capacity or swing space to accommodate new defense acquisition test programs critical to the Nation's defense. The process for any installation obtaining new or replacing current facilities is a long, bureaucratic process under the MILCON program. The approval timeline of any given MILCON, provided it was ranked as a numbered priority from the installation, is at least three fiscal years. What happens when the MILCON process is not flexible enough to meet the demands of new, emerging test programs? What happens when new technologies need to be tested now and not wait for a MILCON to support the development and test? Technology may be replaced in three years by something even more advanced. The MILCON process is not agile enough to meet the needs and demands of todays or tomorrow's technologies.[48,49]

Over the past several years, Edwards has been leading the way to overcome the MILCON barriers. Edwards has found a way to utilize the Defense Logistics Agency, a combat logistics support agency within the Department of Defense, to purchase purpose-built facilities to support emerging mission requirements.

The Air Force Nuclear Weapons Center, Special Program Office approached the 412 TW Plans and Programs office with requirements to support this Acquisition Category (ACAT 1) program. ACAT 1 programs are Major Defense Acquisition Programs.[50] This program required two dedicated hangars, dedicated office space, and a dedicated integrated maintenance facility. The program needed these facilities on-site to conduct tests in a two-year timeframe. The facilities this ACAT 1 program required were occupied with other programs and Edwards had no other available facilities for use. The inbound program had limited funds, and the MILCON timeline would not meet the need. The Plans and Programs Office had to solve for yes. The

solution was to purchase these facilities from the Defense Logistics Agency, Tailored Logistics Support as equipment. This solution provided purpose-built facilities in a fraction of the time as brick-and-mortar construction and at a fraction of the price. This entire process allowed Edwards to have facilities in place and ready to support the program's needs in the two-year timeframe required.

3. PROCESSES

3.1. MILCON PROCESS

For a real property structure on an Air Force installation, one that is brick and mortar, the process for MILCON approval is long and tedious. Once a need or requirement has been identified by the installation, a project is created along with a description of all its requirements. For example, how big is the building; does it require administrative, hangar, warehouse, or other special use space? Are there any special components such as a secure space, explosive setbacks, security concerns, or locations desired? Once these requirements have been solidified, construction costs identified and location determined, the project goes before review and planning boards. After rigorous reviews and approvals, the project is prioritized with other new construction efforts into a base prioritized MILCON list. In conjunction with the prioritization of a potential MILCON project, a 35% design must be completed for each project to be considered on a prioritized list. The 35% design is also known as the concept design. The concept design provides details pertaining to the requirement owners technical and functional needs and shows how the facility will meet those needs. The design package includes an overall narrative of the design, supporting engineering calculations and environmental certifications. It also includes conceptual drawings, scope of work, cost estimate, and a bid schedule.[51] A project

for the 35% design needs to be programmed years ahead of the MILCON cycle. The overall 35% design process takes roughly two years for the funding process, award, and design to be completed. Once complete, the MILCON project is competitive at the next level.

The installation's prioritized MILCON list is sent to the Air Force Civil Engineer Center, and Air Force Test Center in parallel for review. Edwards sends a read-ahead to AFMC (Edwards's Major Command), to allow Command to begin prioritization amongst the installations within that command. This is done to allow the Command to thoroughly review the projects as the timeline provided by the Air Force Civil Engineer Center is not long. Air Force Civil Engineer Center collects MILCON priorities from all Air Force Installations and drafts one prioritized list for the nine Major Commands. The Major Commands approve the list and route it back to the Air Force Civil Engineer Center. Headquarters Air Force and the Air Force Installation Management Sustainment Center receive the proposed list and route it through the Air Force Corporate process (Air Force senior leadership) for review. The list is then finalized as the Air Force MILCON Program, fully endorsed by Air Force Headquarters.

Following Headquarters approval, the MILCON list is reviewed by the Office of the Secretary of Defense where all Department of Defense submittals are combined. The Secretary of Defense provides the prioritized list to the Office of Management and Budget which collects the budgets for all U.S. Federal agencies and allows the senior level of the Executive Branch of the Government (Vice-President and President) to review the program thereby creating the President's budget. This is accomplished before sending the MILCON budget list to Congress for approval. Congress reviews and adjusts before passing the Authorizations and Appropriations Bill (this budget process has been the same since 1961).[52] Congress then submits the Authorizations and Appropriations Bill to the President to approve and sign into law or to

veto and route back to the reconciliation committee in Congress for modifications. This action is ideally accomplished before the end of the government fiscal year (30 September). Details of the MILCON program can be found in Department Air Force Instruction 32-1020, *Planning and Programming Built Infrastructure Projects*.[53] See Figure 3 on the following page for the Edwards MILCON program process. Sister services have a slightly different process through their headquarters, but all proposed MILCON lists are combined at the Secretary of Defense level. See Figure 4 on the following page for the overall MILCON process that includes the sister services and timeline.

The lengthy approval process described above takes a minimum of three years, and that does not include time development of the project requirements, 35% design, or for the physical construction of the facility. The three-year minimum time is if the MILCON project is rated number one at the installation and all pre-work is accomplished. If a MILCON project is needed to support a program that is to start in fiscal year 2026 or 2027, the planning and programming scope should have started in 2022, if not earlier, when the project was put into a prioritized program at the installation level. This equates to approvals by Air Force Materiel Command and Air Force Civil Engineer Center in the late calendar year 2022. By the summer of 2023, Headquarters Air Force must approve the plan. The Secretary of Defense reviews by the fall of 2023, and by February 2024 the package should be presented to Congress. The Air Force MILCON program continues the rigorous reviews at this level, and ultimately the President will sign by late September 2024 in time to be effective for the start of the fiscal year 2025 (1 October 2025). This is the ideal process when the timeline is met before the start of the next fiscal year. Research to date shows that over the past twenty years, Congress has met the end of the fiscal year deadline only five times. [54] When Congress does not meet the timeline, a

government shutdown occurs, or the Government remains operational under a Continuing Resolution. Figure 5 below depicts the MILCON timeline.

Figure 3. Military Construction Project Path to Authorization and Appropriation[55]

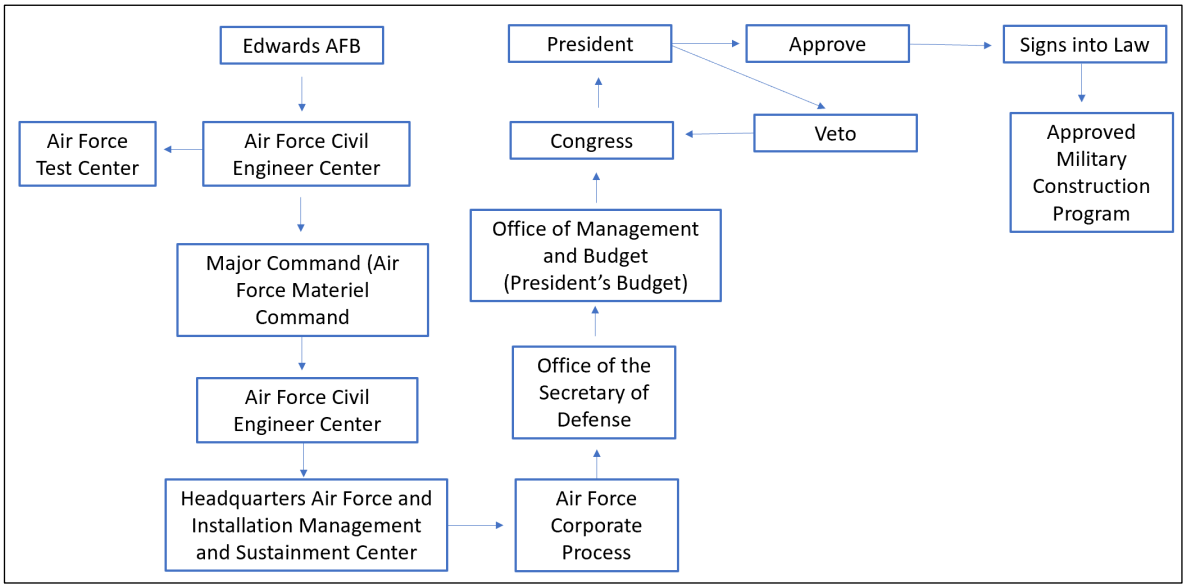


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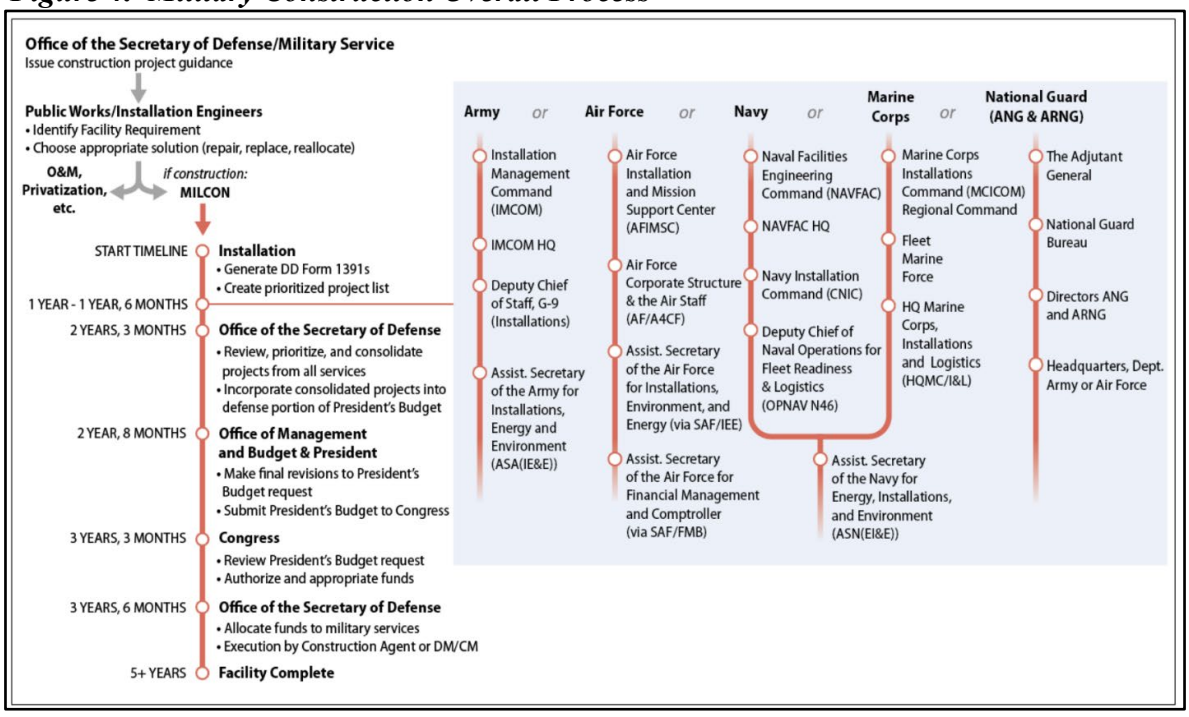
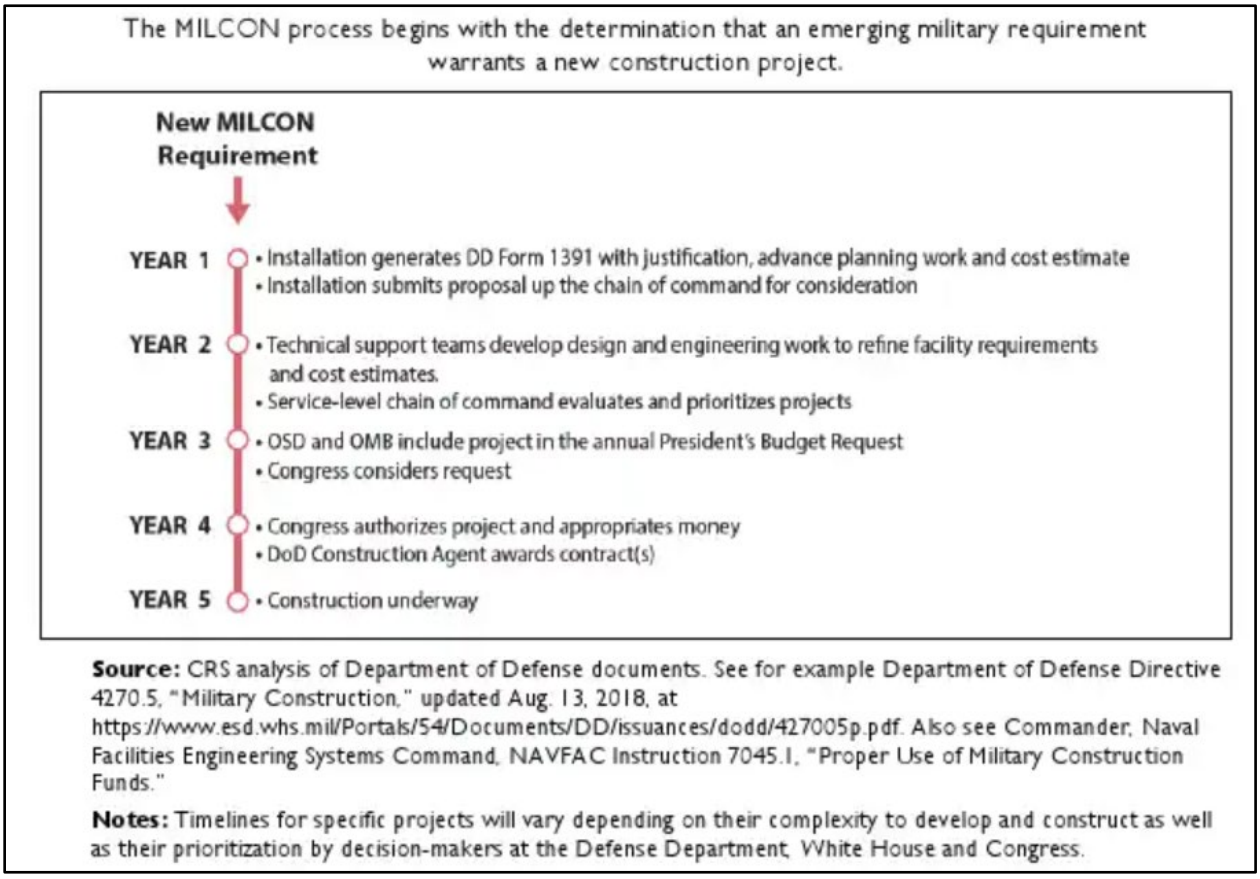
Figure 4. Military Construction Overall Process[56]



Reprinted from Herrera, Congressional Research Service *Military Construction: Authorities, Process, and Frequently Asked Questions* (2019)

Figure 5. Military Construction Timeline[57]



Reprinted from Tilghman, Congressional Research Service, *Military Construction: Authorities and Processes* (2023)

The looming threat of yet another government shutdown on 30 September 2023 was avoided by a 45-day budget extension. It is unknown at this time if Congress and other lawmakers will be able to come to an agreement to avoid a full shutdown in the near future. What message does this send to our allies and adversaries? Not a very positive one. Government acquisition programs and supporting construction efforts could be temporarily halted.

The long bureaucratic MILCON process is especially challenging for the Air Force due to the limited amount of government funding available each year. Considering the Air Force's priorities, the Air Force corporate level must balance risk. The Air Force ensures the development of the most technologically advanced weapons systems and must find the right

balance between the purchase of aircraft, types, and numbers of bombs and bullets, and facility requirements to meet mission needs. In a perfect world, new program requirements would be known and funded several years ahead of time, allowing the MILCON process to work. Such special programs can code their funding as MILCON specific and a facility could be inserted into the MILCON program. This process works when there are new weapon system acquisitions, such as a new aircraft for basing actions. However, that scenario does not happen often due to the needs of the program.

The problem with the MILCON process is that it is not flexible enough to meet emerging program requirements to support today's warfighters. What happens when new programs are introduced with a need to undergo RDT&E in a short period with inadequate facilities to support new advanced technologies? Or how can new programs advance with no facilities? It is important to address this question because as funding continues to be cut, the Air Force will still need to develop the critical advanced weapons systems required to protect the U.S. airspace and interests. A solution is needed sooner than later.

Senior leaders know that there is a problem with the MILCON process, but seemingly refuse to fix it. Why hasn't the MILCON process been fixed? Per 10 U.S.C. § 2802 (2021)[58,59] military construction projects are law, and laws are not only difficult to change, but also take a long time to do so.

The timelines depicted above are those in a perfect world, however, realistically a MILCON project is a ten-year plan even if the project is rated as number one.[60] The reality of the MILCON process is that there is a never-ending list of projects generated across the Services to support requirements, but a finite amount of taxpayer dollars allocated annually to support the military. Only the most critical projects make the top cut for funding, leaving a growing list of

projects for future year funding. As noted above, government laws, regulations and processes are antiquated; government agencies and advisors to lawmakers have followed the same philosophy and system for over 70 years![61] It is time for a change.

3.2. THE RLF APPROVAL PROCESS (DEFENSE LOGISTICS AGENCY (DLA) OR BASE CONTRACTING)

Several questions initially surface when the word relocatable is spoken: Are relocatable facilities even authorized? Who is the approval authority? How long can they be utilized? And then what? DoDI 4165.56 provided a very broad definition of a relocatable facility, however, that instruction does provide guidance that must be adhered to before they can be authorized. This authorization must happen before acquisition/purchase. For AFMC installations, specifically, Edwards, the general officer or senior executive at a centralized headquarters organization (Air Force Civil Engineer Center) must endorse a request package that is submitted for consideration by the Base Civil Engineer.[62] The package prepared by the installation consists of the following: valid requirements; confirmation that there is no other space available that meets the needs of the requirement; a lease versus purchase analysis (also called a business case analysis), cost analysis, and certification that the facility will not be used beyond the maximum prescribed timeline of 14 years.[63] At the end of 14 years (initial authorization of seven years, with one seven-year extension), the base must remove the relocatable per Department of Defense Instruction (DoDI) 4165.56. The above process must happen for any RLF purchase (DLA or base contracting). The DoDI does, however, provide specific guidance on converting a RLF to real property.[64]

3.2.1. INSTALLATION LEVEL CONTRACTING PROCESS

Contracting is one way to obtain RLFs. AFTC Contracting has rules and regulations that

must be adhered to for spending government funding. These rules and guidelines must be adhered to for all Contracting activities. AFMC issued two directives in 2014:

- "**8 Jan 14,** General Wolfenbarger issued a memo directing AFMC Center executive Directors (CAs) to act as the approval authority for decisions to use MIPRs for non-PEO acquisitions $500K and above to ensure small businesses receive maximum opportunities to compete for our federal dollars." [65]
- **"9 April 14,** Col. Jeffrey M. Todd, Deputy Director of Communications, Installations and Mission Support Headquarters Air Force Materiel Command sent an email to Wing/Complex Commanders and Center CA's requesting organizations use "external agencies when necessary and help streamline the coordination and approval of MIPRs in light of AFMC/CC's guidance on small business support."[66]

On 7 Jun 2018, the Executive Director of AFMC/CA amended the MIPR guidance to which delegated the authority for approvals down "to the Wing Commander/Directorate level or their deputy". [67] This memo also referred to a checklist to be used, which was contained in AFI 65-118, *Air Force Purchase Using Military Interdepartmental Purchase Requests,* dated 4 Oct 2016.

Until recently, these memos have provided governing guidance on the MIPR process for AFMC. On August 21, 2023, a memorandum was signed by Ms. Lorna Estep, Executive Director of AFMC/CA rescinding the MIPR guidance from 2018 for non-PEO Acquisitions. This means any non-PEO contracting actions greater than $500K no longer require Headquarters or Center approvals for acquisitions.[68] Essentially, MIPRs over $500K for the purchase of RLFs do not need Wing or Center approvals. This memo speeds up the rate of procurement and reduces some of the bureaucracy associated with the purchase of RLFs.

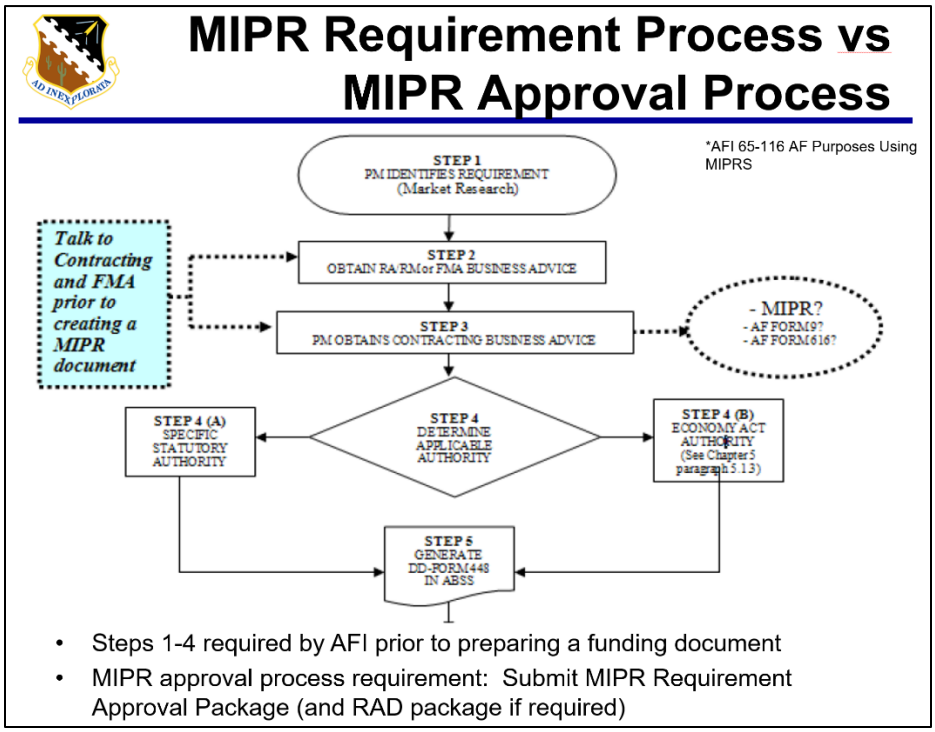
AFI 65-118 outlines the Process for Military Interdepartmental Purchase Requests (MIPR).[69] This process must be adhered to be within the legal purchasing boundaries. Figure 6 depicts the five-step process for submitting a MIPR as provided in the AFI. Figure 7 shows the overall AFTC Enterprise MIPR Requirement Approval Process. Per FAR 7.102, the program

representatives are required to perform market research and provide the need-by date to the local Contracting Office; market research is required regardless of the method used to acquire the requirement.[70] All contracted acquisitions that exceed $500,000 require higher approval from a warranted contracting officer.[71] RLF procurements require additional actions outlined in DoDI 4165.56, *Relocatable Facilities,* to include a validated requirement, confirmation from CE that there is no current facility space available for this requirement, a lease versus purchase analysis (normally performed by the financial management branch on the installation), a cost analysis and notification to the approval authority that the RLF will not be utilized beyond the maximum approval.[72] Recent AFCEC guidance has reduced the maximum allotted timeframe for RLFs. The current maximum approval timeline is seven initial years and one seven-year extension for a total of 14 years.[73]

Once all required documentation has been required, Contracting can solicit bids for contracts (usually a 2-week process). All bids are vetted through the project manager to ensure bid proposals meet the program's intent (usually a 2-week process). Without any issues, Contracting can be awarded in 30 business days. Interestingly, it has been noted by the 412 TW Plans and Programs Installation Partnership (XPP) office that often, the selected vendor is the vendor who would have been contracted through the DLA process, but in a fraction of the time that Contracting takes.

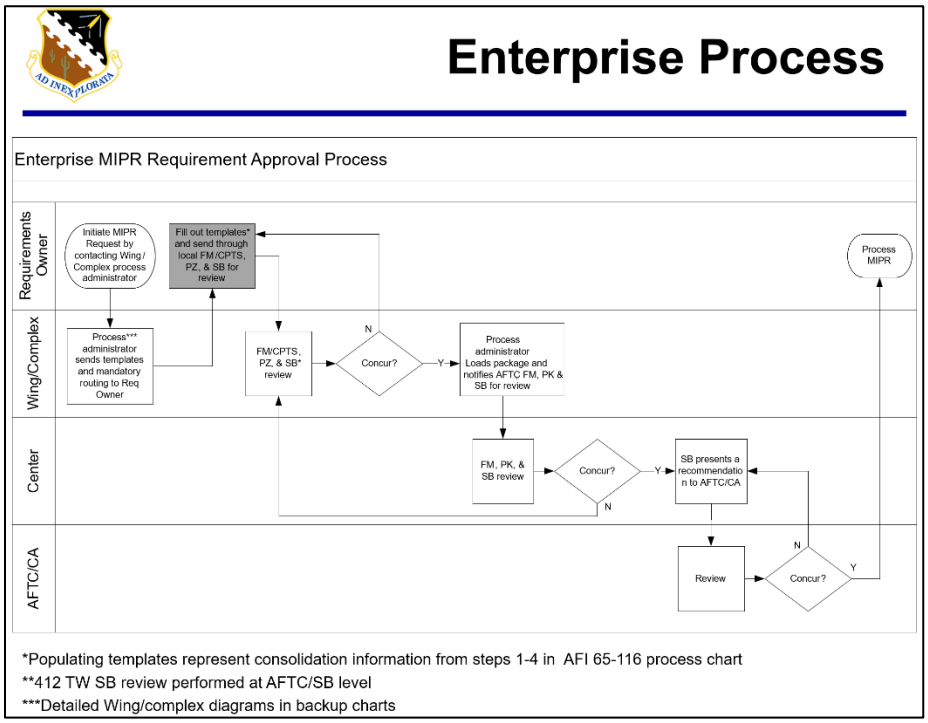
Contracting could be a cheaper alternative to purchasing through DLA as there is no contract/agency 'pass-throughs', potentially up to 5% of the total project cost, saving precious dollars. However, Contracting potentially takes a longer time to get an RLF on contract where the program could suffer or be delayed due to the lack of a timely award if the program is on a tight timeline or has a short need-by date.

Figure 6. MIPR Requirement Process vice MIPR Approval Process[74]



Reprinted from C&S MIPR Team, *AFTC MIPR Team Approval Directive* (2014)

Figure 7. AFTC Enterprise MIPR Requirement Approval Process[75]



Reprinted C&S MIPR Team, *AFTC MIPR Team Approval Directive* (2014)

3.2.2. DEFENSE LOGISTICS AGENCY PROCUREMENT PROCESS

The second method of procuring a RLF is through the Defense Logistics Agency (DLA). First and foremost, the procuring office or ordering activity (person to place the order through DLA) needs to be registered with DLA. This includes submitting an electronic form to DLA with the name and contact information representing the ordering activity, along with their financial point of contact, usually their resource advisor. Once registered, they can electronically submit their requirements on an order request sheet. DLA offers an extensive Customer Assistance Handbook which can be accessed on the DLA website, which is accessible for customers with a ".mil" IP extension.[76] (https://www.dla.mil/Customer-Support/Communications/).

The DLA procurement process is very different from the normal base contracting process. As soon as a program has defined its needs, and CE has been engaged for available space, a call to one of DLA's prime contractors, Atlantic Diving Systems (ADS) Tailored Logistical Support (TLS) vendors is made. TLS is a rapid acquisition program which allows the customer to work directly with one of their prime contractors. A preliminary list of facility requirements is provided to the contractor, which results in a rough concept design. That drawing is then shared with a core team at the installation level for comments and refinement. Shortly thereafter, the vendor is invited to a team meeting to discuss requirements and adjust the concept design accordingly. Once the program project manager concurs with the final design, a formal bid can be requested from DLA. Being able to work directly with the contractor up front affords the installation a huge time-savings to be able to meet the program needs.

This process must also include a portion of the AFTC Contracting Office procedures described above. Compliance with the FAR, AFI, and DoDI are mandatory and not waiverable.

The program representatives are required to perform market research and provide the need-by date to the local Contracting Office, and CE must also provide them with a detailed DD1391 (cost estimate). Base Financial Management is contacted to perform a cost-benefit analysis or a comparative analysis for the project. Once the analysis has been completed, it is provided to CE to be included in a package which is submitted to AFCEC/CC for approval. Once that approval has been granted, and the local contracting office has approved for purchase, an email with a spreadsheet is sent to DLA placing the order.

Once DLA accepts the order, an email is sent to the ordering agency. DLA follows up within 24 hours and sends out the order to ADS for solicitation to their vendors. ADS performs its market research and selects the contractor who provides the specific support requested. Because one can work directly with a vendor in the early stages of project development, as previously described, that vendor provides the bid back to DLA. A specific part number is associated with the facility which ensures the vendor that helped define the concept drawings will bid for that project thereby the customer getting the vendor of choice. The program resource advisor prepares the funding documentation, in the form of a MIPR, which is provided electronically to DLA for contract award. This process allows for the purchase of an RLF as one specific part number. Along with the part number for the relocatable, there are part numbers specifically for delivery and the installation of the RLF. This allows the contractor to be paid during phases of the project instead of waiting for the completed project. Normal timeline from the time the order is sent to DLA to the time the effort is awarded is normally less than 30 days.

The procuring office or ordering activity (person to place the order through DLA) needs to first register with DLA along with their financial point of contact, usually their resource advisor. Once registered, they can electronically submit their requirements on an order request sheet.

DLA offers an extensive Customer Assistance Handbook which can be accessed on the DLA website, which is accessible for customers with a ".mil" IP extension (https://www.dla.mil/Customer-Support/Communications/).

As discussed in a recent research proposal submittal on this topic,[77] research on this topic to date is indicative that the MILCON approvals and appropriations cannot keep up with the changing requirements of new military programs.[78] Viable construction alternatives, such as relocatable construction, are utilized by the Joint Forces at forward-deployed locations and by private industry across the U.S. The Defense Logistics Agency has been supporting U.S. Troops in all corners of the world to improve overall operational readiness, which includes construction activities.[79] Recent investigations revealed that other foreign militaries have utilized prefabricated buildings to support their troops in harsh climates where brick-and-mortar construction is impossible.[80] Edwards, and other military installations, have procured such relocatable structures to support emerging requirements and in certain cases as a response to natural disasters, such as hurricanes and earthquakes.

Further research would support utilizing these structures on military installations as a new way forward for installations to meet their unique emerging facility requirements and to reveal a process to capture these structures as real property assets. The latter is equally important as sustainment dollars would be utilized for needed maintenance and repairs over time, as the additional base operation support (i.e., additional security forces and fire department personnel, housing accommodations, medical support, etc.). Edwards has been utilizing relocatable structures, purchased as equipment for the past six years. They are proven quality and expedient structures that have enhanced the Test Mission. There are many lessons learned to be shared

with and expounded on by others to help other military installations meet their facility requirements when MILCON is not a viable option.

3.3. ALLIED CIVIL ENGINEERING SUPPORT FOR SUPPORTING INFRASTRUCTURE

In addition to both the Contracting and DLA avenues of RLF procurement, there is a vital supporting Civil Engineering (CE) role needed to ensure project success. While facility requirements are being identified, it is critical that the local CE and representatives from the Communications Squadron (Comm) are included in meetings. Together, these two agencies provide the allied support required for a fully functional RLF. CE assists in identifying the locations of utilities such as water, wastewater, electricity, and provides the siting the location of the RLF. It may be possible that water or electrical upgrades are required to the base infrastructure to support the RLF, to include water mains or electrical transformers. Communications representatives provide the locations of the communication lines, and helps with identifying requirements inside the RLF, especially for SAPF and SCIF builds (which would be included in the statement of work to the contractor). The early engagement of CE and Comm enables the team to capture all requirements prior to construction award. It also alleviates change orders that would be seen in standard construction.

All supporting infrastructure is brought within five feet of the approved RLF location. The supporting infrastructure project is funded directly through CE. The installation of the RLF runs in parallel with the allied support once the footings or foundations are in place. Once the RLF has been completely installed, the connection to the base infrastructure is accomplished with CE oversight.

A Texas-based company has introduced an innovative technology to the construction industry. It is not traditional construction and could be utilized to construct military facilities without using the MILCON process. This alternative method to construction may not be classified as MILCON, but also is not classified as relocatable.

3.4. ALTERNATIVE TO MILCON AND RLF – FUTURE POSSIBILITY

3D facility printing is a cutting-edge concept for constructing facilities. Large-scale 3D printers use digital technology and concrete to print facilities. Not many companies currently exist across the globe for this innovative form of construction. Edwards' relocatable SMEs contacted ICON, a company located in Austin, Texas in August 2023 to learn more about their technology and capabilities for possible future AF applications. They saw ICON's large-scale 3D robotic printers in use on-site at Wolf Ranch, where ICON has partnered with Lennar home builders to construct homes ranging from 1,574 square feet (SF) up to 2,100 SF and range from $475K to $590K.[81] These homes have metal roofs and high-end finishes with many amenities. The 3D printing process is fast and allows for extreme precision and placement of walls during printing. With less waste than traditional construction, projects are on budget and schedule. Because these facilities are airtight, a more constant temperature inside is achieved making them energy efficient.[82] The photos below depict a Genesis Collection Model Home at the Wolf Ranch Community, just outside of Austin, Texas.

Photo Credit: reprinted from Iconbuild.com[83]

All print operations are controlled by state-of-the-art digital operating systems proprietary to ICON. The status of every ongoing print, no matter where they are located can be viewed from their systems. A depiction of a print status and the Vulcan printer is pictured below.

Photo Credit: reprinted from Iconbuild.com/[84,85]

ICON has several recent endeavors that support the DoD, including a vehicle hide structure at Camp Pendleton, CA, three barracks at Camp Swift, TX, an innovation center at Camp Mabry, TX, a Robotics Lab at Tyndall AFB, FL, and several rocket landing pads. The barracks were 3D-printed UFC-compliant structures[86], and the robotics lab met the Miami-Dade Hurricane-certified walls. With ICON's technologies, they can 3D print climate-resilient and energy-efficient facilities, at scale. ICON is also partnering with NASA on "Project Olympus", which is aimed at 3D printing capability on the moon to support lunar and space exploration.[87]

Although recent endeavors include off-world printing, there are currently limitations to ICON's building height and seismic adaptability. ICON's Vulcan printers can print up to 10'6" high, with a span of 38' wide and 100' in length.[88] ICON is experimenting with a new type of printer that would allow for the printing of taller structures. This will allow for an expanded variety of structure types that can be printed. ICON is also in the process of placing a structure (walls) on a shake table to simulate an earthquake to determine the feasibility of 3D printing in parts of the world subject to seismic activity. Lastly, ICON is pursuing the construction of an Intelligence Community Directive (ICD) 705 capable facility. Their research team is in contact

with security specialists to learn more about criteria and sound testing their technology. ICON staff did share their future vision of every military installation having a Vulcan 3D printer to enable a rapid and cheaper alternative to construction, that is accomplished at the installation level to fulfill mission requirements.

4. TYPES OF RLFs

Many different types of RLFs exist. For the purpose of this paper, RLFs procured by Edwards will be discussed. Those facility types include standard, and DoD enhanced physical security standard (EPSS) special-purpose aircraft hangar, office or administrative space, munitions storage, warehouse space, and laboratory space. Hangars, office space, laboratory, and even warehouse spaces can be constructed to SAPF or SCIF standards if needed. For specific RLFs at Edwards, see Cost Criteria on page 41 and Appendix A, page 59.

SAPF and SCIF structures are required for Classified programs. They are government-accredited facilities specifically for protecting information from our adversaries. Within these facilities, classified information may be processed, discussed, and stored. These facilities must fully comply with a strict list of physical and technical security requirements,[89] as outlined in the ICD-705,[90] and NAVFACs Technical Specifications for Construction and Management of Sensitive Compartmented Information Facilities.[91] SAPFs and SCIFs have a lot of the same construction criteria, however they are not the same thing.

RLFs need to be transportable to their destinations. Each section or module is wrapped prior to being transported. Some RLFs can be purchased with higher ceilings (10- or 12-feet vice

Photo Credit: Scott Baker, Edwards AFB

typical 8-foot ceilings). The higher ceilings provide the feel of a larger facility once constructed, however, during transport causes additional precautions as some highway or freeway overpasses have height restrictions that are unpassable. This causes the transporter to utilize alternate routes to avoid overpass damage to the module, which could delay delivery.

5. COMPARISON CRITERIA

5.1. CRITERIA 1 – CONSTRUCTION

5.1.1. MILCON / TRADITIONAL FACILITY CONSTRUCTION

Any traditionally built structure that is constructed for the Federal Government or DoD, regardless of the type of facility, must follow the UFC. "The Department of Defense (DoD) initiated the Unified Facilities Criteria (UFC) Program to unify all technical criteria and guide specifications (UFGS) pertaining to planning, design, construction, and operation and maintenance of real property facilities."[92] The UFC provides technical data based off the most recent International Building Code (IBC), and includes design standards for design loads, seismic evaluations, wind loads, etc. The UFCs are overseen and updated by U.S. Army Corps of Engineers, Naval Facilities Engineering Systems Command (NAVFAC), and AFCEC.[93] The last UFGS was updated on 18 August 2023 and uploaded to the Whole Building Design Guide webpage on 24 August 2023; and published electronically only.[94]

In addition to the UFCs, local base design standards should be referenced and included in the build which provide more detailed requirements specific to the Installation. Topics included are architecture, landscaping, civil (infrastructure), mechanical systems, fire protection, electrical, industrial controls, environmental, IDS, and fuels.[95] The Edwards Air Force Base Design Standards were approved for public release [412 TW-PA-17063] and can be found at the

following link, https://govtribe.com/file/government-file/edwards-afb-design-standards-2017-dot-pdf.

All facilities undergo a design phase prior to construction. Earthwork such as grading is also accomplished early on to support facility foundations, roads, parking lots, storm water drainage, and eventual pedestrian circulation (sidewalks). Construction activities occur onsite and usually begin with the installation of the supporting infrastructure systems such as electrical, water, gas, sewer, and communications. Once infrastructure is complete, the facility can begin to go vertical.

5.1.2. RLFs

5.1.2.1. MODULAR OFFICES AND SCIFS

Modular offices have limitless design opportunities, each tailored to meet program/mission needs to include DoD EPSS modular offices. All modular offices are built to UFC requirements (code) which include adherence with International Building Codes (IBCs) with quality materials. They are designed up front before purchase, offer great flexibility, and are 100% relocatable in nature. These structures include all components of real property buildings and can include open office spaces, hard walled offices, restrooms, breakrooms, conference rooms, comm closets, janitorial closets, fire sprinkler riser rooms. They are fully sprinklered facilities complete with fire detection. They include Heating, Ventilation, Air Conditioning (HVAC) (roof or ground mounted), meet Americans with Disability Act requirements (ADA), and come complete with exterior access ramps, stairs, and platform. Security systems and intrusion detection systems may also be included. Modules come in a variety of colors and finishes to meet specific base standards or color schemes.

The following three photos on the next page show various stages of assembly of office

modules. The first photo shows multiple modulars staged side by side ready to be assembled or mated together. As one can see in this photo, two modules with side braces are still installed. Bracing keeps the shape of the module during transport from the factory to its destination. module sections are mated and secured. The braces are removed during assembly when modules are mated and secured together. The photo also shows the end module with its wheels still in place, ready to be relocated closer to the others.

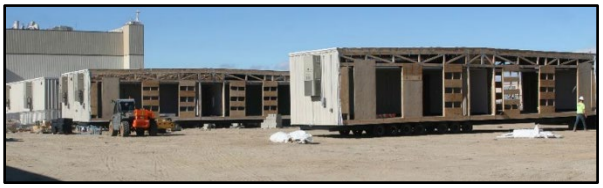


Photo Credit: Scott Baker, Edwards

This photo shows a close-up of the modules being placed on the foundation using concrete blocks. Not shown is the additional seismic bracing required in the state of California.

Photo Credit: Scott Baker, Edwards

Typical assembly of the modules takes two to three weeks depending on the number of modules. Once mated, the shipping bracing is removed, and interior finishes are started.

Photo Credit: Scott Baker, Edwards

5.1.2.2. HANGARS

Hangars are tailored to meet program/mission needs, for example specific aircraft, variety of aircrafts, functions). Like the office modules, they comply with UFCs to include current IBCs. They are designed equivalent to real property structural codes to include live load, snow load, occupancy/exposure factors, wind gusts (up to 110 miles per hour at Edwards), collateral loads, and seismic bracing. The difference is the fabric or membrane materials that can be used on the roof or sides of the structure.

For Edwards, the fabric wall and roof panels are three-ply and, depending on their thickness have insulation values ranging from R11 to R27. The "high-density glass wool insulation" layer is surrounded by an outer flame-retardant layer and an inner PVC fabric which is "self-cleaning".[96] The insulation keeps the hangar comfortable year-round. The PVC fabric is white which reflects heat. Rubb USA (Rubb) advertises low maintenance costs, energy efficient PVC fabric roof membranes. Both Cocoon and Rubb stand behind their projects as being "virtually sustainment-free".[97]

Edwards has procured relocatable hangars through the DLA process which were awarded to Cocoon, Inc. Cocoon, Inc. utilizes Rubb manufactured structures in their builds. Rubb has been in the fabric hangar business for over 40 years, has hangars located in 38 countries, and has completed 668 projects for the military.[98] Every relocatable hangar is truly relocatable in nature and can be extended to meet future changes. Although relocation may be a little challenging, as the hangar must be completely de-constructed, they are relocatable by design. RLF hangars can be seen at US airports across the U.S. A Hawaiian Air hangar is depicted above.[99]

Photo Credit: https://www.rubbusa.com/projects/

The PVC fabric used on roofs and walls has a 25-plus year lifespan. The structure meets all building and fire safety code regulations and meets or exceeds all standard building codes, to include UFCs. The steel utilized to support the structure is corrosion free due to it being hot-dipped galvanized steel.[100] Additionally, all welds are checked prior to the galvanization which ensures "interior and exterior cathodic and barrier protection". [101] These structures are strong, energy efficient, have a sustainable design and a simple, straight-forward warranty.

For a hangar installation, footings and aircraft-rated concrete is required. Existing concrete, if available, or new concrete can be used. Installation requires footings which are designed for each type of hangar. The internal configuration of power, water, heating, cooling, man-doors, everything other than the foundation, can be included in the cost of the design and hangar purchase. Additionally, hangars are complete with LED lighting throughout, radiant heat, and evaporative cooling. Cranes, security systems, and intrusion detection systems can also be included in the purchase, as they were at Edwards.


Photo Credit: Scott Baker, Edwards

Edwards utilized existing concrete for two 44,000 sf hangars. Each location required footings to support the relocatable structure. Footings were designed and installed as part of the supporting infrastructure project provided through a Civil Engineering allied support project. The photo to the right shows the concrete pour for footings and sidewall. The photos below depict the erection of a RLF hangar at Edwards, with a description of each photo on the following page.

Photo Credit: Scott Baker, Edwards

Description of photos

Photo 1: Hangar placed on existing aircraft rated concrete. Foundations were installed and side walls are in place for hangar erection. Supporting infrastructure project is on-going (not shown).

Photo 2: Close-up of concrete footings with galvanized steel wall supports bolted in place.

Photo 3: Both side wall steel bracings are in place. Cranes can be seen moving additional steel supports for real hangar wall along with roof trusses.

Photo 4: Hangar frame in place with continuing placement of roof trusses.

Photo 5: PVC roof panels installed and with metal side wall panels along the west side.

Photo 6: Hangar door pockets can be seen more clearly in this photo, along with metal wall panels along the east wall.

Photo 7: View of west wall from inside the hangar. Top panels of the west wall being installed.

Photo 8: Exterior view of remaining top wall panels on the west side of the hangar.

Photo 9: Sides and back of hangar are enclosed, work begins on the front.

Photo 10: Interior work begins. Installation of lighting of lighting and cranes shown in photo.

Photo 11: Hangar is nearly complete. Hangar doors being installed. To the right of the hangar, the erection of a second identical hangar can be seen.

Photo 12: Hangar erection complete.

5.1.2.3. MUNITIONS STORAGE BUNKER

Photos below depict phases of a munitions storage bunker RLF being manufactured at the Armag facility in Bardstown, KY. A similar photograph-passed process is followed for all RLFs and consistent in meeting SAPF and SCIF structure construction accreditation requirements. During the bunker construction process, Armag shares photos with the installation's physical security officer for proper documentation of DoD EPSS requirements. Similarly, MMG will also provide photos throughout the manufacturing process for DoD EPSS facilities.

Photo Credit: Michelle Perry, Edwards

Photos to the right show the finished bunker.

Photo Credit: Scott Baker, Edwards

5.2. CRITERIA 2 – COST

5.2.1. MILCON PROJECTS

The second criteria to be examined is the cost differences between MILCON projects and RLFs. Due to the price of MILCON projects, they are normally managed through the US Army Corps of Engineers who have a surcharge fee of 6.5% of the project cost for supervision, inspection, and overhead[102] for their management of the project. The contracting office has no additional fees associated with an RLF; Contracting awards the RLF to the lowest bidder meeting the requirements set forth in the scope of work. Purchasing a RLF through the DLA process includes embedded fees. DLA fees are 5.4% of the total cost of the purchase is under $5M, and 2.5% if over $5M.[103] ADS award fees are dependent on the supplier utilized. Edwards' top three vendors fees average about 10%.[104] For the purpose of comparisons, applicable award fees are included in the RLF overall costs.

UFC 3-701-01 provides unit costs for MILCON efforts. Data was extrapolated for comparison purposes to align with comparable RLF efforts. Table 1 below shows the unit costs for specific types of construction projects, along with the number of similar recent MILCON projects. The SF costs are based off historical 2022 data, and a standard deviation is also included which can be applied to the SF cost (for example, using the High-Bay Maintenance Hangar SF cost of $734 and applying the standard deviation (+/- $235), the acceptable range of costs per SF would be $499 - $969). The costs reflected in the table do not include security costs such as Intrusion Detection Systems (IDS) construction specifically for DoD EPSS compliant facilities.

The tables provided on the next few pages break out the MILCON costs as previously described. Important to note, an area cost factor of 1.29% of the total cost is added to projects for Edwards in Kern County, California (Edwards AFB Site #1).[105] Area cost factors are provided in Table 4-1 of UFC 3-701-01.[106]

Table 1. Unit Costs for Military Construction

Unit Costs for Military Construction

RP Construction Type	Recent Number of Projects	SF Costs (Based off Oct 2022)	Standard Deviation (Percentage)
High-Bay Maintenance Hangar (over 40' high, small <100,000sf	7	$734	$235 (32%)
High Explosive Magazine (Munitions Bunker)	4	$909	$127 (14%)
Administrative (multi-purpose)	9	$507	$197 (39%)
Academic Instruction	5	$548	$167 (30%)
General Purpose Maintenance Hangar, Low-Mid bay up to 40' (small hangar)	4	$482	$144 (30%)
Data Processing Area Facility	2	No Data Available	No Data Available
Warehouse, General Purpose-Small	3	$344	$112 (33%)
Academic Instruction (Hands on Training)	7	$734	$235 (32%)

Adapted from *UFC 3-701-01, Table 2, Facility Unit Costs for Military Construction.*[107]

5.2.2 RLFs

Table 2 below shows a breakout of the RLFs procured by Edwards. The chart shows the FY each project was funded, type of security, overall size, and their respective cost per SF.

Reviewing the data provided in Tables 2 and 3, one can see the savings by the DoD and its mission partners by procuring RLFs.

Table 2. Costs for Edwards RLFs

Unit Costs for RLFs

RLF Type	Fiscal Year (FY) Funded	DoD EPSS Security	Size (SF)	Cost per SF
Office	FY18	Yes	14,000	$ 329
Office	FY18	Yes	3,805	$ 447
Office	FY19	None	9,900	$ 195
Office	FY19	Yes	960	$ 195
Office	FY21	Yes	20,000	$ 365
Academic Instruction	FY21	None	9,240	$ 512
Office	FY22	Yes	2,688	$ 465
Office	FY23	None	4,651	$ 484
Office	FY23	Yes	21,954	$ 737
Office	FY23	Yes	20,061	$ 870
Office	FY24	Yes	11,238	$ 799
Bunker	FY19	IDS	5,000	$ 290
Hangar	FY18	Yes	44,000	$ 232
Hangar	FY18	Yes	44,000	$ 231
Hangar	FY19	None	28,220	$ 329
Laboratory (Hands On)	FY18	None	17,000	$ 235
Laboratory (Hands On)	FY22	None	18,125	$ 454
Maint & Instrumentation	FY18	None	7,000	$ 596
Maint & Instrumentation	FY22	None	3,000	$ 644
Warehouse	FY18	None	5,000	$ 94
Warehouse	FY18	None	5,000	$ 94

Data provided by 412 TW Plans and Programs Office, Edwards

Table 3. Side by Side Comparison of Construction Type and Cost

Construction Type Cost Comparison

MILCON Construction Type	$/SF	Edwards RLF Type	$/SF Range
High-Bay Maintenance Hangar (over 40' high, small <100,000sf	$734	Hangar	$231-$232
High Explosive Magazine (Munitions Bunker)	$909	Munitions Bunker	$512
Administrative (multi-purpose)	$507	Office	$109 - $870
Academic Instruction	$548	Academic Instruction	$ 512
General Purpose Maintenance Hangar, Low-Mid bay up to 40' (small hangar)	$482	Dual Hangar	$ 329
Data Processing Area Facility	No Data	Cyber Security Standards	$329 - $870
Warehouse, General Purpose-Small	$344	Warehouse	$94
Academic Instruction (Hands on Training)	$734	Laboratory	$235-$454

Edwards data provided by 412 TW Plans and Programs Office, Edwards

A comparison of the two construction types is depicted in Table 3. MILCON construction type data is taken from Table 1 (UFC 3-701-01, *Facility Unit Costs for Military Construction*, Table 2),[108] and average SF costs for all Edwards RLF types are based off historical data provided by Edwards.

Table 4 on the following page compares the MILCON costs to respective actual RLFs. The overall hangar costs are 50% to 60% less than traditional MILCON brick and mortar hangars. Chart data verifies the claims of Cocoon SME of 50%-60% cost savings.[109] Office, warehouse, munitions bunker, and maintenance and inspection facilities also have lower costs per SF. Note that there are three office-type facilities that had a higher dollar value which is attributed to those facilities requiring DoD EPSS. The UFC does not provide dollar values for construction of any secured space or DoD EPSS facilities for comparison purposes[110]. As such, if RLFs do require DoD EPSS, costs will increase.

Table 4. Cost Comparison between MILCON and Edwards' RLFs

Cost Comparison

MILCON/Traditional Construction	Cost per SF	Edwards RLF Type	DoD EPSS Security	Cost per SF	Cost Savings
Administrative (multi-purpose)	$507	Office*	Yes	$ 329	35%
Administrative (multi-purpose)	$507	Office*	Yes	$ 447	12%
Administrative (multi-purpose)	$507	Office	None	$ 195	62%
Data Processing Area Facility	No Data	Office	Yes	$ 195	N/A
Administrative (multi-purpose)	$507	Office*	Yes	$ 365	28%
Academic Instruction	$548	Academic Instruction	None	$ 512	6.5%
Administrative (multi-purpose)	$507	Office	Yes	$ 465	8%
Administrative (multi-purpose)	$507	Office	None	$ 484	4.5%
Administrative (multi-purpose)	$507	Office*	Yes	$ 737	+31%
Administrative (multi-purpose)	$507	Office*	Yes	$ 870	+42%
Administrative (multi-purpose)	$507	Office*	Yes	$ 799	+37%
High Explosive Magazine (Munitions Bunker)	$909	Bunker	IDS	$ 290	68%
High-Bay Maintenance Hangar (over 40' high, small <100,000sf	$734	Hangar	Yes	$ 232	56%
High-Bay Maintenance Hangar (over 40' high, small <100,000sf	$734	Hangar	Yes	$ 231	69%
General Purpose Maintenance Hangar, Low-Mid bay up to 40' (small hangar)	$482	Hangar	None	$ 329	32%
Academic Instruction (Hands on Training)	$734	Laboratory (Hands-On)	None	$ 235	68%
Academic Instruction (Hands on Training)	$734	Laboratory (Hands On)	None	$ 454	38%
No Data	No Data	Maint & Instrumentation	None	$ 596	N/A
No Data	No Data	Maint & Instrumentation	None	$ 644	N/A
Warehouse, General Purpose-Small	$344	Warehouse	None	$ 94	73%
Warehouse, General Purpose-Small	$344	Warehouse	None	$ 94	73%

Data provided by 412 TW Plans and Programs Office, Edwards

5.3. CRITERIA 3 – CONSTRUCTION TIMELINE

5.3.1 MILCON / TRADITIONAL CONSTRUCTION

As discussed in the background and explained further during the MILCON Process, MILCON construction takes years. In a perfect world where approvals and funding follow the flow, a MILCON project is at a minimum 3 years. More often than not, a typical project that is supported as a number one priority can expect to take 3 years for approvals and appropriations, and another 2 to 3 years for construction. The caveat to that is if a project was directly funded by Congress to the special program office where special congressional appropriations followed for that project. Even then, the construction timeline would be a minimum of 2 – 3 years, possibly longer.

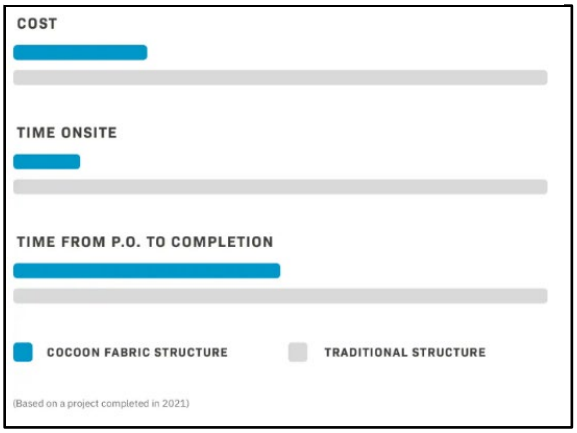
5.3.2 RLFs

Table 5 depicts the construction timeline from time of purchase order to the time the facility was operational. Office modules have proven to be a faster construction method over conventional construction at Edwards; with an overall schedule reduction of 30% to 50%. This is due in part to being constructed indoors, not subjected to weather delays. Average RLF offices take approximately 13 months; RLF offices meeting DoD EPSS average 12.5 months; and laboratories average 11 months.

Once hangar materials arrive on site, the structure is erected and completed within months. From the time the order is placed to the time it is fully occupiable is two years. The long lead time is manufacturing the steel beams and the insulated fabric panels.

Cocoon offers a chart (Figure 8) on its web page that specially addresses cost, time onsite, and timeline from purchase order to completion that compares a relocatable hangar to a traditional stick and mortar hangar project in 2021.[111]

Figure 8. Cocoon Cost, Time Onsite, and Timeline for Hangar Project Completed in 2021



Reprinted from https://www.cocoon-inc.com/

Table 5. RLF Construction/Project Duration (Purchase Order to Operational)

RLF Timeline PO to Operational

RLF Type	Security	Size (SF)	Time (Months)
Office	Yes	14,000	15
Office	Yes	3,805	13
Office	IDS	9,900	13
Office	Yes	960	8
Office	Yes	20,000	
Academic Institutional	IDS	9,240	14
Office	Yes	2,688	14
Office	IDS	4,651	On-Going
Office	Yes	21,954	On-Going
Office	Yes	20,061	On-Going
Office	Yes	11,238	On-Going
Munitions Bunker	IDS	5,000	8
Hangar	Yes	44,000	24
Hangar	Yes	44,000	30
Hangar	IDS	28,220	24
Laboratory	IDS	17,000	8
Laboratory	IDS	18,220	14
Maint & Inspection	IDS	7,000	24
Maint & Inspection	IDS	3,000	On-Going
Warehouse	IDS	5,000	6
Warehouse	IDS	5,000	6

Data provided by 412 TW Plans and Programs Office, Edwards

5.4. CRITERIA 4 – LIFESPAN

5.4.1. EXPECTED LIFESPAN OF REAL PROPERTY FACILITIES.

DoD 7000.14-R, *Financial Management Regulation,* provides the life span for real-property buildings, structures, and linear structures (i.e., utility lines). The life span is determined by the actual beneficial occupancy date, or the date it was placed into service (not when it was occupied).[112] Figure 9 shows the expected lifespan of real property buildings, structures, and linear structures (utility lines). For comparison purposes, the lifespan of buildings is used.

Figure 9. DoD Useful Life for Depreciable Real Property Assets[113]

Real Property Classification	Real Property Useful Lives	Capital Improvements (if useful life is not provided by an engineering estimate)(ii)
Buildings	45 years	20 years
Structures	35 years	15 years
Linear Structures	40 years	20 years

Adapted from Department of Defense 7000.14-R, *Financial Management Regulation (2019)*

5.4.2. EXPECTED LIFESPAN OF RLF

Today's RLFs are of sturdy construction, fully comply with the UFC and are seismically designed. According to the RLF industry, office RLFs are expected to have a general lifespan of 25 years. MMGs Subject Matter Expert advised RLFs such as office/administrative type facilities in desert climates (such as California) have a 30-year expectancy, and for more severe weather like in Florida, a 20-year expectancy.[114] Today's RLFs are not the flimsy single-wide trailers of the 1960s era.

Hangars have an even longer life expectancy, up to 50 years except for the fabric tension skin (some exterior walls, and exterior roofing fabric), which has a life expectancy of 25 years.

If the fabric skin is replaced at 25 years, the structure is good for an additional 25 years. The structure of the hangar is hot-dipped galvanized steel, has an indefinite lifespan, and is corrosion free.[115]

5.4.2.1. APPROVED TIME RLFS CAN BE IN PLACE

Changes were made to DAFI 32-1020, *Planning and Programming Built Infrastructure Projects,* in January 2022 which altered the language of usage for relocatable facilities from initial use of 5 years and re-approval every five years. Updated guidance is now an initial use of seven years and one additional approval of seven years; after 14 years the RLF is to be removed.[116,117] Extensions to the 14-year rule are allowed if the mission supports a "continuing military contingency operation", if a MILCON project has been submitted and is included in the "Air Force's Future Years Defense Plan", or approved and funded by Congress. [118] The DAFI does however, offer that the RLF could be transferred to a different user which would essentially re-start the timeline.[119] It is anticipated that additional guidance will be offered to address other RLFs that have been on an installation and in use longer than 14 years, performing the same function with a valid MILCON project waiting in the MILCON queue.

According to the 412 TW Plans and Programs Office, there are several relocatable facilities in place that have actively supported the 412 TW missions for well over 25 years. These RLFs do have MILCON projects programmed to replace them; however, due to the multitude of MILCON projects across the DoD, the likelihood of those projects ever bubbling to the top of the prioritized MILCON list is very unlikely. Again, the question is raised as to how to address these facilities? An alternative to extending the approvals, especially for the newer RLFs, would be to convert them to Real Property. Guidance has been published in DoDI

4165.56, *Relocatable Facilities* on how to convert relocatable or temporary structures to Real Property.[120] Edwards has not yet attempted to convert any RLF to Real Property.

5.5. CRITERIA 5 – FUTURE MAINTENANCE, SUSTAINMENT, AND REPAIR COST

5.5.1. MILCON / TRADITIONAL CONSTRUCTION O&M COSTS

Traditional construction facilities are added to CE's real-property records upon construction completion. All real property structures are centrally funded for maintenance and sustainment for the life of the facility. Additionally, these facilities provide Base Operating Support (BOS) to the installation in the form of additional personnel billets in the base clinics, security forces, fire department, and services.

5.5.2. RLF O&M COSTS

In contrast, RLFs do not have built-in maintenance dollars. All maintenance and repairs are funded solely by the customer or program that purchased the RLF. If a program ends, they have the option of removing the RLF, at their cost, or gifting it to the AF. If gifted to the AF, the AF could utilize it for another test program/customer with the understanding that the new occupant would then be responsible for all maintenance and repairs during their occupancy. If no customer is available at the time, the 412 TW would be responsible for funding any needed repairs/maintenance. Unlike real property facilities, RLFs do not have base operating support such as additional manning for security forces, firefighters, or medical staff. Therefore, the installation does lose out on additional manpower along with sustainment funding.

To calculate annual maintenance and repair costs, the industry standard for calculations is used. This formula is also utilized when preparing the Cost Benefit analysis. The 1% rule is a

calculation of the facility purchase price multiplied by one percent.[121] The calculated number is what is recommended to be set aside for maintenance and repairs. For instance, take one percent of the total purchase price of a home, and set it aside for future maintenance and needed repairs (i.e., $500,000 home would be $5,000 annually set aside). As stated above, this is industry standard. Another way of calculating repairs would be to utilize the formula found in UFC 3-701-01, "SR=Q x SUC x SACF x I".[122] The sustainment requirement equals the facility quantity multiplied by the sustainment unit cost (UFC 3-701-01, Table 3), multiplied by the sustainment area cost factor (UFC 3-701-01, Table 4-1) multiplied by the value representing the future year escalation (UFC 3-701-01, Table 4-4). RLFs do not provide any BOS to the installation.

The SME's in the modular business advised the HVAC condensers may require replacement in approximately 10 years, and whole air conditioning unit replacement being $6K upon failure. As a rule of thumb, they recommend a $500 per unit per year as a maintenance reserve.[123]

5.6. CRITERIA COMPARISON AND ANALYSIS

Five key criteria were compared and analyzed. Research suggests that for Criteria 1 (Construction Methods) both MILCON/Traditional construction comply with the UFCs and UFGS, and local base design standards. The major difference is that MILCON/traditional construction is an onsite only process with no pre-fabrication. RLFs are mostly manufactured off-site and in an environmentally controlled area and components are shipped to the site for installation. Both types of facilities may be purpose built to meet the needs of the user, but only RLFs are designed to be agile, relocatable, and easily expanded to meet new demands or new users.

Criteria 2 (Cost Comparison) looked at the average costs of both types of construction at the SF level. RLF munitions storage bunkers cost 68% less than MILCON. High-bay hangars averaged 57% cheaper than MILCON and a smaller hangar was 32% the cost of MILCON. Laboratory spaces on average were 53% cost savings over MILCON and warehouses had the greatest overall savings of 73%. Office spaces varied depending on the needs of the user. The majority of RLF office modules met DoD EPSS requirements which did not have a line item to compare itself to. That said, the costs for DoD EPSS office spaces still resulted in a cost savings over MILCON non-DoD EPSS offices from anywhere from 4.5% to 62%.

Criteria 3 (Construction Timeline) also weighed in the favor of RLFs. As discussed previously in the MILCON process and background sections, MILCON cycles are long, drawn-out bureaucratic processes. In a perfect world, a MILCON project could be executed in 3-5 years. Based on Edwards' historical timelines for RLFs, the longest project took 30 months (2.5 years) from start to finish. That project was for a 44,000SF hangar. Office spaces were operational in as little as 13 months, warehouses in 6 months, and munitions storage bunker in 8 months. These construction times are unrivaled when compared to traditional construction and have a proven track record to supporting emerging mission requirements.

Criteria 4 (Lifespan) comparison was close. The lifespan of MILCON building is 45 years. Although some sub-systems will fail over that time, such as HVACs, roof, etc., the structure itself is sturdy. RLFs, specifically modulars, have a desert life span of 30 years. Given the historical data at Edwards, there are currently modular offices that have been in place for over 25 years. One would assume those facilities were not built to the higher standards of today yet will last at least an additional 5 years. That said, newer modulars are on track to exceed the 30-year expectancy. RLF hangars are anticipated to have the same life span as a permanently

constructed hangar. The exception would be a new skin (replacement of PVC membrane panels on the hangar at approximately year 25. This is a best guess on the replacement; it could be sooner due to environmental conditions; however, it could be longer for that same reason.

Criteria 5 (Future O&M costs) assessment showed that MILCON projects have O&M funding available at the base level to take care of any issues that surface. Some projects must be prioritized for funding such asl large roof replacement projects. However, these repairs are funded through CE's O&M budget. RLFs do not have a built-in repair budget, they do not come with sustainment or maintenance funding, those costs are burdened on the customer or test program. If the program is unable to fund the repairs or maintenance, those repairs or maintenance are not accomplished to that facility. Additionally, RLFs do not come with BOS to include manpower for first responders. RLFs do however come with a 5-year warranty, whereas MILCONs do not.

5.7. NATURAL DISASTER SURVIVAL

5.7.1. RLFS SURVIVE TWIN EARTHQUAKES

On July 4, 2019, a 6.4 magnitude earthquake occurred just outside of Ridgecrest, California, and the following day July 5, 2019, a 7.1 magnitude earthquake occurred in the same location. Naval Air Weapons Station China Lake (China Lake) is in Ridgecrest, approximately 60 miles, as the bird flies, from Edwards. China Lake, like Edwards, has aged facilities, most constructed before 1980, and some circa WWII. China Lake reported to the NavyTimes that approximately twenty percent of their 1,200 facilities (240 facilities) were confirmed dangerous, and damage from the earthquakes to multiple facilities exceeded allowable repair costs and needed to be replaced.[124] Damage from these earthquakes rendered China Lake "not mission

capable" due to its operating capacity being barely 50%; damages were later assessed at $2.9 billion.[125] Edwards and the surrounding communities also were hit by these back-to-back earthquakes, but luckily did not sustain the amount of damage that China Lake had. Surveys were conducted at Edwards, specifically in both 44,000 square-foot relocatable hangars, and both were found unscathed. These structures were designed, engineered, and constructed according to all applicable UFC requirements and specific California seismic codes, and proved to be as durable as a real property brick and mortar facility.

Shortly following the earthquakes, China Lake representatives reached out to Edwards' Plans and Programs office to learn more about the hangars that were undamaged. They inquired how they might be successful in obtaining relocatable facilities, as many hangars at China Lake were deemed unusable. In fact, following that site visit, China Lake successfully procured several relocatable aircraft hangars to allow mission success.

5.7.2. OTHERS INTERESTED IN EDWARDS' RLFs

Edwards hosted NAVFAC leadership, and other supporting NAVFAC representatives over the past six months to showcase Edwards' relocatable facilities. Recently, NAVFAC representatives to the Civil Engineering trade toured Edwards to gain firsthand working knowledge of processes and procedures pertaining to the procurement of relocatable facilities.

412 TW/XP SMEs are called upon frequently to consult with various DoD organizations on the feasibility of utilizing relocatable facilities, in lieu of real property, to meet emerging requirements. Discussions enable other organizations to capitalize on the experiences learned, utilizing relocatable facilities to meet aggressive program requirements necessitating rapid

procurement and facility erection to meet mission milestones. Edwards has been leading the charge with utilizing RLFs and has hosted many departments from across the DoD.

In addition to NAVFAC leadership, other recent DV visitors to Edwards included AFMC Air Force Installation and Mission Support Center (AFIMSC). This day-and-a-half visit encompassed tours of the RLFs that have been acquired in recent years, the same facilities showcased later in this report. During this tour, a briefing on the history and processes of procuring these facilities was followed by an informal question-and-answer session. AFMISC representatives commented that what they had seen during the tour were the facilities of the future and the method of getting them.

Since October 2022, Edwards' SMEs have hosted numerous personnel from across the DoD, to include USAF HAF, AFMC/DS, AFRL, AFCEC, AFLCMC, ACC MSG, and US Navy. Each of these visits included site visits to the RLFs, along with cost benefits, time to Initial/Full Operational Control, and lessons learned to include the lack of sustainment funding/base operating support. Follow on discussions provided DVs data to take back to their respective offices to make informed decisions based on their unique mission requirements. Over the past six months, Edwards has received at least four inquiries per month on their RLF process and have hosted at least one monthly site visit.

6. SUBJECT MATTER EXPERT VIEWPOINT AND WAY FORWARD

6.1. NAVFAC

There has been much discussion at the upper echelons of NAVFAC. NAVFAC refers to fabric tension hangars as Code Compliant Fabric Adaptive Structures (CCFAS). CCFAS, by definition, are facilities that are code compliant, meet or exceed all UFC requirements, and

include technical requirements of the 2021 IBC. They may or may not have a fabric component, and most importantly are adaptive to meet the ever changing and dynamic missions of the DoD. As previously mentioned, Edwards has hosted numerous site visits to support NAVFAC in their pursuit to change facility policies. NAVFAC has realized the advantages that CCFAS bring to the DoD now, and in the future.

6.2. COCOON

6.2.1. CONGRESSIONAL COMMITTEE

Cocoon SME has partnered with NAVFAC at the Pentagon and Norfolk as well as Congressional committees to update policies and procedures for the DoD, and to figure out how to solve impending future construction dilemmas. Current processes, as described earlier, utilize funding such as RDT&E to purchase a CCFAS as equipment, but once constructed is not supported for maintenance, repairs, etc., by CE. There has been a proposal submitted to Congress for consideration to allow the appropriations budgeted to government departments to use those funds to purchase CCFAS as equipment. Once constructed, CCFAS would be capitalized as real property (be put on the permanent structure list), and to be maintained using CE O&M funds. This would allow each Department to work through their internal issues, such as replacing decrepit facilities or responding to an emerging requirement, on their own outside of the MILCON process.[126]

The proposal would open an avenue to facility construction other than MILCON; facilities would be real property, CE would support, and requirements would be met in a timely fashion. This would be a substantial benefit to the U.S. Government as well as DoD by saving 50% to 60% of what was budgeted to address other issues, while meeting rapid operational timelines.

6.2.2. UFC UPDATE ISSUE

UFC 3-301-01, *Structural Engineering*, had a recent update on 2 Oct 2023. The update surprisingly added language which prohibits the use of fabric or membrane clad structures in windborne debris regions, such as along the east coast. This is due largely in part to potential sharp airborne debris going through fabric, causing death or injury or damage to high value assets.[127] Cocoon SME advised this was an interesting challenge as the fabric membrane utilized by Cocoon, in fact, is designed to withstand severe wind loads. This policy does apply to areas specific to coastal areas which experience typhoon, hurricane, or cyclone force winds.[128] Cocoon SME also is working with NAVFAC Norfolk to offer the UFC writers additional language for future update to the UFC, because not all CCFAS are created equally. Their response proposes an exception to the prohibited structures. They recommend adding the use of specially designed fabric membranes specific for Miami-Dade County.[129] This fabric withstood Hurricane Michael without fail. If an exception to the UFC is not granted, CCFAS usage would not be allowed. If the exception is granted, the DoD would be able to continue to utilize CCFAS as affordable, agile, and swiftly constructed structures to support their various missions.

6.2.3. ADDITIONAL CHALLENGE

Another challenge that exists is the policy writers lack of exposure to new technologies and techniques. Policy writers, especially when it pertains to technical specifications, are engineers who are by nature resistant to change and lack the forward thinking of incorporating change into possible solutions.[130] There are not many organizations who are willing to try something new, something unconventional, to meet mission needs. Edwards was willing to take the risk and push the envelope to achieve a rapid solution to facility needs. Edwards tried new

products and worked with Cocoon to design, engineer, and construct a CCFAS which included fire suppression and cranes; a first of its kind. The result was a purpose-built hangar that not only met the needs of their customer but has also exceeded all expectations.

7. RECOMMENDATION

The process of data gathering the facts, opinions, and working with RLFs and CCFAS daily has solidified the background of this paper. Further research into the policy development and the struggles of not only the AF, but also the Navy, more than establishes the dire need for policy and procedure changes across the DoD for the procurement and use of RLFs. It is the recommendation of this paper, SMEs at Edwards, NAVFAC, and SMEs who represent private industry and government contracts, that facilities designed to be temporary, but engineered to be permanent, should be utilized as much as possible to meet the needs of the Installations. These facilities, coupled with some policy changes provide the entire DoD intangible benefits to include limited on-site disruption during installation, time of purchase order to completion being a fraction of the normal construction time with a huge cost benefit, and future options to relocate or to reconfigure to meet the next demand.

Additional research revealed a thesis written in 2018, which recommended steel framed fabric hangars, such as those utilized by Edwards, be considered as an alternate means of hangar construction.[131] Through his research, Iungerich concluded there were no impediments to the DoD or AF to constructing these types of hangars as real property. [132] Similarly, his findings aligned with the same findings of this paper: cost savings, shorter construction times, flexibility for missions, and reduced maintenance.[133] Lastly, he provided a total of 23 recommended edits for the design and construction of RLF hangars to the UFC.[134]

8. CONCLUSION

Themes across the DoD leadership are synched for a united message to the U.S. Gen Richardson, AFMC Commander, urges the U.S. to change – or lose; Secretary of the Air Force (SECAF) messages accelerate change to win, and the Chairman of the Joint Chiefs of Staff agrees the U.S. needs to "Adapt Now, or Lose Later".[135] This messaging is hitting home to across the DoD, and aligns with President Biden's confidence in the U.S. to "win the competition for the 21st century".[136] SECAF Kendall released a memo to the AF for the need to reoptimize for GPC. He identified the "necessity for efficient and focused enterprise level efforts to meet GPC challenges effectively".[137] He put forth an aggressive reoptimization timeline and outlined phased details. There are five lines of effort which include organization, equip and sustain (includes acquisition functions), people, readiness, and support. Stressed are solutions which value AF missions and results, vice processes. Processes need to be "agile and adaptive" to react to a rapidly changing environment and the need for quick, precise accomplishment of mission sets.[138] As the PRC continues to push to be the rising competitor in GPC, the U.S. must flex to maintain the lead. This starts by changing how the U.S. does business. Business rules and processes need to be more streamlined and quickly addressed to meet the emerging needs of today's warfighter. Starting with facilities to meet rapid acquisition programs.

Edwards Air Force Base has successfully demonstrated an efficient and legal method of acquiring relocatable facilities (RLFs), setting a precedent for the MILCON process in line with SECAF Kendall's directive. RLFs are purpose-built, durable, and constructed to meet UFC criteria, offering significant cost savings compared to traditional MILCON projects, thus benefiting taxpayers. Research indicates that RLFs can be constructed in a fraction of the time, have a long lifespan, and are adaptable, requiring lower maintenance costs. Consequently, it is

logical to utilize relocatable facilities to support future mission requirements for the warfighter. Other organizations are already adopting Edwards' RLF processes, recognizing the tangible benefits through firsthand experience. Edwards remains committed to hosting DoD visitors and facilitating open discussions on the progress made in the MILCON process, showcasing the capability, flexibility, durability, and adaptability of RLFs. If NAVFAC Norfolk fails to secure a policy change or exception, the DoD will miss out on obtaining much-needed facilities for their installations, resulting in a loss for the entire Department. Additionally, the departure of NAVFAC leaders would lead to a loss of knowledge regarding RLFs and CCFAS. It is crucial for the DoD to build and share knowledge, including successes, failures, and lessons learned, to improve all departments. These changes must be implemented now to shape the future of construction and enable the U.S. to meet mission requirements and support the Joint Force effectively. In today's evolving threat landscape, traditional thinking and building practices are insufficient, demanding adaptability, preparedness, and a competitive mindset.

APPENDIX A: EDWARDS RELOCATABLE FACILITY PURCHASES

Hangars

Hangars, DoD EPSS

Photo Credit: Scott Baker, Edwards

Twin hangars, each hangar is 44,000SF, with steel frame construction and sides with an insulated fabric roof. Hangars have evaporative cooling and radiant heat. Both meet DoD EPSS, security, and IDS standards. Hangar 1 project duration was 2 years, and Hangar 2 project duration was 2.5 years. Price per square foot (per hangar) was $231 (not including infrastructure and security costs). These hangars were purchased through DLA.

Dual Hangars

Photo Credit: Scott Baker, Edwards

These two hangars total 28,220SF. It has barn door style doors with a pass through in the middle. It has steel frame construction with fabric walls and roof. It has evaporative cooling and radiant heat. The facility was installed upon existing aircraft concrete. The project duration was 2 years. The price per square foot was $328 (not including the foundation or supporting infrastructure). Infrastructure costs were shared with one of the standard office modules referenced below. Those costs are not reflected in either square foot cost.

DoD Enhanced Physical Security Standard Office

This RLF is 960SF and sits on a concrete pad. The project duration was 8 months. Price per square foot was $886 (price does not include supporting infrastructure or security). This facility was purchased through DLA.

Photo Credit: Scott Baker, Edwards

Office Space

Education Module

The facility is 9,240SF and includes multiple classrooms, project lab spaces, a briefing room, an open office area, restrooms, and a break area. The project included all modular office furnishings. The project duration was 14 months. Price per square foot was $512 (price does not include supporting infrastructure). This was a purchase through DLA.

Photo Credit: Contracted Module Vendor

Office & Maintenance Complex, DoD EPSS

This complex is comprised of four stand-alone structures. Three DoD EPSS office spaces, each with restrooms, office spaces, break room, hard-walled offices, and conference rooms. The fourth structure is a facility for maintainers which includes hot desks, hard-walled offices, and a large break area. All structures are interconnected with ramps and stairs. The

Photo Credit: Scott Baker, Edwards

combined total is 14,000SF. The effort included all equipment and office furnishings. Price per square foot was $328 (price does not include supporting infrastructure or security costs). This was purchased through DLA.

Office Space, Standard

Photo Credit: Scott Baker, Edwards

The facility is 9,990SF. Space includes office area, conference rooms, restrooms, hard offices, and breakroom and all modular furnishings. The project duration was 13 months. The price per square foot was $195 (price does not include supporting infrastructure). This facility was purchased through DLA.

Office and Warehouse Space, Standard

Photo Credit: Scott Baker, Edwards

The warehouse (left side in photo) is 2,240SF, and office space is 3,300SF. All modular office furniture is included. The project duration was 7 months. The combined price per square foot was $301. These facilities were purchased through.

Office Space, DoD EPSS

Photo Credit: Scott Davis, Edwards

This is a 3,800SF office space. The purchase included all modular office furniture. The project duration was 13 months. Price per square foot was $447 (including supporting infrastructure and security).

DoD EPSS

Office

Photo Credit: Edwards

This is a 2,688SF facility that was previously used. This RLF was relocated from inside a hangar at another Air Force installation, transported to Edwards and reassembled. The relocated RLF included interior modular furnishings, ramp, and stairs. This facility was purchased directly from a relocatable vendor at a reduced cost. The project duration was 12 months. Price per square foot was $465 (price includes supporting infrastructure and security).

Office

Photo Credit: Eugene Berg, Edwards

This is a 20,000SF facility. This project included the RLF, office furnishings, and supporting infrastructure. The project duration was 18 months. The price per SF was $365 (price does not include supporting infrastructure; security is included).

Munitions Storage Bunker

Photo Credit: Scott Baker, Edwards

This RLF is a 5,000SF munitions storage facility with drive-through capability. It is comprised of 8 modulars and is of all steel construction. The project duration was 8 months. Price per square foot was $290 (price does not include supporting infrastructure or alarms). This facility was purchased through DLA.

Laboratory Space

Engineering Instrumentation Laboratory

This relocatable is installed inside an existing real property facility. It is a 2-story, 17,000 SF structure. All modular furnishings were included. The project duration was 8 months.

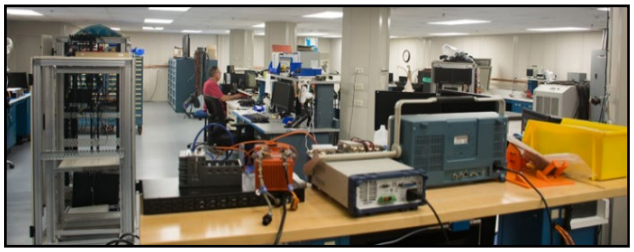


Photo Credit: Edwards

The price per square foot was $235, purchased through DLA.

Special Instrumentation Laboratory

This facility has 18,125SF of lab, warehouse, and administrative space. All modular furnishings were included. The project duration was 14 months. Price per square foot was $453 (price does not include supporting infrastructure). This was purchased through DLA.

Photo Credit: Scott Baker, Edwards

Tactical Equipment

Large Area Maintenance Shelter (LAMS)

This structure was purchased as tactical equipment and is not considered an RLF.[139] The LAMS is 12,000 SF with insulated liners, and accommodates two electric vertical take-off and landing (eVTOL) aircraft. This structure was added to the squadron's equipment

Photo Credit: Celina Tent, Inc.

account, as it is fully deployable. This project was installed on existing concrete. It was purchased through DLA and awarded to Celina Tent, Inc. The project included external ground mounted HVAC units and a lightning protection system. Supporting infrastructure was provided by CE allied support project. The project duration was 15 months. Price per square foot was $97. *Above photo taken from Celina Tent, Inc. web site.*[140]

Recently Awarded Projects

Addition to Real Property Facility

This purchase directly supported a surge in squadron manning. This facility is 4,650SF of administrative space. All modular furnishings were included. The project duration is TBD. This purchase was done by Base Contracting. The timeline from customer request to award date was 5 months. Price per square foot is $484 (price does not include supporting infrastructure costs of $450K).

DoD EPSS Offices

Two 22,210SF office facilities were recently awarded by Base Contracting. Like all administrative RLFs, Comm connections, restrooms, HVAC, break areas, conference areas, hard walled offices, and modular furnishings are included. This facility will meet all DoD EPSS requirements upon installation completion and includes comm work. Project duration is TBD. The timeline from customer request to award date was 13 months. Price per square foot averaged $803 (price does not include supporting infrastructure; security was included).

APPENDIX B: LESSONS LEARNED

The following are lessons learned over the past six years at Edwards. Some items are things that were missed or overlooked due to unknown requirements at the time of purchase, and due to the speed at which the RLFs were purchased. Early involvement of all key players is essential to success. Some organizations that should be included in initial meetings include representatives from the Program, CE, fire department, safety office, communications squadron, security office, environmental, and strategic planner. Once the team agrees on a final scope of work and design layout, have key team members sign off on the final scope of work provided by the contractor prior to purchase. This eliminates the "I didn't agree to that" and keeps everyone honest with what the facility requirements were. After several months, people tend to forget what they did agree to. If changes are needed, changes to the purchase can be made via amendment to the original order and can be worked expeditiously with no negative impacts to the procurement and construction schedule.

Supply chain shortages because of the COVID-19 pandemic plagued multiple projects not only for Civil Engineering, but for RLFs as well. Critical electrical components, such as step-down converters, distribution panels, and transformers caused delays and workarounds to meet mission timelines. Fire alarm systems compliant with installation standards were also hard to get. Fortunately, the base fire department and the RLF manufacturer were able to work out an agreement for acceptable temporary parts until the permanent base approved parts arrived; this allowed for occupancy of the facility to continue vice waiting 9 months until permanent parts arrived.

Water supply calculations for fire suppression are a must; ensure the pipes are properly sized to sustain the fire sprinklers. If an IDS is desired, ensure the right system is utilized, this

applies for the security system as well. For instance, sensitivity of the system may not be a good choice depending on the circumstance. The external power conduit for the modules need to meet the prevalent environmental challenges. At Edwards, exposed PVC pipe gets dry-rotten by the intense sun, causing not only discoloration quickly, but also degrades the strength causing premature failure and exposed wires to the elements.

Specific to hangars, the prevailing winds could cause the intake and exhaust vents to flap which trip the alarm system. Edwards now stipulates that the vents are connected to avoid this in future projects. Hangars require a lightning protection system. Ensure this meets the activities internal to the hangar. Additionally, the aqueous film-forming foam fire protection system testing and clean up was a big problem. The hangars utilized rough, existing airfield concrete which restricted the foam disbursement times which caused expensive repeated testing, along with the foam clean up. Future hangars on existing concrete had epoxied floors (epoxy applied on top of concrete) which allowed the foam to disperse more evenly. The DoD conducted a review of 84 incidents of accidental foam activations. These activations collectively cost the DoD $24.5M due to damages to 120 aircraft, over 20 personnel injuries, and one death.[141] the AF issued a Sundown Policy for the requirement of foam fire suppression systems in 2021, so this is no longer an issue. Currently, code calls for a water fire suppression system, which still needs to be included in future scopes of work.

APPENDIX C: LOCAL/COMMERCIAL/INDUSTRY USERS

Below are some examples of RLFs utilized across the United States.

Photo Credit: Rubb

Basketball and volleyball court constructed for a High School in Acton, CA (left).[142] An indoor vehicle testing structure large enough for vehicle turns was constructed for Chrysler Motors in Sterling Heights, MI (right).[143]

Photo Credit: Rubb

Photo Credit: Rubb

A total of 6 facilities installed at Idaho National Labs to support nuclear waste recycling for Battelle Energy Alliance in Scoville, ID (left).[144] The image to the right is storge for Portland International Jetport in Portland, ME.[145]

Photo Credit: Rubb

Photo Credit: Rubb

A municipal salt shed was constructed in Stonington, ME complete with doors, for the storage of salt for maintaining local roads in the winter (left).[146] A facility for the containment of wood fibers and operating equipment was constructed in Schofield, WI (right).[147]

Photo Credit: Rubb

Photo Credit: Rubb

Fabric replacement to a 29-year-old structure constructed by Rubb at the Port of Los Angeles, Los Angeles, CA (left) [148], and fabric replacement on a 27-year-old Rubb structure in Pennsylvania (right)[149].

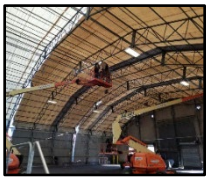


Photo Credit: Rubb

Photo Credit: MMG

Commercial education facility (relocatable), constructed for Head Start and Women, Infant and Children (WIC) located in Arvada, CO (left),[150] and another constructed in Rocksprings, TX (right). [151]

Photo Credit: MMG

Photo Credit: MMG

Commercial healthcare facility (medical clinic) constructed in Oklahoma City, OK (left),[152] and another healthcare facility in Richmond, TX (right).[153]

Photo Credit: MMG

Additional projects and details can be found on-line for Rubb (https://www.rubbusa.com/projects/) and for MMG (https://www.modularmanagementgroup.com/).

APPENDIX D: OTHER DOD LOCATIONS UTILIZING RLFS

Who else utilizes relocatable facilities? In addition to the military utilizing RLFs for deployment purposes, RLFs have responded to natural disasters which effected hurricane and earthquake in the U.S.

Following Hurricane Michael, Tyndall AFB, FL has leased RLFs to continue their mission until such time MILCON funding becomes available for permanent replacement facilities. Tyndall AFB is leasing over 90,000SF of modular space; photos below depict multiple facilities on the installation.[154]

Photo Credit: Reprinted from MMG website.

Following the back-to-back earthquakes in July 2019, China Lake Naval Air Weapons Station (NAWS), CA lost the use of many facilities, as noted previously on page 50. It was reported by U.S. Naval Institute News that the USN spent $1.07M on RLFs to support the base gym, air operations, and magazine storage.[155] Photos of those facilities are unavailable.

APPENDIX E: ACRONYMS

412 TW	412th Test Wing
ACAT	Acquisition Category
ADA	Americans with Disabilities Act
ADS	Atlantic Diving Supply
AF	Air Force
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
AFIMSC	Air Force Installation Management Service Center
AFMC	Air Force Material Command
AFTC	Air Force Test Center
BOS	Base Operating Support
CA	Center Executive Director
CCFAS	Code Compliant Fabric Adaptive Structure
CE	Civil Engineering
Comm	Communications Squadron
DAFI	Department of the Air Force Instruction
DoD	Department of Defense
DoDI	Department of Defense Instruction
DLA	Defense Logistics Agency
DV	Distinguished Visitor
Edwards	Edwards Air Force Base
EPSS	Enhanced Physical Security Standards

eVTOL	electric Vertical Take Off and Landing
FY	Fiscal Year
GAO	Government Accountability Office
GPC	Great Power Competition
HVAC	Heating, Ventilation and Air Conditioning
IBC	International Building Code
ICD	Intelligence Community Directive
IDS	Intrusion Detection System
LAMS	Large Area Maintenance Shelter
MILCON	Military Construction
MIPR	Military Interdepartmental Purchase Request
MMG	Modular Management Group
NAVFAC	Naval Facilities Engineering Systems Command
O&M	Operations and Maintenance
PEO	Program Executive Office
PRC	People's Republic of China
PVC	Polyvinyl Chloride
RDT&E	Research, Development, Test & Evaluation
RLF	Relocatable Facility
Rubb	Rubb USA Building Systems
SF	Square Foot
SAPF	Special Access Program Facility
SECAF	Secretary of the Air Force

SCIF	Sensitive Compartmented Information Facility
SME	Subject Matter Expert
TLS	Tailored Logistical Support
UFC	Unified Facilities Criteria
UFGS	Unified Criteria Guide Specifications
UMMC	Unspecified Minor Military Construction
XPP	Plans and Programs Installation Partnership
U.S.	United States

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