2018-12

A-10 ADAPTIVE BASING OPERATIONS AND APPLICATIONS IN SUPPORT OF SOF

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THESIS

A-10 ADAPTIVE BASING OPERATIONS AND APPLICATIONS IN SUPPORT OF SOF

by

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December 2018

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2018	**3. REPORT TYPE AND DATES COVERED** Master's thesis

4. TITLE AND SUBTITLE A-10 ADAPTIVE BASING OPERATIONS AND APPLICATIONS IN SUPPORT OF SOF	**5. FUNDING NUMBERS**
6. AUTHOR(S) Leif C. Nordhagen	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

What are the advantages and disadvantages of pushing A-10 operations away from main operating bases (MOBs) in future operating environments? What are the critical requirements, risks, and challenges associated with operating from forward locations? The conventional U.S. Air Force understands that it will need to operate away from MOBs in future conflicts in order to project forward, remain tactically unpredictable, increase combat resiliency, and ultimately win. Research on non-traditional basing strategies has garnered many terms: Agile basing, adaptive basing, forward basing, FARP operations, austere operations, distributed basing, untethered operations, disaggregated basing, lily-pad strategy, and Rapid-X among others. This study analyzes the A-10 enterprise's ability to operate away from a MOB, in austere environments, to provide fire support to special operations forces. This study shows adequate potential of the A-10 enterprise to operate in austere environments bringing significant benefits to the joint force without substantial risk. The demonstrated capability during the Cold War, Desert Storm, and recent SOF-specific exercises highlight tangible benefits that bode well for future conflicts.

14. SUBJECT TERMS agile basing, austere basing, adaptive basing, FARP, FAARP, A-10, A2/AD environment, close air support, special operations forces, rapid next, rapid x	**15. NUMBER OF PAGES** 103
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

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A-10 ADAPTIVE BASING OPERATIONS AND APPLICATIONS IN SUPPORT OF SOF

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Submitted in partial fulfillment of the
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**MASTER OF SCIENCE IN DEFENSE ANALYSIS
(IRREGULAR WARFARE)**

from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

What are the advantages and disadvantages of pushing A-10 operations away from main operating bases (MOBs) in future operating environments? What are the critical requirements, risks, and challenges associated with operating from forward locations? The conventional U.S. Air Force understands that it will need to operate away from MOBs in future conflicts in order to project forward, remain tactically unpredictable, increase combat resiliency, and ultimately win. Research on non-traditional basing strategies has garnered many terms: Agile basing, adaptive basing, forward basing, FARP operations, austere operations, distributed basing, untethered operations, disaggregated basing, lily-pad strategy, and Rapid-X among others. This study analyzes the A-10 enterprise's ability to operate away from a MOB, in austere environments, to provide fire support to special operations forces. This study shows adequate potential of the A-10 enterprise to operate in austere environments bringing significant benefits to the joint force without substantial risk. The demonstrated capability during the Cold War, Desert Storm, and recent SOF-specific exercises highlight tangible benefits that bode well for future conflicts.

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LIST OF ACRONYMS AND ABBREVIATIONS

A2/AD	anti-access/area denial
ACC	Air Combat Command
AF	assault force or Air Force
AFSOC	Air Force Special Operations Command
AGM	air-to-ground missile
ALR	acceptable level of risk
AMC	Air Mobility Command
AOR	area of responsibility
CAF	Combat Air Force
CAS	close air support
CCD	camouflage, concealment, and deception
COB	collocated operating bases
CSAR	combat search and rescue
CSBA	Center for Strategic Budgetary Analysis
DOD	Department of Defense
DOL	distributed operating location
FS	fighter squadron
FW	fixed wing
HAS	hardened aircraft shelter
HLZ	helicopter landing zone
ICT	integrated combat turnaround
ISR	Intelligence Surveillance and Reconnaissance
KKMC	King Khalid Military City
LIMFAC	limiting factor
MANPADS	man-portable air defense system
MESL	minimum equipment subsystem list
MEZ	missile engagement zone
MOB	main operating base
MOPP	mission oriented protective posture
MRSP	mission ready spare package

MRT	maintenance recovery team
NTC	National Training Center
OBOGS	onboard oxygen generating system
OEF	Operation Enduring Freedom
OIR	Operation Inherent Resolve
POL	petroleum, oil, lubricants
PR	personnel recovery
QRF	quick reaction force
RIP	relieve in place
S/S	surface-to-surface
SAM	surface-to-air missile
SOWT	Special Operations Weather Technician
SSE	sensitive sight exploitation
STS	Special Tactics Squadron
TD&E	tactics development and evaluation
TIP	tactics improvement proposal
TO	technical order
TTP	tactics, techniques, and procedures
USAF	United States Air Force
USAFE	United States Air Forces in Europe
USAFWS	United States Air Force Weapons School
USSR	Union of Soviet Socialist Republics
UTC	unit tasking code
WPTO	Western Pacific Theater of Operations

I. HISTORICAL LOOK AT ADAPTIVE BASING

A. INTRODUCTION TO THE PROBLEM

In the 2018 National Defense Strategy (NDS), Secretary of Defense James Mattis stated "much of our force employment models and posture date to the immediate post-Cold War era, when our military advantage was unchallenged."[1] For the U.S. Air Force (USAF), this has meant flying unchallenged, unthreatened, under an air supremacy umbrella from Main Operating Bases (MOBs) nearly impervious to enemy attack. Vulnerable high value air assets (HVAA) and tanker aircraft presently operate within miles of the front lines unthreatened from air defenses. A 72-hour Air Tasking Order (ATO) cycle provides adequate flexibility against predictable enemies. A centralized Command and Control (C2) structure pulls tactical decisions away from flight leads and lower level commanders.

The NDS and Quadrennial Defense Review (QDR) acknowledge that the post-Cold War focus on defeating rogue regimes has been replaced by strategic competition from peer or near-peer advisories and protecting the homeland from terrorist attacks requires the ability to interdict terrorist cells worldwide. The NDS states U.S. and coalition forces must posture forward and remain agile, capable, resilient, and unpredictable to succeed in future conflicts.[2] The 2014 *Quadrennial Defense Review* goes on to say the Department of Defense will:

> enhance capabilities to disperse land-based and naval expeditionary forces to other bases and operating sites, providing the ability to operate and maintain front-line combat aircraft from austere bases while using only a small complement of logistical and support personnel and equipment.[3]

For the USAF, increasing agility and survivability potentially means projecting forward from MOBs, distributing airplanes and logistical support to strategically

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[1] Jim Mattis, *National Defense Strategy: Unclassified Summary* (Washington, DC: Department of Defense, 2018), https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf, 4.

[2] Mattis, *National Defense Strategy: Unclassified Summary*, 7.

[3] Martin E. Dempsey, *Quadrennial Defense Review 2014* (Washington DC: Department of Defense, 2014), 38.

advantageous locations, moving away from centralized command and control, operating in a contested environment, and developing the ability to rapidly deploy a scalable force and operate in all areas of the world to defeat any future advisory. In a 2018 speech, General Mike Holmes, commander of Air Force Air Combat Command (ACC) stated:

> ACC will train its junior officers in how to quickly deploy small groups of aircraft to austere fields, quickly move them again in order to avoid being hit, and make those calls on their own initiative, it will mean driving decision making authority to lower and lower levels and expecting young leaders to use their wits to carry out "commander's intent.[4]

The concept of operating away from MOBs is not new. Fighter units regularly trained to operate from contingency locations in Europe during the Cold War. In Desert Storm, A-10s utilized forward operating locations (FOLs) to extend their range and expedite rearming for SCUD hunting missions in western Iraq. Since the end of Desert Storm, the conventional Air Force has migrated back towards operating from MOBs and abandoned some of key maintenance practices that facilitate adaptive basing and operating in austere environments.

B. RESEARCH QUESTION

How can the DOD leverage the A-10's ability to operate from forward operating locations to provide flexible, rapidly deployable, and lethal fires support to current and future operations areas in support of SOF?

- What are the benefits and risks of operating away from MOBs?
- What theaters, missions, and OPLANs can benefit from adaptive basing at FOLs?
- What is the current capability and LIMFACs of the A-10 enterprise to operate in austere environments?

[4] John Tirpak, "The Air Force's 'Forever War' is its Toughest Pill to Swallow," *Air Force Magazine*, March, 2018, http://www.airforcemag.com/MagazineArchive/Pages/2018/March%202018/The-Air-Forces-Forever-War-is-its-Toughest-Pill-to-Swallow.aspx.

To address these questions, the thesis will analyze several potential advantages and disadvantages of applications of adaptive basing and executing forward arming and refueling at a FOL. These potential advantages include:

- Positioning airplanes closer to an operating area, reducing transit times, minimizing tanker support requirements, and maximizing on-station time.
- Quicker refueling and rearming, getting airplanes back to the fight faster.
- Pre-staging assets to provide responsive on-call personnel recovery (PR) or quick reaction force (QRF) support.
- Allows aircraft to rapidly deploy to new Areas of Responsibility (AORs) before an airbase infrastructure can be built or acquired.
- Minimizing targetable signature for surface-to-surface missiles in an Anti-Access Area Denial (A2/AD) environment.
- Distributing airplanes to reduce the effect of a MOB attack.
- Maximizing flexibility to adapt to changes in mission timelines.
- Enabling pilots to project forward, face-to-face mission plan, brief, and rehearse with the supported force.

Potential disadvantages include:

- Maintenance complications while operating away from a MOB.
- Operating an airfield without robust security forces or firefighting services.
- Weather impacts on flying operations and non-traditional runway surfaces.
- Centralized command and control challenges.
- Challenging logistical support.

These potential advantages and disadvantages are not platform specific. They may apply to any airplane with the ability to land and operate temporarily away from a MOB. This thesis will focus on operations and applications of A-10 aircraft in support of special operations forces (SOF). The A-10, with high mounted turbofan engines, rugged landing gear, and maintenance simplicity, allow it to operate from areas not accessible to other jet aircraft.

C. KEY DEFINITIONS AND CONCEPTS

Adaptive Basing—A basing strategy that leverages "alternate basing options to enable flying operations. It calls for forces to disaggregate capabilities from a single base and disperse forces and capabilities to many locations for operational maneuver."[5]

Agile Basing—The ability to move rapidly from base to base, or relocate base infrastructure and logistical support to a new location in a combat environment.

Distributed Basing—A concept of basing airplanes in small groups at multiple airfields as opposed to basing airplanes in large groups at a central location.

Austere Airbase—A runway with little to no existing infrastructure.

Semi-Prepared Surface—An unpaved runway surface (Gravel/Dirt). "Semi-prepared surfaces may include deserts, dry lakebeds, flat valley floors, dirt roads."[6]

Unimproved Surface—Same as semi-prepared surface, includes deserts, dry lakebeds, flat valley floors, dirt roads.

Prepared Surface—A paved runway surface (concrete). "Prepared surfaces may include airfields, roads, highways, or other paved surfaces."[7]

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[5] Patrick Mills et al., *Estimating Air Force Deployment Requirements for Lean Force Packages: A Methodology and Decision Support Tool Prototype* (Santa Monica, CA. RAND Corporation, 2017), https://www.rand.org/content/dam/rand/pubs/research_reports/RR1800/RR1855/RAND_RR1855.pdf, 22.; David Dammeier, Meka Toliver, and Logan Smith, "Future Concepts: Overcoming a Power Projection Problem," *Air Force Civil Engineering Center*, Spring 2016, https://www.afcec.af.mil/News/CE-Online/Article-Display/Article/1004470/overcoming-a-power-projection-problem.

[6] Department of the Air Force, *Drop Zone and Landing Zone Operation*, AFI 13–217 with AFSOC Supplement (Washington, DC: Department of the Air Force, 2007, AFSOC Supplement 2014), http://static.e-publishing.af.mil/production/1/afsoc/publication/afi13-217_afsocsup/afi13-217_afsocsup.pdf.

[7] Department of the Air Force, *Drop Zone and Landing Zone Operations.*

Forward Operating Location (FOL) / Forward Operating Base (FOB)—"An airfield used to support tactical operations without establishing full support facilities."[8]

Forward Arming and Refueling Point (FARP)—"A temporary facility, organized, equipped, and deployed to provide fuel and ammunition necessary for the employment of aviation maneuver units in combat."[9] Sometimes abbreviated as FAARP to distinguish it from the Air Force specific acronym that does not include Arming.

Integrated Combat Turnaround (ICT)—The process of refueling, reloading, and providing general aircraft servicing with one or more engines running. Similar terms are hot pitting, concurrent servicing.

Untethered Operations—The ability to operate fighter aircraft and generate sorties from forward bases without being "tethered" to MOBs[10]

Mission-Type Orders—"An order to a unit to perform a mission without specifying how it is to be accomplished."[11]

Mission Command—"The conduct of military operations through decentralized execution based upon mission-type orders."[12]

D. CURRENT A-10 FARP TRAINING AND CAPABILITY

Since 2007, the Air Force A-10 community began developing new tactics, techniques, and procedures (TTPs) and reinvigorating old TTPs to operate in austere environments away from MOBs, on dirt runways or unimproved surfaces with little to no

[8] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms*, JP 1–02 (Joint Chiefs of Staff, 2018), http://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf?ver=2018-09-28-100314-687

[9] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms.* AFI 11–235 defines FARP as Forward Area Refueling Point. AFI 11–235 strictly discusses refueling from cargo aircraft does not address refueling from other platforms or reloading weapons at the forward area. For the purposes of this paper, the JP 1–02 of FARP will be used.

[10] Adapted from Charles Brown, Bradley Spacey, and Charles Glover, "Untethered Operations: Rapid Mobility and Forward Basing Are Keys to Airpower's Success in the A2/AD Environment." *Air and Space Power Journal (*Maxwell AFB, AL: Air University, 2015), http://www.dtic.mil/dtic/tr/fulltext/u2/a618930.pdf.

[11] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms*

[12] Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Associated Terms*

infrastructure or external support. Tactics Improvement Proposal (TIP) 04–0401 directed the A-10 test community to undertake Tactics Development and Evaluation (TD&E) to evaluate the A-10s ability to utilize a Forward Arming and Refueling Point (FARP) in an austere environment. The TIP stated "A-10s were sometimes required to operate from austere forward operating locations because of the unavailability of airborne refueling due to either air threat or lack of tankers"[13]

Air Combat Command (ACC) Project 06–025A *A-10 Forward Area Arming and Refueling Tactics and Development and Evaluation* concluded in 2009. The project codified procedures to operate and refuel at a forward location from Air Force Special Operations Command (AFSOC) platforms (MC-130) and Air Mobility Command (AMC) platforms (C-17, C-130). The project demonstrated the A-10s ability to operate from unimproved and non-traditional runway surfaces and developed a pilot training program to qualify pilots in unimproved surface landings. Although it was an objective of Project 06–025A, it did not develop TTPs or Technical Order (T.O.) data to rearm A-10s in an austere environment due to a lack of a tasking for ACC maintainers to hold the qualification, resulting in no qualified maintainers available for the test.

Since Project 06–025A Final Report was published in March 2009, operational A-10 units and the A-10 division of the United States Air Force Weapons School (USAFWS) trained pilots on FARP procedures and unimproved surface landings. A-10 operational units qualify a majority of pilots in unimproved runway and refueling operations. However, without specific training for maintenance personnel to rearm jets in austere environments, the capability never reached an operational status.

In November 2016, an A-10 reserve unit, through its own motivation and extensive self-derived training program, completed the first full-scale exercise encompassing all aspects of FARP from an austere environment. The 303 FS certified the first deployable Operations and Maintenance Unit Tasking Code (UTC) capable of supporting full scale

[13] USAF Warfare Center, *A-10 Forward Area Arming and Refueling Tactics Development and Evaluation Final Report,* ACC Project 06–025A Report (Nellis AFB, NV: Air Combat Command, 2009), 2.

FARP operations from austere locations.[14] The success of the 303rd FS UTC creation did not resonate throughout the rest of the A-10 community or higher headquarters. As of November 2018, they remain the only unit capable of deploying with this capability.

E. HISTORICAL CONTEXT

1. The Cold War

The concept of dispersed modern fighter basing originally surfaced after Vietnam as a tactic to counter a Soviet Invasion in Western Europe. The Air Force conducted and sponsored numerous studies on basing operations in Europe. After several studies, the Air Force decided on basing A-10s at MOBs in England and deploy them forward to the European mainland if required.[15] The concept made sense based on the threat. Planners in Europe acknowledged the A-10 was needed to counter mass amounts of Soviet armor. The A-10 needed the ability to rapidly rearm at FOLs and return to the fight without returning to England. Establishing MOBs on the European mainland made them vulnerable to Russian attack. In response, six squadrons of A-10s were based in England. Each squadron made routine exercise deployments to FOLs in Europe.[16]

A 1987 study by RAND, titled *Tactical Dispersal of Fighter Aircraft: Risk, Uncertainty, and Policy Recommendations*, author John Halliday ran a series of simulations comparing European basing options. His simulations suggested a mix of MOBs and distributed operating locations (DOLs) provided the most amount of protection against a Soviet attack. He accurately points out that the European basing structure at the time was not based on any coherent strategy, but rather an evolutionary necessity of the international political process.[17] In 1987, the main threat to U.S. airbases in Europe came from a direct airborne attack by Union of Soviet Socialist Republics (USSR) fighters and

14 Anthony Roe. "2016 Nellis AFB "Strike 2.0" 442 FW Deployment After Action Report." (Whiteman AFB, MO: 442 Fighter Wing, 2016).

15 Douglas N. Campbell, *The Warthog and the Close Air Support Debate* (Annapolis, MD: Naval Institute Press, 2003), 126

16 Campbell, *The Warthog and the Close Air Support Debate*, 129–131.

17 John M. Halliday, *Tactical Dispersal of Fighter Aircraft: Risk, Uncertainty, and Policy Recommendations* (Santa Monica, CA: RAND Corporation, 1987), https://www.rand.org/pubs/notes/N2443.html, 4.

bombers. Halliday cites several key historical events to show the vulnerability and devastation caused by a successful air attack. Most notably, Halliday references the Israeli attack on Egyptian airfields in 1967 that destroyed 416 Arab planes, 393 of which were ground kills. In turn, the Israeli Air Force lost merely 26 aircraft.[18] Halliday's simulations conclude tactical dispersal of aircraft to DOLs will significantly lower the impact of an airfield attack and lead to sustained aircraft sortie generation. Of note, he did not do a deep dive into sustaining DOLs but expected essential supplies like POL and munitions to be a mixture of pre-staged and ground delivered supplies throughout western Europe.

In Halliday's study, the key goal was aircraft survival while on the ground and maintaining sortie generation, not to decrease distance to the front lines, provide quicker aircraft and weapons turnaround, or extend the range of unrefueled fighters. At the time, long range strategic surface-to-air missile systems (SAMs) were not as significant of a factor, which permitted the use of tankers for AAR near the front lines. In 1987, the most capable long-range SAM, the SA-10 (S-300 V1) had a nominal range of 90 km and served mostly as point defense around Moscow.[19] Additionally, since highly accurate conventional ballistic and cruise missiles did not exist yet, or pose a significant threat to European airbases, commanders assumed they would have some sort of advance warning to launch alert fighters to counter a Soviet air attack.

In 1988, Spangdahlem Air Base in Germany conducted the Salty Demo to simulate a sustained air attack on a MOB. The demo illustrated the vulnerability of MOBs and severe degradation to air operations caused by an enemy air attack. Recommendations focused on hardening MOBs, stockpiling key infrastructure repair equipment, employing camouflage, concealment and deception (CCD), and making more taxi and runway surfaces available for use.[20]

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[18] Halliday, *Tactical Dispesal of Fighter Aircraft: Risk, Uncertainty, and Policy Recommendations*, 13.

[19] Federation of American Scientists. n.d. *SA-10 Grumble.* Accessed October 15, 2108. https://fas.org/nuke/guide/russia/airdef/s-300pmu.htm.

[20] Christopher J. Bowie, "The Lessons of Salty Demo" *Air Force Magazine* (March 2009). http://www.airforcemag.com/MagazineArchive/Pages/2009/March%202009/0309salty.aspx.

A second RAND study, *A Perspective on USAFE Collocated Operating Base System*, conducted in the same era by Lewis et al., analyzed the use of collocated operating bases (COBs) throughout Europe. COBs, in concept, would be used to bed down the influx of tactical aircraft in the event of an invasion by the USSR. At the height of the cold war, the U.S. Air Force had around 500 tactical fighter aircraft based in Europe. War plans called for an additional 1000 to deploy and bed down in Europe.[21] The influx of airplanes would use COBs for the duration of the deployment. At the time of the Lewis study, NATO had 43 fully functioning COBs with adequate equipment to sustain aircraft bed down.[22] USAFE desired 70 COBs by FY 1991, but the requirement dissolved as the Soviet Union weakened in the late 80's and ultimately collapsed in 1991.[23]

Many of the Cold War COBs and MOBs were abandoned or transferred to civil authorities, but could potentially be used today if required for contingency operations. Bitburg municipal airport (ICAO: EDRB) in western Germany is a good example. At its height, three squadrons of U.S. F-15s were based at Bitburg Airbase. The base was transferred back to Germany in 1994 as part of the post-Cold War draw down.[24] Bitburg's 10026x148 foot runway could still support fighter and cargo aircraft operations, and a multitude of the abandoned hardened aircraft shelters (HAS) could potentially be used for aircraft or equipment.[25]

2. Desert Storm

As the Cold War drew to an end, focus turned to Iraq in 1991, and eliminated the large-scale pursuit and study of distributed or adaptive basing operations. During Desert Storm A-10s utilized two FOLs in western Saudi Arabia to refuel and rearm during SCUD hunting missions in western Iraq. Figure 15 shows these locations. William Smallwood's

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[21] Halliday, Tactical Dispesal of Fighter Aircraft: Risk, Uncertainty, and Policy Recommendations, 5.

[22] Donald Lewis et al. *A Perspective on the USAFE Collocated Operating Base System* (Santa Monica, CA: RAND Corporation, 1986), 4.

[23] Lewis et al., *A Perspective on the USAFE Collocated Operating Base System*, 4.

[24] Jennifer H. Svan, "Americans close door on operations at Bitburg after more than 60 years." *Stars and Stripes*, November 7, 2017, https://www.stripes.com/news/americans-close-door-on-operations-at-bitburg-after-more-than-60-years-1.496618.

[25] Runway data pulled from www.skyvector.com

Warthog: Flying the A-10 in the Gulf War describes how the A-10 effectively used integrated combat turnarounds (ICTs) at Al Jouf and KKMC. Smallwood recounts how pilots would often fly 3 missions per day without leaving the cockpit.[26] Smallwood's writing is an entertaining narrative, not an academic research piece, however several useful FARP concepts can be pulled from Smallwood's text:

- A-10s effectively used FARPs at FOLs to extend its combat range without relying on tanker support.
- FARPs enabled pilots to return to the target area quickly with new weapons. Returning to the MOB took significantly longer and required tanker support. Simply refueling at a tanker and returning to the target area did not replenish weapons.
- FOLs required only a minimal footprint of essential personnel and equipment to operate effectively.

William Smallwood's book *Warthog: Flying the A-10 in the Gulf War* recounts the details of one of the most successful A-10 missions in Desert Storm. On February 25, 1991, one 2-ship of A-10s, piloted by Captain Eric "Fish" Salomonson and Lieutenant John "Karl" Marks destroyed 23 Iraqi tanks and damaged up to 10 additional tanks in one day. Most of the kills were by AGM-65 Maverick missiles with the remainder from 30mm Combat Mix. Salomonson and Marks FARPed two times at a FOL in Saudi Arabia allowing them to return to the target area quicker reloaded with the deadly AGM-65s. In addition to killing the tanks, the duo supported several Marine units in desperate need of close air support (CAS).[27] Figure 1 pictures the two pilots at KKMC FOL during a ground alert shift.

[26] William L. Smallwood, *Warthog: Flyting the A-10 in the Gulf War* (Washington, DC: Potomak Books Inc, 1993), 109.

[27] Smallwood, Warthog: Flying the A-10 in the Gulf War, 195–197.

Figure 1. A-10s at KKMC FOL during Desert Storm[28]

Following the end of the Desert Storm, there are some sporadic accounts of A-10s using FOLs in Operation Southern Watch but nothing that contributes to significant findings for this thesis topic. One key development was USAF A-10 maintainers stopped training to full integrated combat turnarounds in the mid-1990s. More importantly, maintenance technical order data changed and removed this as an approved option.[29] To date, A-10s still conduct hot pit refueling (taking on fuel with the engines running) but can no longer be loaded with weapons or countermeasures with engines running.[30] This limitation is one of the significant roadblocks to operationalize the full capacity of A-10 austere capabilities.

3. Operation Enduring Freedom

In March 2002, A-10s were the first fighter jets to operate from Bagram airfield. Gary Wetzel accounts for this in his book, *A-10 Thunderbolt Units of Enduring Freedom 2002–2007*.[31] Pilots describe the difficulty in operating off of the crumbling Soviet era runway, weaving around repairs and even utilizing the parallel taxiway for flight operations. Other fighter aircraft did not operate from Bagram until years later, after significant runway repairs were completed. Even as late as 2014, A-10s operated from

[28] Source: John Marks personal archive

[29] Anthony Roe, personal communication, November 20, 2018.

[30] Anthony Roe, personal communication, November 20, 2018.

[31] Gary Wetzel, *A-10 Thunderbolt II Units of Operation Enduring Freedom 2002–2007* (Oxford: Osprey Publishing, 2013), 33–54.

Bagram's parallel taxiway while the main runway was closed for repairs. Other fighter aircraft were moved to Kandahar Air Base while until the runway repairs were completed.

4. A2/AD Environment

In November 2011, President Obama declared an "Asian Pivot" for U.S. defense strategy while addressing the Australian Parliament. The rise of Chinese influence in the region, coupled with their exploding economy and significant increase in defense spending caught the attention of the president and the Department of Defense (DOD). This inspired the next generation of research into untethered and dispersed operations. Fighting an air and sea battle against the People's Republic of China presents a daunting task. Advanced Chinese ballistic missiles coupled with a robust surface-to-air and air-to-air threat manifested the term anti-access/area denial (A2/AD). Most U.S. MOBs in Korea, Guam, and Japan are within range of Chinese weapons. U.S. air defenses and ballistic missile defenses could be easily overwhelmed by the sheer number of Chinese weapons.[32]

Lt Col Robert Davis wrote an informational piece for *Air and Space Power Journal* about "Rapid Raptor." Rapid Raptor conceptually pairs a 4-ship of F-22s with a single C-17 to deploy out of Alaska as a single package to fight in the Western Pacific. The C-17, carrying weapons, additional pilots, maintenance personnel, and fuel can sustain with 4-ship of Raptors for two to three days of fighting prior to returning to Alaska or another MOB in the area of responsibility (AOR). The F-22/C-17 package can utilize up to 400 potential runways in the first and second island chains off the east coast of China to conduct a full FARP and return to the fight.[33] The concept minimizes duration on the ground, maintains unpredictability of FARP location, and limits static targets available to Chinese ballistic missiles and aircraft. The Rapid Raptor concept is one of the promising tactics to survive and conduct an air war an A2/AD environment.

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[32] Jan Van Tol et al. *AirSea Battle: A Point-of-Departure Operational Concept* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010), https://csbaonline.org/research/publications/airsea-battle-concept.

[33] Robert Davis, "Forward Arming and Refueling Points for Fighter Aircraft: Power Projection in an AntiAccess Environgment." *Air & Space Power Journal* 28, no 5 (September-October 2014): 5–28. https://www.airuniversity.af.edu/Portals/10/ASPJ/journals/Volume-28_Issue-5/F-Davis.pdf

The Asian Pivot combined with the Rapid Raptor construct inspired more literature on leveraging FARP and dispersed operations to counter the Chinese threat in the A2/AD environment.[34] Maj Badowski and Maj Hutter wrote papers for the Air Command and Staff College analyzing the advantages/disadvantages of the Rapid Raptor concept and how best to conquer the logistical and command and control challenges of conducting dispersed operations at multiple locations simultaneously in the Western Pacific. Major Hutter promoted using sea-based platforms to alleviate strain on the mobility air force. Major Badowski encouraged using broad mission orders to overcome command and control challenges.[35]

So where is the Air Force going in 2018 and beyond? Maj Gen Brown and colleagues wrote a senior-level perspective piece for *ASPJ* describing multiple scenarios utilizing dispersed and untethered operations to solve tactical problems and address strategic threats. Vignettes include a coalition effort using austere COBs in Eastern Europe to fight the Russians and a Rapid Raptor concept to fight the Chinese. More importantly they suggest using untethered operations to solve the tyranny of distance problem in Africa. This is one of the first pieces in the last five years to apply USAF FARP operations beyond the A2/AD near peer threat environment.[36]

5. Current Literature

The A-10 community is investigating austere FARP operations across a broader spectrum, not just a tool to operate inside of the A2/AD environment. The A-10 differs from the F-22 and other fighter jets in the sense it is not hand cuffed to smooth concrete runways; it can operate off dirt, asphalt, rough concrete, highways, or other suitable surfaces. The A-10 community wants to be closer to the fight, conduct face-to-face mission

[34] "Asia Pivot" or "Pacific Pivot" refers to President Barak Obama shifting foreign policy focus to East Asia and away from Europe and Middle East. The Asian Pivot started circa 2011.

[35] Russel Badowski. Airpower Projection in the Anti-Access/Area Denial Environment: Dispersed Operations (Maxwell AFB: Air Command and Staff College, 2015); Ryan Hutter, *Cutting the Cord: Sustaining Untethered Air Superiority Operations in the Pacific* (Maxwell AFB, AL: Air Command and Staff College, 2016).

[36] Brown, Spacey, and Glover. "Unteathered Operations: Rapid Mobility and Forward Basing Are Keys to Airpower's Success in the A2/AD Environment," 24.

planning with the supported unit, rapidly reload to get back to the fight sooner, and fly in places not accessible or reachable by traditional means. There are a series of Air Force press releases about A-10s conducting austere training in Eastern Europe, the National Training Center at Ft Irwin, and dry lake beds in remote Nevada ranges.[37] Figure 2 shows an A-10 conducting austere operations in the Nellis Test and Training Range (NTTR). The gap in literature is not one of these reports or stories is published in a credible defense journal. It is merely a conglomeration of local base press news articles covering local unit training. There has been a significant amount of FARP and austere operations testing and training, but it has not been finalized, or officially released through DOD channels. That is one of the goals of this thesis is to acquire, consolidate, summarize, and analyze this unpublished bank of work to highlight the testing and exercise progress and potential.

Figure 2. An A-10 performs a dry lake bed landing near Las Vegas, NV[38]

[37] Ryan Brown, "A-10s make rare highway landing near Russian border," CNN, June 27, 2016, http://www.cnn.com/2016/06/23/politics/a10-warthog-highway-landing-russia-border-estonia/index.html; Mikaley Towle, "'Thunder' rolls at Fort Irwin." Nellis Air Force Base Public Affairs, July 23, 2015. http://www.nellis.af.mil/News/Features/Article/665451/thunder-rolls-at-fort-irwin/; Joshua Kleinholz, "Weapons School gets down and dirty in degraded conditions exercise" Nellis Air Force Base Public Affairs, May 5, 2017, https://www.nellis.af.mil/News/Article/1174392/weapons-school-gets-down-and-dirty-in-degraded-conditions-exercise/

[38] Source: https://www.nellis.af.mil/News/Photos/igphoto/2001742739/

II. LEVERAGING THE BENEFITS OF FARP

Why should a Combatant Commander take additional risk by forward deploying airplanes? Joint Publication 3–09.3 *Close Air Support* suggests placing CAS airplanes and pilots at FOBs or FOLs near the operational area improves flexibility, responsiveness, and effectiveness of the CAS team.[39] This chapter will discuss some of the major benefits of operating fixed wing aircraft from a FOL with a FARP available. The list of benefits is not all inclusive and not all benefits are realized on each mission or in every area of operations. FARP requirements and risks will be discussed in upcoming chapters.

A. INTEGRATED MISSION PLANNING WITH FORWARD DEPLOYED TROOPS.

Face-to-Face, integrated mission planning, briefing and rehearsal better prepares Close Air Support (CAS) aircrew to support Joint Terminal Attack Controllers (JTAC) with fires closely integrated with the maneuver unit according to the supported commander's requirements. Joint Publication 3–09.3 *Close Air Support* defines CAS as:

> Close air support (CAS) is air action by fixed-wing and rotary-wing aircraft against hostile targets that are in close proximity to friendly forces and requires detailed integration of each air mission with the fire and movement of those forces.[40]

JP 9–09.3 goes on to say:

> [T]he preferred use of a CAS asset is to have it preplanned and prebriefed. Rehearsals provide participants an opportunity to walk through the scheme of maneuver; gain familiarity with terrain, airspace restrictions, and procedures; and identify shortfalls.[41]

In order to leverage the benefits of integrated, face-to-face mission planning, the 66th Weapons Squadron began deploying A-10s to Bicycle Lake, starting in 2014, from

[39] Joint Chiefs of Staff, *Close Air Support*, JP 3–09.3 (Joint Chiefs of Staff, 2014), https://fas.org/irp/doddir/dod/jp3_09_3.pdf, I-8.

[40] Joint Chiefs of Staff, *Close Air Support*, xi.

[41] Joint Chiefs of Staff, *Close Air Support*, I-7.

Nellis AFB, NV in support of brigade-level offensive and defensive decisive action exercises at the National Training Center at Ft Irwin, CA as part of an A-10 Weapons Officer upgrade syllabus. During these events, four A-10s fly to Bicycle Lake, a dirt strip within the NTC training complex, one day prior to the planned exercise. After securing their airplanes on the dirt field, the A-10 pilots spend a few hours at the Brigade Main Command Post developing the next day's fire and maneuver plan and participating in Combined Arms Rehearsals (CARs).[42] Figures 3 and 4 show A-10s conducting operation from Bicycle Lake.

Figure 3. A-10 departs FOL location at Ft Irwin, CA.[43]

"Airmen assigned to the 22nd Special Tactics Squadron, Joint Base Lewis-McChord, WA, look on as an A-10 Thunderbolt II departs from the National Training Center at Fort Irwin, CA, July 16, 2015. An austere field landing allows for the A-10 pilots to push in, refuel, and provide support in a heavily-contested environment."

[42] Aaron Brady "66 WPS FAC(A) Sylabus Events" (presentation, 66 WPS, Nellis AFB, NV, June 14, 2017)

[43] Source: Image and associated caption: https://www.nellis.af.mil/News/Features/Article/665451/thunder-rolls-at-fort-irwin/

Figure 4. A-10 at Fort Irwin, CA[44]

The pilot of this A-10 slung a hammock between the weapons pylons of the A-10 for a place to spend the night between mission planning and taking off the next morning to support the exercise.

The next day, the A-10 pilots take off from Bicycle Lake to provide CAS and Forward Air Controller (Airborne) (FAC(A)) support of the brigade decisive action exercise. According to the 549th Combat Training Squadron Director of Operations, brigade commanders continue to give rave reviews for the performance of the forward deployed pilots. Four years of feedback show an increased success rate in main battle exercises with forward deployed aircrew compared to exercises where the pilots remain at Nellis AFB. Forward deployed pilots cited a higher level of situational awareness and ground units cited a higher confidence level in assigned CAS aircraft and aircrew as reasons for increased success.[45] According to Captain Gonsalves, one of the forward deployed pilots pictured in Figure 5:

[44] Source: 66 WPS Archives

[45] Jason Feuring, "Green Flag West After-Action Brief" (presentation, 66 WPS, Nellis AFB, NV June 1, 2016)

> I don't think there is a better medium of communication than meeting face-to-face and seeing the actual battlespace and area that they're operating in. It gives us a chance to visualize what their conditions are like, see what they're dealing with, and understand their limiting factors. This helps strengthen the relationship. When you're fighting a fight, relationships are what it's all about[46]

Figure 5. Pilots at the Brigade tactical operations center (TOC), Ft Irwin[47]

"U.S. Air Force Capt. Erik Gonsalves, 75th Fighter Squadron A-10 Thunderbolt II instructor pilot, meets with U.S. Army service members in support of Green Flag West 15–08.5 on the National Training Center range at Fort Irwin, Calif., July 16, 2015. This was the first time Air Force pilots met face-to-face with the U.S. Army troops on the ground to discuss tactics that were going to be employed during this Green Flag West exercise."

The current Air Force trend of operating from main MOBs does not allow for face-to-face mission planning for conventional CAS pilots and often leads to pilots with low situational awareness attempting to support a ground unit with a complicated scheme of maneuver. Under the standard Air Force 72-hour ATO construct, pilots rarely get an opportunity to brief face-to-face or even telephonically with the supported unit. Typically, the Ground Liaison Officer (GLO), an Army representative attached to the aviation unit, will contact the supported unit's JTAC or Fires Support Officer (FSO) the night prior to the mission while the pilots are asleep. After the pilots report to work, they receive a 15-minute brief from the GLO on their assigned mission of the day. Missions and supported

[46] Towle. 2015. "'Thunder' rolls at Fort Irwin."

[47] Source: Image and associated caption. https://www.nellis.af.mil/News/Features/Article/665451/thunder-rolls-at-fort-irwin/

units vary greatly day-to-day and offer a pilot little continuity with a particular region or unit.[48]

Other times, airplanes are put in XCAS (airborne alert CAS) orbits. In these operations, pilots are not assigned to a specific mission but are assigned to a specific place to hold to allow for a dynamic reroll if a unit requires CAS during mission execution. Pilots are rerolled to support units after ground units make an immediate request for CAS, typically as a result of Troops in Contact (TIC). Pilots are rerolled by the Air Support Operations Center (ASOC) often with little more information than a location, frequency, and call sign of the JTAC supporting the ground unit. After the pilot makes radio contact with the ground unit, he or she receives a situation update IAW JP 3–09.3.[49] Table 1, from JP 3-09.3 lists the elements of a situation update.

Table 1. Close air support situation update[50]

Situation Update Example 1		
Situation Update Line	**Close Air Support (CAS) Situation Update**	**Battlefield Handover (BHO)**
Threat	- General locations of surface-to-air threats not already covered. - Time of last observed surface-to-air fires may also be passed.	- General locations of surface-to-air threats not already covered. - Time of last observed surface to air fires may also be passed.
Targets	- General enemy disposition. - Avoid giving a list of grids. Specific targets and locations will be addressed in CAS briefs.	-General enemy disposition. Include ground combat element (GCE) targeting priorities. - Include target location grids, may require breaking up the transmission. - GCE attack guidance matrix and target priority list.
Friendly	- General friendly situation and scheme of maneuver. -Use geographic references, phase lines, checkpoints, etc. Technique is to use general terms: *"all friendlies are east of the 94 easting."* - Friendly grids should not be passed if it can be avoided. If necessary, use no more than 6 digits. - Should include all friendlies that may be a factor during time on station (TOS), not just joint terminal attack controller (JTAC). - Include all CAS assets, ordnance, and TOS remaining for BHO.	
Artillery	- Indirect fire assets that may be a factor during TOS, may include general direction of fire.	- Firing unit location, call sign, frequency, status.
Clearance Authority	- May be omitted if the speaker has control. - If there may be confusion due to multiple voices on tactical air direction, roles should be clarified: *"Savage 13 has control and is located in the COC, my JFO call sign E4B is located with Charlie company, and is up this net."* - Define who has which elements of brief, stack, mark, and control. - If not already prebriefed, a game plan for the approval of fires should be passed for BHO.	
Ordnance	Expected ordnance required to achieve ground commander's intent. Any restrictions to ordnance allowed such as no cluster bomb units, or low CD bombs only.	
Remarks and Restrictions	-Additional radio calls that will be included for the whole TOS. - JTAC capabilities (laser, infrared sparkle, video downlink, etc.) - Intent for aircraft (CAS, multisensory imagery reconnaissance, etc.) - Hazards (weather) or other remarks.	- Additional radio calls that will be included for the whole TOS. - Hazards (weather) or other remarks. - At the conclusion, a positive passing of the appropriate elements of brief, stack, mark, and control should occur.
Example Situation Updates:		
CAS: "Current surface-to-air threat is a SA-6 at KJ 123 456, just west of MSR Tampa; target is light armored company attempting to flank us to the north and two companies dug in three klicks to our west, break." *"Friendlies are two companies in the vicinity of OP 2, one on the high ground and the other in a blocking position to the east. I am with the company on the high ground. There is also a Recon team at the northwest tip of Black Mountain, arty is firecapped at Firebase SE, firing generally west, break."* *"Savage 13 has control. Plan on using your GP bombs to disrupt the light armor. Winds on the deck are 10-knots out of the west. Savage is laser and IR capable, advise when ready for game plan."*		

[48] Pat Parrish "*451 AEW Tactical Lessons Learned"* (presentation, 75 EFS, Bagram Air Base, Afghanistan, March 1, 2015)

[49] Parrish "*451 AEW Tactical Lessons Learned";* Note: CAS procedures and the command and control architecture are described in detail in JP 3–09.3 *Close Air Support.*

[50] Source: Joint Chiefs of Staff, *Close Air Support*, V-18.

While the situation update attempts to build a pilot's awareness and understanding of the ground situation, it is often insufficient compared to face-to-face mission planning with a supported unit. More often, situation updates passed over the radio, usually passed under duress, are abbreviated, rushed, and generic, offering a pilot little chance to build his situational awareness before CAS fires are required. Operating from a FOL allows face-to-face mission planning on a more regular basis giving pilots a higher level of situational awareness and ground units a higher level of confidence in their assigned CAS aircrew.

B. REDUCE DEMAND AND RISK TO TANKER FORCE

1. Demand

Currently the USAF has 457 tanker aircraft capable of refueling fixed wing USAF jets.[51] Tanker aircraft are in high demand stateside and overseas. In 2015, USAF tankers flew over 20,000 sorties and conducted 110,000 aerial refuelings delivering 1.1 billion pounds of fuel in support of OIR and OEF.[52] In a deployed environment, oftentimes, every gallon of tanker gas is spoken for. A single B-1 CAS mission flown to Afghanistan from Al Udeid airbase departs with 180,000 pounds of fuel and can require two tankers offloading in excess of 200,000 pounds of fuel to support one mission.[53] Any tanker fall-out can jeopardize the mission or drastically limit on-station time. Positioning aircraft at FOLs, utilizing fuel from cargo aircraft, fuel trucks, prepositioned fuel bladders, or fuel tanks can greatly reduce the strain and high demand for tankers.

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[51] Air Force Association, "2018 USAF Almanac" *Air Force Magazine* 100 no. 6 (June 2018) http://www.airforcemag.com/MagazineArchive/Magazine%20Documents/2018/June%202018/Air%20Force%20Magazine%202018%20USAF%20Almanac.pdf, 48. Note: 457 is the number of KC-135 and KC-10s in the USAF inventory as of 30 Sep 17. This number is higher than the amount of operational aircraft as many are assigned to training units. USAF fighter jets can only accept boom type refueling. Navy and Marine jets utilize drogue chute refueling.

[52] USAF Central Command Combined Air Operations Center, "CFACC 2012–2017 Airpower Statistics." June 30, 2017, http://www.afcent.af.mil/Portals/82/Documents/Airpower%20summary/Airpower%20Summary%20-%20June%202017.pdf?ver=2017-07-10-040401-420.

[53] Chris Travelstead, personal communication, October 1, 2018.

2. Risk

Future operating areas will likely pose a significant risk for the tanker force. Long-range radar surface-to-air systems and even short-range man-portable air defense system (MANPADS) pose a significant risk to tanker aircraft. USAF tanker aircraft, all of which were adapted from civilian airliner airframes, lack the maneuverability and defensive systems needed to operate within ranges of surface-to-air missile systems (SAMs). The only option is for tankers to orbit outside the ranges of these missiles called the missile engagement zone (MEZ). During the 2011 Libya air campaign, tankers occupied refueling tracks over the Mediterranean Sea, hundreds of miles from the operations area, to avoid Libya's antiquated air defense systems. Distant tanker orbits significantly reduced the on-station time of fighter and bomber aircraft.[54] Future air campaigns against peer or near-peer enemies will push tankers further and further from the operations area. Utilizing ground based refueling locations may be necessary to conduct refueling closer to the operational area.

C. FLEXIBLE DEPLOYMENT TIMELINES AND PERSISTENT CAS FAR FROM MOBS

Air campaigns often require a MOB or Naval Carrier Group close to the AOR to sustain air operations. Constructing or securing a MOB capable of supporting sustained fighter or bomber operations takes a significant amount of time, resources, and security. Utilizing a FOL concept can greatly decrease the deployment timeline and host base requirements. A FOL can also enable persistent FW operations in "tyranny of distance" scenarios.

1. Enabling Rapid Deployment Timelines: A-10s in Operation Anaconda

A-10s forward deployed from Al Jaber Kuwait to Jacobabad, Pakistan on one day's notice to support Operation Anaconda.[55] A-10s operated for ten days from Pakistan with a

[54] Matt Orlovsky," Flying in Operation Odyssey Dawn" (presentation, 66 WPS, Nellis AFB, NV, June 14, 2015)

[55] Wetzel, *A-10 Thunderbolt II Units of Operation Enduring Freedom 2002–07,* 10–32.

minimal footprint and host base support.[56] Jacobabad shortened the enroute commute to one hour per direction compared to five hours each way from Al Jaber. During Anaconda, the U.S. did not operate any MOBs or FOL inside Afghanistan capable of supporting FW aircraft. A-10s were not part of the original plan for Operation Anaconda, they were rapidly mobilized while supporting Operation Southern Watch after Americans started to take significant casualties during the mission and more CAS was requested.[57] The two pilots, Scott "Soup" Campbell and Eddie "K-9" Kostelnik, each received a distinguished flying cross for their efforts in supporting the complicated mission. They expertly provided lethal fires and crucial stack management, fires integration, and deconfliction as FAC(A)s. The two pilots were credited with killing over 200 enemy fighters on a single mission.[58]

Two weeks after Anaconda ended, A-10s were moved to Bagram Air Base, Afghanistan and operated off of Bagram's crumbling Soviet constructed runway. A-10s were also the first coalition aircraft to base inside Iraq in 2003. A-10s landed at Tulil, Iraq, April 4, 2003, 14 days after the start of combat operations.[59] In both of these examples, A-10s were able to project forward from MOBs with a minimal footprint to be closer to the fight and supported units. According to the Marine Corps Warfighting Publication (MCWP) 3–32-1 *Close Air Support* "to facilitate the integration necessary for effective CAS, aircraft are normally based as close as possible to supported units"[60] These moves enabled A-10s to provide crucial close air support early in each conflict before MOBs were established.

2. Africa and the "Tyranny of Distance"

The October 2017 attack on Army Special Forces troops in Niger, resulting in four American fatalities, highlighted that U.S. troops are being deployed to all corners of the

[56] Edward Kostelnik, personal communication, November 26, 2018.

[57] Wetzel, *A-10 Thunderbolt II Units of Operation Enduring Freedom 2002–07,* 10–32.

[58] Rebecca Grant "The Airpower of Anaconda." *Air Force Magazine*, September, 2002. http://www.airforcemag.com/MagazineArchive/Pages/2002/September%202002/0902anaconda.aspx

[59]Air Force Historical Support Division, "2003—Operation Iraqi Freedom." *USAF History*, June 13, 2013, https://www.afhistory.af.mil/FAQs/Fact-Sheets/Article/458942/operation-iraqi-freedom/.

[60] Department of the Navy. *Close Air Support*, MCWP 3–23.1 (Washington, DC: U.S. Marine Corps, 1998).

globe to combat terrorism. As efforts in Africa increase to dismantle terrorist groups like the Islamic State or Boko Haram, U.S. troops are extending further and further from available U.S. close air support and persistent intelligence, surveillance, and reconnaissance (ISR) support. In the Niger tragedy, at least 50 plus armed militants were able to assemble and stage a well-organized attack against U.S. and Nigerian forces.[61] In the end, four Americans and five Nigerians were killed.[62] U.S. Forces required emergency CAS and casualty evacuation support (CASEVAC) from French aircraft launched from Mali.[63] French fighter aircraft arrived two hours after the ambush commenced, provided a non-lethal show-of-force and departed.[64]

The continent of Africa, three times larger than the United States, poses a significant "tyranny of distance" problem for the U.S. military. The attack on the U.S. soldiers in Tongo Tongo, Niger was over 2350 nautical miles away from Camp Lemonnier, Djibouti. Camp Lemonnier is the only MOB with a permanent American presence on the African continent.[65] Other European bases such as Rota Naval Air Station, Spain or Sigonella Naval Air station are closer, but still over 1400NM away.

These vast distances are difficult to comprehend. Djibouti, 2350NM from Tongo Tongo, is the equivalent distance between Bangor, ME, and Los Angeles, CA. Rota Naval Air Station, Spain is the closest permanent U.S. facility capable of supporting fighter or bomber aircraft, yet it still is over 1400NM away. This distance is the roughly the equivalent distance between Chicago, IL, and Los Angeles, CA. Land-locked countries in sub-Saharan Africa are often inaccessible to amphibious based airplanes as well. Figure 6 shows the vast distances in Africa compared to the United States.

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[61] Eric Schmitt, "U.S. Soldiers Were Separated from Unit in Niger Ambush, Officials Say," *New York Times* October 26, 2017. https://www.nytimes.com/2017/10/26/world/africa/niger-soldiers-killed-ambush.html.

[62] Schmitt, "U.S. Soldiers Were Separated from Unit in Niger Ambush, Officials Say"

[63] Schmitt, "U.S. Soldiers Were Separated from Unit in Niger Ambush, Officials Say"

[64] Schmitt, "U.S. Soldiers Were Separated from Unit in Niger Ambush, Officials Say"

[65] John Vadiver, "Staging sites enable AFRICOM to reach hot spots 'within 4 hours' leader says." *Stars and Stripes,* May 8, 2015, https://www.stripes.com/news/africa/staging-sites-enable-africom-to-reach-hot-spots-within-4-hours-leader-says-1.345120.

Figure 6. Africa / United States comparison

To help visualize the vast distances forces must traverse in Africa, these two maps are set to equal scales. Side-by-side it is easier to compare the distances between Tongo Tongo Niger, Camp Lemonnier (2350NM) Rota NAS (1400NM) and Sigonella NAS (1400NM) with similar distances in the U.S. In the U.S., Bangor, ME to Los Angeles, CA (2300NM) and Chicago, IL to Los Angeles, CA (1400NM) represent similar distances.

Utilizing a "Lily-Pad" strategy to leverage existing cooperative security locations (CSL), Forward Operating Sites (FOS) and contingency locations on the African continent, A-10 and other fixed wing aircraft capable of austere operations can extend the reach of air assets.[66] This can help eliminate reliance on tanker support, enable persistence CAS operations, and limit excessively long combat sorties and pilot fatigue. According to AFRICOM there are 46 locations available contingency use on the African continent.[67] The specific locations and capabilities of these locations is beyond the classification of this paper.

[66] Cooperative Security Location (CSL) – "A facility located outside the United States and US territories with little or no permanent US presence, maintained with periodic Service, contractor, or host-nation support. Cooperative security locations provide contingency access, logistic support, and rotational use by operating forces and are a focal point for security cooperation activities." Source: JP 1-02

A warm base is a facility with a small permanent presence of U.S. support personnel and is capable of supporting operations with rotational units. It may contain prepositioned equipment or POL. Also known as a forward operating site (FOS)

A cold base is similar to warm base without a permanent presence of support personnel when the facility is not in use.

[67] David Vine, "The Lily-Pad Strategy: How the Pentagon is Quietly Transforming Its Overseas Base Empire," *Huffington Post*, December 6, 2017, https://www.huffingtonpost.com/david-vine/us-military-bases_b_1676006.html.

D. REDUCES RISK OR EFFECT OF MOB ATTACK.

Main operating bases provide a lucrative, high-payoff target for the enemy. Inflicting damage to a few aircraft or damaging a runway can significantly affect U.S. air operations. Whether it is a group of insiders wearing U.S. uniforms, a commercially purchased drone with a small chemical weapon attached to it, or high-tech surface-to-surface (S/S) missile, static MOBs are vulnerable to attack. Dispersing aircraft, basing in unpredictable locations, or quickly relocating after a base attack can reduce the likelihood and effects of an enemy attack on an airfield.

1. Effects of MOB Attack

On September 14, 2012, 15 Taliban insurgents dressed in U.S. uniforms launched an attack on Camp Bastion, a MOB in Helmand Province, destroying six Marine AV-8s and damaging two others. The attack destroyed or damaged 80% of fixed wing (FW) CAS airplanes at Camp Bastion and killed the VFA-211 commanding officer.[68] The successful attack temporarily eliminated U.S. Marine Corps' ability to provide close air support in the Helmand province.[69] Reports of the well-rehearsed attack, suggest the 15 Taliban attackers had ample time to prepare for the assault and attacking fixed wing aircraft was the main objective. The aircraft, located in close proximity to each other, on one ramp, at a single airfield provided an easy, high-payoff target for the attackers.

2. WPTO and Eastern Europe: Dispersing Assets to Decrease Targetable Signature

In the West Pacific Theater of Operations (WPTO), nearly every coalition base in Pacific Command (PACOM) is within range of Chinese S/S missiles.[70] Figure 7 illustrates Chinese S/S missile rages compared to U.S. bases in the region. A Center for Strategic and Budgetary Analysis (CSBA) report suggests active U.S. missile defenses at MOBs would

[68] John D. Gresham, "Attack on Camp Bastion: The Destruction of VMA-211," *Defense Media Network.* September 20, 2012, https://www.defensemedianetwork.com/stories/attack-on-camp-bastion-the-destruction-of-vma-211.

[69] Gresham, "Attack on Camp Bastion: The Destruction of VMA-211"

[70] Van Tol et al. *AirSea Battle: A Point-of-Departure Operational Concept*, 18.

become overwhelmed by Chinese attack leading to significant MOB damage or complete destruction.[71] The CSBA lists base diversification as a strategy to limit the ability and effectiveness of the Chinese to attack airplanes with S/S missiles.[72]

Figure 7. Chinese S/S missiles compared to U.S. bases in the region.[73]

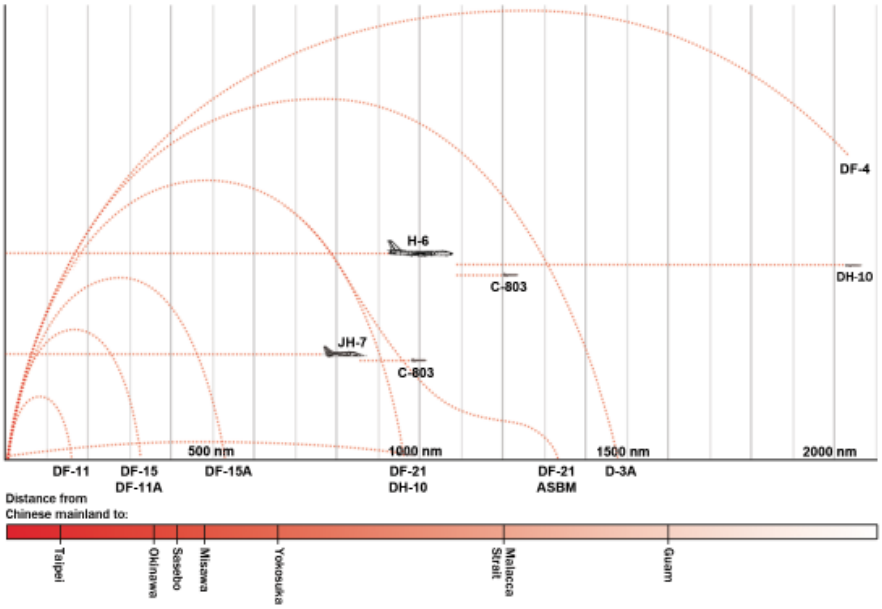


Image: CSBA

Lt Col Robert Davis, promoting F-22 FARP operations in the WPTO, cites 258 runways that potentially meet length and materiel requirements to support fighter operations in the 1st and 2nd island chains.[74] Figure 8 illustrates the 1st and 2nd island chains of the WTPO. The 258 potential airfields found by Lt Col Davis does not include potential highway surfaces. See Lt Col Benjamin Hatch's Air War College Paper for

[71] Van Tol et al. *AirSea Battle: A Point-of-Departure Operational Concept*, 36

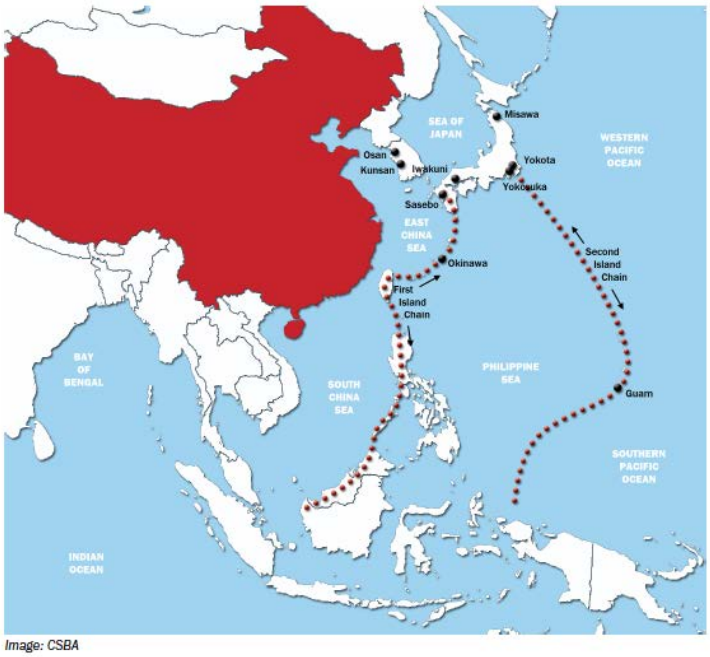
[72] Van Tol et al. *AirSea Battle: A Point-of-Departure Operational Concept*, 39

[73] Source: Van Tol et al. *AirSea Battle: A Point-of-Departure Operational Concept*, 18

[74] Davis, "Forward Arming and Refueling Points for Fighter Aircraft" 15

analysis on the potential use of roadways in the WPTO.[75] Dispersing aircraft to FOLs combined with efforts to limit an enemy's ability to collect real time Intelligence, Surveillance and Reconnaissance (ISR) can reduce the likelihood of a successful S/S missile attack.

Figure 8. WPTO first and second island chains[76]



Rapid Raptor looks to utilize distributed basing in the 1st and 2nd island chains to operate F-22s close to mainland China. Four F-22s, supported by a C-17 loaded with maintenance equipment, personnel, and weapons can fight two to three days away from a MOB.[77]

The CSBA report only focused on the WPTO. A similar, and potentially more difficult A2/AD environment exists in the Balkans. Russian S/S missiles S/A missiles located in Kaliningrad, Crimea, and Russia can target most bases on the European continent

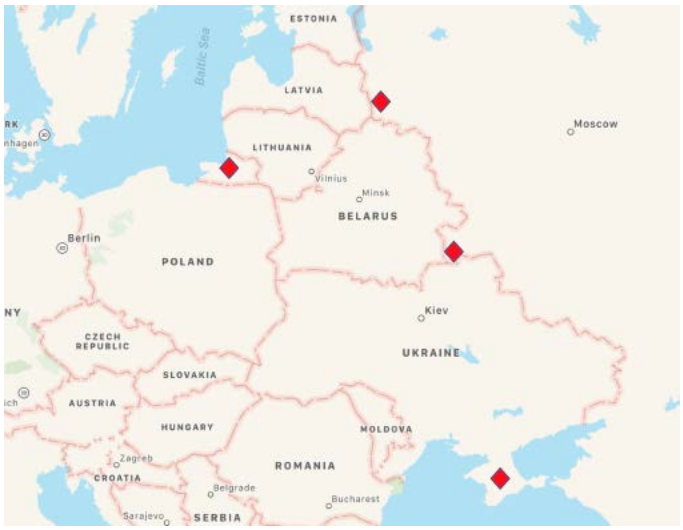
[75] Benjamin B. Hatch, *Optimizing Dispersed Air Operations: A Concept to use Highways as Improvised Airfields in a Contested Environment* (Maxwell AFB, AL: Air Command and Staff College, 2015).

[76] Source: Van Tol et al. AirSea Battle: A Point-of-Departure Operational Concept, 13

[77] Davis, "Forward Arming and Refueling Points for Fighter Aircraft"

and airplanes flying east of Berlin.[78] Figure 9 shows potential Russian S/S and S/A missile locations. Redundant, hardened, mobile, and layered air defense systems make them extremely difficult to target or neutralize with kinetic or nonkinetic weapons.

Figure 9. Potential locations of Russian S/S and S/A missiles



Red triangles represent potential Russian A/S and S/S missile sites. S/A missile systems in Kaliningrad can target large aircraft operating east of Berlin and target most aircraft operating in the Baltic States. The layered air defense system presents a significant threat to air operations.

During the Cold War, NATO countries planned to use an extensive network of contingency bases to employ airpower against the Soviets. Figure 10 shows an A-10 lading on a strip of autobahn in the 1980s. Any future conflict with Russia will likely require the same strategy to increase the survivability and decrease vulnerability of NATO airplanes from Russian attack. Sections of Autobahn, abandoned Cold War airstrips, and host-nation airfields in eastern Europe provide options for base diversification options in Europe. U.S. and NATO forces continue to exercise adaptive basing concepts to provide force projection in Eastern Europe. Figure 11 shows an A-10 conducting training from a highway strip in Estonia in 2017. In 2018, the USAF began funding DABS (deployable airbase system).

[78] S300V4 can target airplanes out to and unclassified range of 400km. Based on these unclassified ranges, aircraft could be targeted soon after passing east of berlin. Large airplanes with limited maneuverability such as tankers, AWACS, and JSTARs, are most susceptible to be targeted at maximum ranges

DABS, known as a "base in a box," contains all equipment required to set up a sustain airfield operations.[79] The rapidly deployable DABS will be staged at strategic places around the European continent and leverage the $4 billion plus in recent airfield and infrastructure upgrades as part of the European Deterrence Initiative.[80]

Figure 10. An A-10 executes an Autobahn landing in the early 1980s[81]

Sections of the German autobahn were specifically constructed to be used as emergency air strips. Cold War OPLANs called for utilizing these emergency strips to extend the range and of European based fighters, absorb the influx of CONUS based fighters, and disperse assets to reduce vulnerability to Soviet air attack.

[79] Valarie Insinna, "US Air Force tests 'base in a box' in Poland to prep for future wars." *Defense News*, August 26, 2018, https://www.defensenews.com/air/2018/08/27/us-air-force-tests-base-in-a-box-in-poland-to-prep-for-future-wars/.

[80] Defense News Video "What's the U.S. Air Force upgrading in Europe?" *Defense News* https://www.defensenews.com/air/2018/08/27/us-air-force-tests-base-in-a-box-in-poland-to-prep-for-future-wars/; Pat Towell and Aras D. Kazlauskas, *The European Deterrence Initiative: A Budgetary Overview*, CRS Report No. IF10946 (Washington, DC: Congressional Research Service, 2018), https://fas.org/sgp/crs/natsec/IF10946.pdf.

[81] Source : https://www.news.com.au/technology/innovation/motoring/the-highways-masquerading-as-secret-military-airfields/news-story/adccbeb1ed6ab0d4ce20ac92bce72d20

Figure 11. An A-10 takes off from a highway in Estonia in 2017[82]

NATO aircraft frequently practice operating from highways and abandoned runways in the Baltic States. Sophisticated Russian Surface-to-Air missile systems could preclude airborne refueling near the area of operations necessitating FARP operations to sustain air operations.

3. Korea: Maintaining Sortie Generation Rates if a MOB becomes Unusable

The U.S. Air Force maintains two MOBs on the Korean Peninsula, Osan AB near Seoul and Kunsan AB on the western coast.[83] These MOBs will likely be priority military targets for North Korea. Osan AB, in particular, presents a difficult force protection problem in the event of hostilities with North Korea. Osan is within range of Democratic People's Republic of Korea (DPRK) long range artillery and SCUD missile systems.[84] Urban surroundings around Osan Air Base offer potential attackers concealment close to the base. Local workers with access to the base present a credible insider threat.

[82] Source: https://www.businessinsider.com/air-force-a-10s-practice-takeoff-and-landings-on-a-highway-in-estonia-2017-8

[83] "PACAF Units," Pacific Air Forces, accessed October 15, 2018, www.pacaf.af.mil.

[84] Michael Mazarr et al., *The Korean Peninsula: Three Dangerous Scenarios* (Santa Monica, CA: RAND Corporation, 2018), https://www.rand.org/pubs/perspectives/PE262.html.

DPRK likely possesses mass amounts of chemical weapons (CW) to include blister and nerve agents.[85] Even small amounts of CW delivered on an airbase could severely limit sortie production rates even without causing casualties. The 51st Fighter Wing at Osan routinely conducts exercises under the threat of a chemical or biological attack conducing operations in Mission Oriented Protective Posture (MOPP) gear. Even with frequent rehearsals, conducting operations in restrictive MOPP gear is cumbersome and can severely limit sortie production rates, pilot capability, and sortie effectiveness.[86]

Maintaining the capability to quickly move air operations to alternate sites on the Korean peninsula can help mitigate the effects of a Chemical/Biological Weapon (CBW) attack on a MOB like Osan AB. Quickly relocating to an alternate site can reduce the likelihood of turning jets in full MOPP gear. Conducting full integrated combat turnarounds (ICTs) at an alternate site is a viable option to maintain sortie generation rates and reduce aircraft turn-around time.

E. FACILITATES RAPID WEAPONS RELOADING

1. OEF versus OIR

Sixteen years of "safe" air operations if Afghanistan have led the DOD to mostly forget valuable lessons on aircraft and weapons scarcity. At the height of the Afghanistan war in 2011, over 100,000 U.S. troops were deployed all throughout the country. A continuous rotation of two USAF fighter squadrons, one Marine squadron, multiple squadrons from NATO partners, a carrier air wing, bombers flying from the Persian Gulf, and a continuous presence of AFSOC AC-130s flooded skies of Afghanistan. For aircraft stationed in country (Kandahar, Bagram, or Camp Bastion) rarely did missions extend

[85] Nuclear Threat Initiative, *DPRK Chemical Weapons*, updated April 2018. https://www.nti.org/learn/countries/north-korea/chemical/.

[86] Eli Cullpepper "Fighting on the 'Pen'" (presentation, 66WPS, Nellis AFB, NV, December 15, 2016)

beyond 150 NM from home base. A constant presence of tanker aircraft, often within 50 NM of the area of operations, kept fighters airborne for the typical four to five-hour fighter aircraft combat mission. Low weapons employment rates meant a flight of aircraft rarely went "Winchester."[87] If weapons or fuel state became low, multiple flights of aircraft were available to relieve in place (RIP) if the ground situation required follow on CAS.[88]

The application of airpower in future conflicts will likely not resemble the limited employment rates accustom to Afghanistan. At the height of the air campaign against ISIS in Iraq and Syria, weapons employment rates vastly exceeded those in Afghanistan. In August 2017, coalition aircraft conducted nearly 1500 airstrikes dropping over 5000 weapons in Operation Inherent Resolve (OIR) in one month alone.[89] In comparison, the most kinetic months at the height of the OEF air campaign tallied less than 600 weapons dropped.[90] Figures 12 and 13 compare sortie numbers and quantity of weapons released between OEF and OIR. According to Air Force Central Command data, approximately 50% of CAS sorties supporting OIR released weapons in comparison to just 5–10% of OEF sorties.[91]

[87] Winchester is a brevity term meaning an aircraft is out of ordnance. Reference JP 1-02.

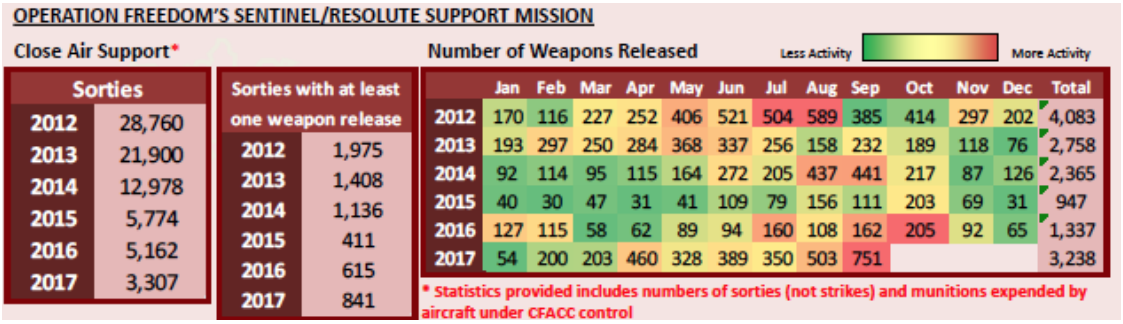
[88] Parrish,*"451 AEW Tactical Lessons Learned."*

[89] USAF Central Command Combined Air Operations Center, "CFACC 2012–2017 Airpower Statistics."

[90] Stephen Losey, "Afghanistan airstrikes hit highest point in years." *Air Force Times.* October 9, 2017. https://www.airforcetimes.com/news/your-air-force/2017/10/09/afghanistan-airstrikes-hit-highest-point-in-years/.

[91] USAF Central Command Combined Air Operations Center, "CFACC 2012–2017 Airpower Statistics."

Figure 12. Sorties/airstrikes supporting OEF[92]



OPERATION FREEDOM'S SENTINEL/RESOLUTE SUPPORT MISSION

Close Air Support*

Number of Weapons Released — Less Activity — More Activity

Sorties	
2012	28,760
2013	21,900
2014	12,978
2015	5,774
2016	5,162
2017	3,307

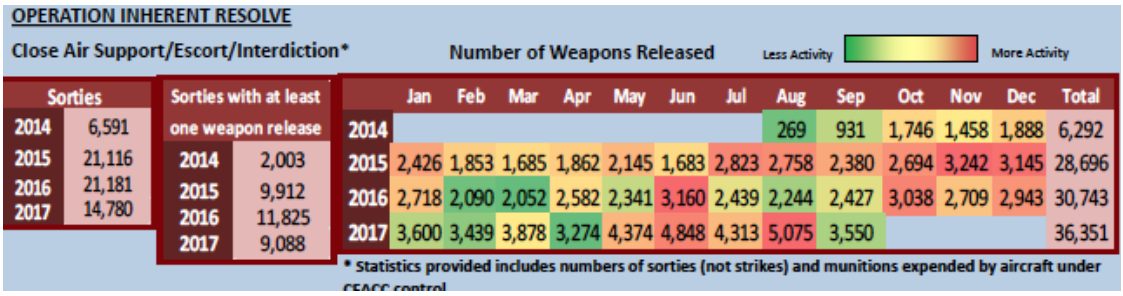
Sorties with at least one weapon release	
2012	1,975
2013	1,408
2014	1,136
2015	411
2016	615
2017	841

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	170	116	227	252	406	521	504	589	385	414	297	202	4,083
2013	193	297	250	284	368	337	256	158	232	189	118	76	2,758
2014	92	114	95	115	164	272	205	437	441	217	87	126	2,365
2015	40	30	47	31	41	109	79	156	111	203	69	31	947
2016	127	115	58	62	89	94	160	108	162	205	92	65	1,337
2017	54	200	203	460	328	389	350	503	751				3,238

* Statistics provided includes numbers of sorties (not strikes) and munitions expended by aircraft under CFACC control

AFCENT data showing number total number of CAS sorties, CAS sorties that released weapons, and number of weapons released 2012–2017 in support of OEF. Most years, less than 10% or CAS sorties released weapons. During the busiest year (2012) only 1,975 CAS sorties release weapons out of a staggering 28,760 CAS sorties flown.

Figure 13. CAS sorties/airstrikes supporting OIR[93]



OPERATION INHERENT RESOLVE

Close Air Support/Escort/Interdiction*

Number of Weapons Released — Less Activity — More Activity

Sorties	
2014	6,591
2015	21,116
2016	21,181
2017	14,780

Sorties with at least one weapon release	
2014	2,003
2015	9,912
2016	11,825
2017	9,088

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2014								269	931	1,746	1,458	1,888	6,292
2015	2,426	1,853	1,685	1,862	2,145	1,683	2,823	2,758	2,380	2,694	3,242	3,145	28,696
2016	2,718	2,090	2,052	2,582	2,341	3,160	2,439	2,244	2,427	3,038	2,709	2,943	30,743
2017	3,600	3,439	3,878	3,274	4,374	4,848	4,313	5,075	3,550				36,351

* Statistics provided includes numbers of sorties (not strikes) and munitions expended by aircraft under CFACC control

AFCENT data showing number total number of CAS sorties, CAS sorties that released weapons, and number of weapons released 2012–2017 in support of OIR. In 2016, 54% of CAS sorties employed weapons totaling over 30,000 weapons.

Stationed out of Incirlik Air Base in Turkey supporting OIR, A-10s, carrying two times the payload of A-10s operating in Afghanistan, occasionally dropped all of their munitions. More frequently A-10s, would run out of a specific weapon needed to meet ground commander's intent.[94] Figure 14 shows a typical A-10 weapons loadout for OIR. Like Afghanistan, if an OIR CAS mission ran low on weapons or lacked a specific weapon

[92] Source: USAF Central Command Combined Air Operations Center, "CFACC 2012–2017 Airpower Statistics."

[93] Source: USAF Central Command Combined Air Operations Center, "CFACC 2012–2017 Airpower Statistics."

[94] Christopher Pezzini, *"74 EFS Operations in Syria"* (presentation, 66 WPS, Nellis AFB, NV, June 14, 2018).

to meet ground commander's intent, another flight could be diverted to support. The high sortie numbers supporting OIR combined with a limited ground campaign meant multiple flights were typically available to fill an air request or RIP a flight low on weapons or fuel. The 74 FS weapons officer stated that during a six-month deployment a flight of A-10s never had to return to base (RTB) to retrieve a new airplane due to a low weapons state. If a flight did have to depart from Raqqah to Incirlik it would have taken approximately three hours to return with new airplane.[95] Theoretically, this could have been cut down to one to one-and-a-half hours if a FARP was established at a potential FARP location in Turkey, 75 NM from Raqqah.[96]

Figure 14. A-10 over Syria with nearly full complement of weapons[97]

This picture shows the SCL of an A-10 supporting OIR in 2016. It is missing two 500lb bombs. Despite being loaded with six bombs, one A/G missile, seven rockets, and 1150 30mm rounds, flights of A-10s frequently returned to base nearly out of weapons during the heavy air campaign periods of OIR.

[95] Time calculated based on 250 NM flight path each way and 50 min on ground to swap airplanes.

[96] Potential FARP location is Sanliurfa Airport Turkey ICAO: LTCH. (7100' RWY) 75NM from Raqqah. Includes 30 min ground time for FARP

[97] Source: www.af.mil. Note: Picture taken from Tanker after refueling the A-10. The A-10 had already expended 1xGPS guided munition.

2. Desert Storm FOLs

During Desert Storm in 1991, A-10s utilized Al-Jouf and King Khalid Military City FOLs to increase station time and decrease off-station time when more weapons were required. Figure 15 shows the location of FOLs utilized by A-10s during the Gulf War. Pilots often returned to a FOL and FARPed two to three times per day while battling Iraqi forces or executing SCUD hunting missions in western Iraq.[98] A 2-ship of A-10s piloted by Capt. Eric Salomonson and Lt. John Marks, reloaded weapons at KKMC two times on their infamous sortie that destroyed 23 Iraqi tanks and damaged up to 10 more tanks on a single mission.[99] The key to their success was reloading AGM-65 missiles, which have one of the highest probability of kills (Pk) against armor of any aircraft munition in the DOD inventory.[100] Figure 1 shows Lt Marks standing next to an A-10 loaded with two AGM-65 Ds. Without the ability to FARP at a FOL, the flight would have been Winchester after destroying only eight tanks. Returning to the MOB for a new jet would have taken several hours. Weather and other operational requirements negated the availability of replacement fighters during Capt. Salomonson and Lt. Marks' sortie.[101]

Marks also described how FARPing during a mission offered tremendous flexibility to tailor an aircraft loadout to an evolving mission, environmental conditions, or anticipated target set. He described a FARP as a "Burger King drive-thru" of weapons; a pilot could pull into the FARP, request a specific assortment of weapons, and 20 minutes later his jet would be loaded and ready with his requested weapons.[102] As an example, a pilot could elect to reload a jet with all infrared (IR) maverick variants instead of electro-optical (EO) variants if they provided better target contrast on that specific day. Typically, jets were loaded with a mix of both. Or pilots could elect to not load free fall munitions to reduce weight and increase performance if the target set did not require bombs.[103]

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[98] Smallwood, *Warthog: Flying the A-10 in the Gulf War*, 195–197.

[99] Smallwood, *Warthog: Flying the A-10 in the Gulf War*, 195–197.

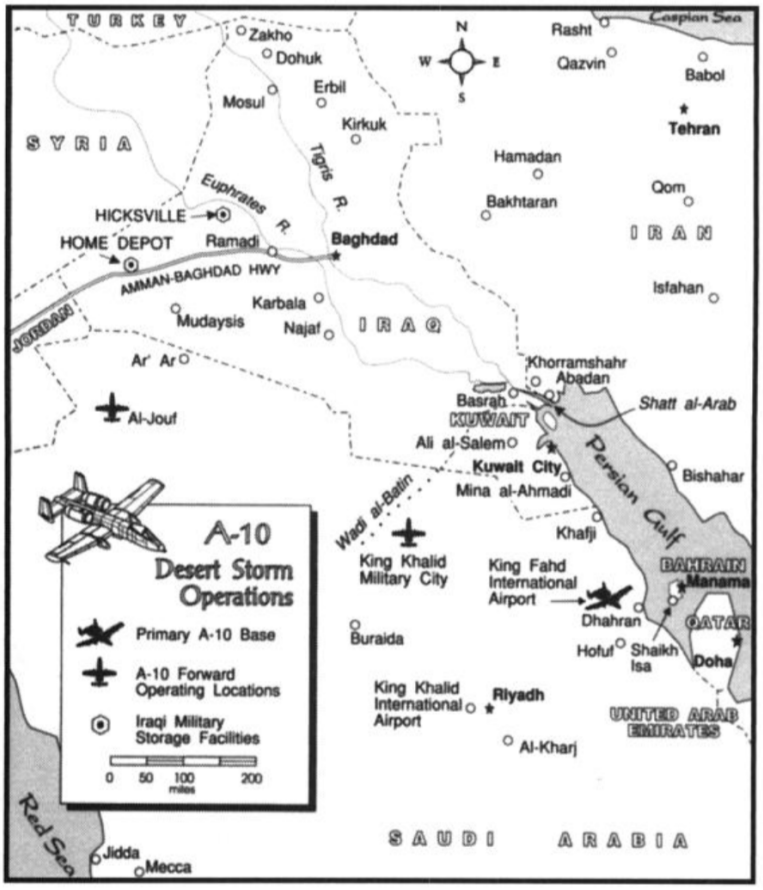
[100] Actual Pk data classified

[101] Smallwood, *Warthog: Flying the A-10 in the Gulf War*, 195–197.

[102] John Marks, personal communication, November 25, 2018.

[103] John Marks, personal communication, November 25, 2018.

Figure 15. A-10 FOLs used in Gulf War.[104]



A-10's utilized Al-Jouf and KKMC FOLs to service targets in central and western Iraq. Returning to KFIA was often too far, too time consuming, and required support from scarce tankers.

F. INCREASES ON-STATION TIME

In the absence of tanker support, basing closer the area of operations means a longer on-station time before an aircraft has to depart due to a low fuel state. Reference Figure 16 for an example of available A-10 on-station time compared to distance from target. In the campaign to expel ISIS from Raqqah, A-10s would have around 0+30 hours of playtime if flying from Incirlik without tanker support compared to 1+20 hours if moved to a FOL near Sanliurfa, Turkey, 75NMs north of Raqqah.

[104] Source: Smallwood, *Warthog: Flying the A-10 in the Gulf War*, 2.

Figure 16. A-10 time on target available.[105]

CLOSE AIR SUPPORT EFFICIENCY IN THE TARGET AREA				
DISTANCE (nm) TO TARGET	TOTAL SORTIE TIME (HR+MIN)	ENROUTE / ADMIN TIME	TIME ON TARGET (HR+MIN)	% OF TIME ON TARGET
350 (W/TANKER)	3+50	2+50	0+38	16%
250 (W/TANKER)	3+25	2+10	0+53	25%
250 (NO TANKER)	2+32	1+40	0+30	19%
150 (NO TANKER)	2+23	1+00	1+01	42%
100 (NO TANKER)	2+18	0+40	1+16	55%
50 (NO TANKER)	2+14	0+20	1+32	68%

G. PREPOSITION ASSETS CLOSE TO EXPECTED FIGHT

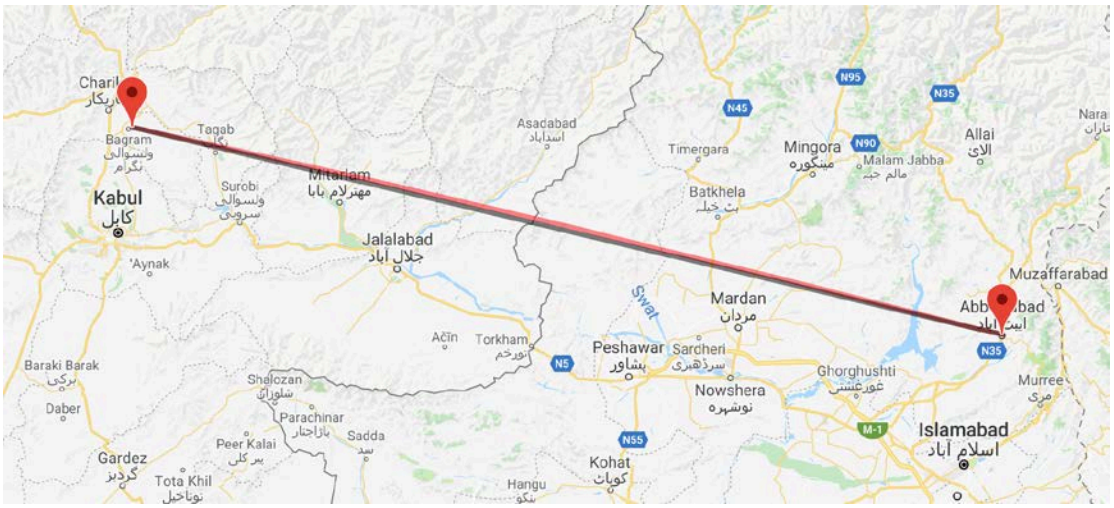
1. Forward Basing for a Quick Reaction Force

What if the Osama Bin Laden raid on his Abbottabad compound happened in December 2001 instead of May 2011? How could the U.S. provide a quick reaction force to the Navy SEALs, if the assault force experienced a significant firefight? In December 2001, around the timeframe of the battle of Tora Bora, the U.S. did not have any permanent MOBs established in Afghanistan, it relied heavily on long range bombers flown from outside the country. If the U.S. stacked up aircraft along the Afghanistan/Pakistan border, it could have likely tipped-off the Pakistanis that a U.S. led operation was going on inside their borders. However, if the U.S. had forward deployed A-10s to Bagram AB, kept them on 5-minute ground alert, it could have provided a flexible, timely QRF without telegraphing U.S. intentions.[106] Figure 17 shows the relative position of Bagram AB compared to Abbottabad.

[105] Source: Ryan E. Haden, *A-10 FARP OPERATIONS Forward Arming and Refueling Point.* (student paper, USAF Weapons School, 2004), 2.

[106] There are different levels of alert readiness. See Table 3. five-minute alert means aircraft are waiting at the end of the runway ready for takeoff. As mentioned earlier, A-10s were not based at Bagram until Apr 2002 following Operation Anaconda.

Figure 17. Bagram to Abbottabad map



The distance from Bagram to Abbottabad is 200 NM. If on five-minute ground alert, A-10s could be overhead Abbottabad in 40 minutes with 40–60 minutes of on station time without tanker support. Reaction times from aircraft based outside of Afghanistan would be several hours.

2. Forward basing for combat search and rescue

The A-10 FOL concept can also be used to provide Combat Search and Rescue (CSAR) coverage for long range strike missions. Taking Operation El Dorado Canyon for example, the U.S. could have deployed A-10s to a FOL in Sicily, Crete, or even the Tunisia to provide CSAR coverage for the long-range mission launched from U.S. bases in England against targets in Libya. One F-111 was shot down during the 1986 bombing raid, and the crew was lost. The Navy 6th Fleet was charged with providing SAR coverage for the mission. The Navy dedicated SAR helicopters to the mission but lacked FW pilots qualified as Sandy 1.[107] Forward deploying AF CSAR assets will become more crucial if long range strike missions are conducted in land-locked areas of the world.

[107] Note: Sandy 1 is the callsign of a specifically trained Rescue Mission Commander (RMC). RMCs are designated to control recovery efforts in the objective area and coordinate all recovery mission requirements. For more info on RMC responsibilities reference JP 3–50 *Personnel Recovery*.

Figure 18. Operation El Dorado Canyon flight path[108]

Due to country overflight restrictions, F-111 aircraft were forced to fly around the western flank of Europe to conduct and air raid in Libya. One F-111 was lost due to enemy fire and the crew perished. Forward staging dedicated AF CSAR assets to Sicily or Tunisia could have increased the probability of a successful rescue. Forward staging CSAR assets for future strike missions in land-locked countries could be even more critical.

H. ALLOWS FOR A FLEXIBLE MISSION TIMELINE WHILE MAINTAINING POTENTIAL ON-STATION TIME.

The dynamic nature and fluid timeline of special operations missions makes it difficult to match aircraft on-station time and available coverage when air missions are launched from hundreds of miles away. Trigger-based or event-based SOF missions are particularly difficult to cover. Due to long transit time, often airplanes need to launch before a mission is a go or a trigger is met. If an aircraft cannot maintain coverage for the entire mission, typically coverage is prioritized for the most dangerous portions of the

[108] Source: Screen shot taken from video: "Operation El Dorado Canyon 1986 Libya" 7:45, posted by jaglavaksoldier, September 6, 2008, https://www.youtube.com/watch?v=pgqDT2mlENo.

mission (e.g. infil, actions on, exfil). Any slip in a planned timeline, once an aircraft is airborne, may limit or eliminate an aircraft's ability to cover key mission events.

Keeping assets on various levels of ground alert before or during the mission allows for timeline flexibility without significantly sacrificing on station time. It is common for Army rotary wing assets to maintain a ground alert posture (Level 1, 2, 3.) during SOF missions. Most commonly, the conventional Air Force exercises ground alert status for standby CSAR operations. The key to ground alert operations is the launch and transit time must be fast enough to meet mission requirements. Maintaining ground alert from a distant MOB will typically not meet SOF mission requirements. Keeping FW assets on ground alert at a FOL can increase mission flexibility required by SOF missions. See Table 2 for examples of mission timeline slips on aircraft on-station time.

Table 2. Mission slip effects to on- station time.

Available On-Station Time	
No Slip	1+30
1-hour slip airborne	0+40
1-hour slip engines running on ground	1+10 (1+30 if hot gas available)
1-hour slip APU alert on ground	1+25

This data shows aircraft can maintain potential on station times if kept on ground alert. Once an aircraft is airborne, reductions in engine power while loitering only provides a limited slip capability without air refueling or significantly impacting on station time.

The AF does not use the same terminology to describe levels of ground alert as Army rotary wing. Table 3 is a list of alert levels typically used by A-10 squadrons.

Table 3. Typical A-10 alert status terminology and fuel burn.

Alert Status		
	Aircraft Status	Fuel Burn
Airborne	Aircraft maintaining gas saving orbit	2400 lbs / hr
5-minute	Aircraft fully ready, waiting at end of runway	800 lb/hr
15-minute	Aircraft engines running, in chalks.	800 lb/hr (refueling possible)
30-minute	Aircraft APU running.	100 lb/hr
1-hour	Pilots waiting in squadron operations	N/A

The following fictional scenario was published in the *Air and Space Power Journal* June 2015. It is a good example how U.S. and NATO forces can utilize FARP to remain unpredictable, lethal, and survivable against a near peer threat in future conflicts.

> A lone C-17 landed smoothly in the predawn hours at Amari Air Base, Estonia. The C-17 was from the Heavy Airlift Wing in Papa, Hungary. Amari had yet to experience the devastation of a Russian air attack. The sheer number of NATO basing options made targeting all of them impossible and had so far kept Amari safe. The cargo ramp was already lowering as the C-17 taxied to a stop and USAF Airmen piled out. The seemingly deserted base came alive as Airmen began organizing the ramp. There were aircraft maintainers, operations and intelligence personnel, and a squad of security forces. They went to work immediately, unlocking and organizing munitions, connecting fuel lines to hydrants, and setting up expeditionary defensive fighting positions. The operations and intelligence personnel set up a deployed ops center. In less than an hour, four Dutch F-16s entered the traffic pattern and landed quickly. Like the C-17, the fighters had barely come to a stop before Airmen clambered over them, helping the pilots unstrap and egress. The aircrews were hustled to the waiting intelligence officers while the aircraft were reloaded with bombs and fuel. The operations update and intel briefings would last just as long as it took the Airmen to rearm and refuel the jets. They would then depart on their next combat mission—their third of the night. In less than two hours, the F-16s were gone, and the C-17 was taxiing for takeoff. The next base was Łask in Poland where a flight of U.S. F-16s was scheduled to join them. The C-17 could do this three more times before it had to return to Ramstein and refit. NATO forces were repeating this scene all over Eastern Europe. The war is going well; Russia simply doesn't have the capacity to fight across such a broad front.[109]

[109] Entire scenario taken from Brown, Spacey, and Glover. "Unteathered Operations: Rapid Mobility and Forward Basing Are Keys to Airpower's Success in the A2/AD Environment,"18.

The previous scenario, combined with statements in the most recent Quadrennial Review and National Defense Strategy indicate defense senior leaders understand the benefits and risks of dispersed, adaptive, agile, austere, and untethered operations. Future operational areas and threat environments will not resemble the Iraq and Afghanistan fights of the past decade. As stated in the 2018 National Defense Strategy, to be successful in future conflicts the United States must remain "strategically predictable, but operationally unpredictable"[110] The benefits of adaptive basing provide some of the operational unpredictability required to be successful in future conflicts.

[110] Mattis, *National Defense Strategy: Unclassified Summary*, 5,

III. REQUIREMENTS AND CONSIDERATIONS FOR A-10 FARP

The following chapter highlights some of the requirements and considerations for A-10 operations at austere locations. This list is not all encompassing, but offers some considerations for mission planners and helps set realistic expectations for capabilities and LIMFACs.

A. RUNWAY LENGTH

The A-10 cannot operate from the same short assault strips utilized by conventional an unconventional cargo aircraft. Table 4 shows minimum runway lengths for cargo aircraft that will typically accompany A-10s at austere locations. A-10s demonstrated the capability to operate off of runways as short as 3000 ft in European exercises in the 1980s.[111] A-10 operating instructions state the minimum runway dimensions for A-10 operations is 5000 ft in length by 75 ft wide. However, operating an A-10 from a 5000 ft runway is impractical or impossible for most environments and most weapons and fuel loads required for combat.

[111] Haden, *A-10 FARP OPERATIONS Forward Arming and Refueling Point*, 3.

Table 4. Minimum runway lengths for cargo aircraft.[112]

Type AC	Length (Ft) (NOTE 1)	Width (Ft) (NOTE 1)		
		No Turn Required	180 Degree Turn (Normal)	180 Degree Turn (3 Point)
U-28A	2,000	30	30	30
C-130	3,000	60	60	50 (**NOTE 2**)
MC-130	3,000	60	60	50
HC-130	3,000 (NOTE 4)	60	60	50
C-130J-30	3,000	60	85	75 (NOTE 2)
C-17	3,500 (**NOTE 4**)	90	143	80 (**NOTE 2**)
C-5	6,000 (**NOTE 3**)	150	150	

NOTES:

1. Minimum operational criteria without a waiver during peacetime operations

2. Does not include any safety margin. Increase by 10 feet for routine operations

3. Waiverable to 5,000 feet by MAJCOM/A3 or DIRMOBFOR

4. Waiverable to computed ground roll plus (+) 500 ft by the MAJCOM/A3 or DIRMOBFOR

C-130s and C-17s can operate from fields as short as 3000 feet. While longer runways may be required for heavy cargo loads or runway environments, the required runway for these cargo aircraft is significantly shorter than A-10 runway requirements.

A-10 takeoff distance is the key factor in determining the required runway length. There are six key factors that affect take off distance (Runway Elevation, Temperature, Aircraft Weight, Runway Surface, Runway Slope, Surface Wind). Required runway length will be drastically different while conducting summer operations in Afghanistan compared to winter operations in South Korea. Table 5 shows approximate elevations and temperature ranges for potential future operating areas.

[112] Source: Department of the Air Force, *Drop Zone and Landing Zone Operations*, 46.

Table 5. Elevation and temperature rages of potential operating areas.

Country Data			
Location	Typical Runway Elevations in Country	Average July Temps (H/L)	Average January Temps (H/L)
Niger	1500’	41°C/26°C	28°C/11°C
Central Syria	1000’-3000’	36°C/20°C	11°C/1°C
South Korea	<1000’	28°C/22°C	0°C/-6°C
Balkans	1000’	20°C/13°C	0°C/-6°C
Yemen	1000’-3000’	30°C/16°C	25°C/4°C
C Iran	1000’-6000’	37°C/16°C	10°C/-3°C
S Afghanistan	3000’-6000’	41°C/28°C	13°C/3°C
Libya	1000’	33°C/21°C	16°C/9°C
South China Sea	0’	33°C/23°C	19°C/13°C
Notes: Temperature data pulled form Accuweather.com.			

Air Force regulations state takeoff distance should not exceed 80% of available runway length in training.[113] While 80% is a training restriction, it does help add a margin of safety to account for fluctuations in engine performance, environmental conditions, and pilot proficiency in an operational environment. For the following tables, the 80% rule will be used to calculate minimum runway requirements.

1. Elevation

The elevation of the take-off field can significantly impact take off distances. Jet engines lose thrust as runway elevation increases.[114] Lower thrust equates to longer take off distances. Table 6 and Table 7 show the effect of elevation on A-10 takeoff distance for a 43,000 lb and 40,000 lb aircraft.

[113] AFI 11–2A-10C vol 3, *A-10C—Operations Procedures* states “On training missions, do not takeoff if the computed takeoff roll exceeds 80 percent of the available runway.” Per 11–2A-10C operational missions can break the 80% criteria, however even for combat mission it is a good planning criteria to add a small margin of safety.

[114] An increase in runway elevation or increase in temperature leads to an increase in pressure altitude. Pressure altitude, for lack of a better term, describes the “thickness of the air.” Thinner air equals less thrust.

Table 6. Elevation effects on takeoff distance for a 43,000 lb A-10[115]

	Effects of Field Elevation on A-10 Take Off Distance			
	43k @ 20C			
Field Elevation	T/O Distance Concrete	T/O Distance Dirt	Minimum Runway Length Concrete	Minimum Length Runway Dirt
0’ MSL	5479	6027	6849	7534
2000’ MSL	6855	7541	8569	9426
4000’ MSL	8119	8931	10149	11164
6000’ MSL	9586	10545	11983	13181

Notes:
All Distances in Feet with a 43,000 lb aircraft at 20 degrees Celsius
Assumed CBR of dirt is 16 (10% increase in T/O Distance)
Minimum Runway Length is calculated so T/O distance does not exceed 80% of available runway.

Table 7. Elevation effects on takeoff distance for a 40,000 lb A-10[116]

	Effects of Field Elevation on A-10 Take Off Distance			
	40k @ 20C			
Field Elevation	T/O Distance Concrete	T/O Distance Dirt	Minimum Runway Length Concrete	Minimum Runway Length Dirt
0’ MSL	4498	4948	5623	6185
2000’ MSL	5594	6153	6993	7692
4000’ MSL	6710	7381	8388	9226
6000’ MSL	7923	8715	9904	10894

Notes:
All Distances in Feet with a 40,000 lb aircraft at 20 degrees Celsius
Assumed CBR of dirt is 16 (10% increase in T/O Distance)
Minimum Runway Length is calculated so T/O distance does not exceed 80% of available runway.

2. Temperature

Jet engines lose thrust as temperature increases leading to longer take off distances at higher temperatures. Planning around average high temperatures is a good starting point, but mission planners must also consider an appropriate margin of error, and consider

[115] Calculated with A-10 mission planning software JMPS UPC Suite 8 SR1.

[116] Calculated with A-10 mission planning software JMPS UPC Suite 8 SR1.

weapons of fuel adjustments in case temperatures are unseasonably warm. Tables 7 and 8 show the effects of temperature on T/O distances.

Table 8. Temperature effects on takeoff distance for a 43,000 lb A-10[117]

	Effects of Temperature on A-10 Take Off Distance			
	43k @ Sea Level			
Field Temperature	T/O Distance Concrete	T/O Distance Dirt	Minimum Runway Length Concrete	Minimum Runway Length Dirt
0 C	4138	4552	5173	5690
10 C	4775	5253	5969	6566
20 C	5479	6027	6849	7534
30 C	6312	6943	7890	8679
40 C	7492	8241	9365	10302

Notes:
All Distances in Feet with a 43,000 lb aircraft at Sea Level
Assumed CBR of dirt is 16 (10% increase in T/O Distance)
Minimum Runway Length is calculated so T/O distance does not exceed 80% of available runway.

Table 9. Temperature effects on takeoff distance for a 43,000lb A-10[118]

	Effects of Temperature on A-10 Take Off Distance			
	40k @ Sea Level			
Field Temperature	T/O Distance Concrete	T/O Distance Dirt	Minimum Runway Length Concrete	Minimum Runway Length Dirt
0 C	3413	3754	4266(5000)	4693(5000)
10 C	3910	4301	4888(5000)	5376
20 C	4498	4948	5623	6185
30 C	5217	5739	6521	7173
40 C	6192	6811	7740	8514

Notes:
All Distances in Feet with a 40,000 pound aircraft at Sea Level
Assumed CBR of dirt is 16 (10% increase in T/O Distance)
Minimum Runway Length is calculated so T/O distance does not exceed 80% of available runway.
Minimum A-10 runway length is 5000 ft per A-10 operating instructions

[117] Calculated with A-10 mission planning software JMPS UPC Suite 8 SR1.

[118] Calculated with A-10 mission planning software JMPS UPC Suite 8 SR1.

3. Aircraft Weight

Takeoff distances increase as aircraft weight increases. As aircraft take on more fuel and weapons, weight increases. To reduce weight, fuel quantities can be reduced. An A-10 with a full fuel load under normal operating conditions, utilizing standard fuel reserves, can stay airborne for two to two and a half hours depending on throttle positions required during flight. A full fuel load is around 11,000 pounds. Reducing the fuel load by 1000 pounds reduces flight time by approximately 20 minutes or .3 hours.[119]

An aircraft can also reduce weapons load to shorten takeoff distances. The tactical situation will determine if reducing weapons or fuel is appropriate for the mission. Table 11 shows estimated A-10 weights for basic weapons and fuel loads. Ground commanders should communicate weapons capability and on station time requirements to mission planners to ensure the proper weapons loadout and fuel quantity is identified. Table 10 shows how A-10 takeoff distance is affected by aircraft weight.

Table 10. Aircraft weight effects on A-10 takeoff distance[120]

	Effects of Weight on A-10 Take Off Distance			
	Sea Level @ 20 Degrees C			
Aircraft Weight	T/O Distance Concrete	T/O Distance Dirt	Minimum Runway Length Concrete	Minimum Length Runway Dirt
38k	4001	4401	5001	5501
40k	4584	5042	5730	6303
42k	5191	5710	6489	7138
44k	5769	6346	7211	7932
46k	6457	7103	8071	8878

Notes:
All Distances in Feet with a field at Sea Level 20C
Assumed CBR of dirt is 16 (10% increase in T/O Distance)
Minimum Runway Length is calculated so T/O distance does not exceed 80% of available runway.

[119] Based on an A-10 burning 3000 lbs of fuel an hour. Fuel burn can increase 6000lb/hr if operating at low altitudes with high power settings.

[120] Calculated with A-10 mission planning software JMPS UPC Suite 8 SR1.

Table 11. Basic aircraft weights for example weapons and fuel load outs

	Aircraft Weight vs Example Load Out	
A/C Weight	Loadout	Typical Flight Time
34k	1/2 Gun, 40% Fuel	45 min
36k	1/2 Gun 60% Fuel	1 hr 20 min
38k	RKTs, 85% Fuel	2 hr
39k	2x RKT Pods, AGM65, 85% Fuel	2 hr
40k	Full Gun, Full Fuel	2.5 hr
41k	RKTs, AGM65	2.5 hr
42k	RKTs, AGM65, 2x SM Bombs	2.5 hr
43k	RKTs, AGM65, 4x SM Bombs	2.5 hr
44k	RKTs, AGM65, 1x LG Bomb, 2x SM Bombs	2.5 hr
46k	Rkt, AGM65, 2xBomb, Ext Fuel Tank	3.75 hr
	Notes: All load outs include a TGP and full fuel, full gun, unless otherwise noted. LG Bomb equals a 2000-pound bomb (GBU-31). SM bomb equals a 500-pound bomb (GBU-38, GBU-12, MK-83. AGM65 assumes a Laser variant with a 300lb warhead. Full fuel is 11000 pounds. External fuel tank holds an additional 4000 pounds of fuel and must be a Sgt Fletcher type. Typical flight time is time from takeoff to landing with required fuel reserves, burning 3200 lbs/hr. Fight time can fluctuate based on increased fuel reserve requirements and power settings required during flight.	

4. Runway CBR rating.

Airfield surveyors use California Bearing Rating (CBR) to measure the hardness, strength, and durability of semi-prepared surfaces IAW Engineering Technical Letter (ETL) 02–19: *Airfield Pavement Evaluation Standards and Procedures.* For A-10 aircraft, the runway CBR value determines the maximum take-off weight, maximum landing weight, and percentage of takeoff distance increase compared to a concrete runway. A-10 takeoff distance increases as a percentage of the concrete takeoff distance per Table 12.

Table 12. Percent increase in T/O distance versus CBR rating[121]

CBR	Increase
<14	20%
14–16	10%
>=17	5%

CBR can also determines maximum takeoff and landing weight. The takeaway from the two tables below is that operating on dirt runways with less than a CBR of 16 could significantly impact operations. The absolute minimum is 10 with a recommended minimum CBR of 14 for training.[122] Table 13 shows the maximum A-10 takeoff weight as a function of CBR while Table 14 illustrates the maximum landing weight. In addition to length and CBR rating, the runway should be free of debris chunks greater than 1.5 inches diameter, unavoidable ruts greater than 3 inches deep, and free of any sharp metal debris such as shrapnel, metal links, or bullet casings.[123]

Table 13. Maximum A-10 takeoff weight versus runway CBR ratings[124]

CBR	Max Takeoff GW (lbs)
10	34,000
11	35,000
12	36,000
13	37,000
14-15	39,000
16	42,000
>16	Std -1 limits

[121] Source: USAF Warfare Center, *A-10 Forward Area Arming and Refueling Tactics Development and Evaluation Final Report*, 7.

[122] USAF Warfare Center, *A-10 Forward Area Arming and Refueling Tactics Development and Evaluation Final Report*, 6.

[123] USAF Warfare Center, *A-10 Forward Area Arming and Refueling Tactics Development and Evaluation Final Report*, 5.

[124] Source: USAF Warfare Center, *A-10 Forward Area Arming and Refueling Tactics Development and Evaluation Final Report*, 6.

Table 14. Maximum A-10 landing weight versus runway CBR ratings[125]

CBR	Max Landing GW (lbs)	CBR	Max Landing GW (lbs)
10	32,500	15	38,000
11	33,500	16	39,000
12	34,500	17-20	40,000
13	35,500	21-29	41,000
14	37,000	30-40	42,000

The biggest takeaway for mission planners is small assault strips utilized by C-130s, CASAs, or other tactical airlift may not work for A-10 FARP operations. Mission planners and Combat Control Teams (CCTs) should contact the A-10 unit directly for specific runway requirements for a specific location and desired combat load out. However, 8000 feet in length is a good rule of thumb for airfield elevations less than 2000 feet MSL and temperatures less than 30 degrees Celsius and 10000 feet in length for airfield elevations greater than 2000 feet MSL or temperatures above 30 degrees Celsius.

B. COMBAT CONTROL TEAM (CCT)

A team of combat controllers is essential for conducting air operations at an austere location. The CCT will be responsible for certifying the runway is ready for operations, completing a landing zone survey and FARP survey if required, providing air traffic control (ATC) services at the airfield (air and ground aircraft movement and deconfliction), or even providing terminal attack control in the event of a base attack. The CCT is responsible for a wide variety of critical mission tasks. Mission planners must consult a CCT expert to ensure an adequate amount Combat Controllers are assigned to the mission to accomplish these tasks and provide some redundancy. The single CCT member assigned to a SOF element to provide JTAC support is likely not sufficient to accomplish airfield survey and ATC functions.

[125] Source: USAF Warfare Center, *A-10 Forward Area Arming and Refueling Tactics Development and Evaluation Final Report*, 6.

C. LZ AND FARP SURVEY

Operations in combat and training, require two important documents to conduct air operations at an austere field. A landing zone LZ survey and FARP survey must be completed and approved prior to commencing operations. An LZ survey is annotated on an AF IMT 3822. In a deployed environment, LZ surveys of prepared and semi-prepared surfaces can be conducted by a Combat Control Team (CCT) or Contingency Response Group (CRG) airfield assessment teams that include Air Force Civil Engineering Support Activity (AFCESA) personnel.[126] During normal operations, request for LZ surveys should at least 120 days prior to intended use.[127] During contingency operations, with the appropriate remote Intelligence Preparation of the Operational Environment (IPOE) CCT teams can verify and certify LZ surveys within a matter of minutes from boots on the ground.[128]

In addition to the an LZ survey, Air Force aircraft also require a completed AF 4006 to complete FARP operations. Details on AF 4006 requirements can be found in AFI 11–235 *Forward Area Refueling Point (FARP) Operations*. Of note, AF 11–235 only discusses refueling requirements, it does not discuss weapons reloading requirements and considerations. Army Field manual 4–30.13 Appendix J discusses some considerations for reloading munitions at FOLs.[129]

D. FIRE FIGHTING

As learned from Operation Eagle Claw, fires at a FARP location can be deadly, especially FARP locations that lack firefighting capability (Figure 19). Commanders must balance the acceptable level of risk (ALR) with mission requirements, available assets, and expected contingencies. Having an appropriate level of fire-fighting equipment and

[126] Department of the Air Force, *Drop Zone and Landing Zone Operations*, 57.

[127] Department of the Air Force, *Drop Zone and Landing Zone Operations*, 57.

[128] Jimmy Larsen, personal communication, September 4, 2018. Surveys can be verified within 30 minutes if utilizing a prepared surface. If using a semi-prepared surface and soil samples need to be taken, the process can take up to 4 hours. Once the LZ Survey is complete it must be forwarded to the appropriate authority for approval. Approval authorities can be found in 13–217. Completed LZ surveys can be found at located at https://afkm.wpafb.af.mil/ASPs/CoP/OpenCoP.asp?Filter=OO-OP-AM-40.

[129] Department of the Army, *Ammunition Handbook: Tactics, Techniques, and Procedures for Munitions Handlers*, FM 4–30.13 (Washington, DC: Department of the Army, 2001), http://www.bits.de/NRANEU/others/amd-us-archive/fm_4-30.13%2801%29.pdf

personnel available at a FOL can reduce overall mission risk, but can drastically increase logistical requirements. Table 15 lists the desired and minimum levels of firefighting capability per type of aircraft. Further details can be found in AFPAM 32–2004 *Aircraft Fire Protection for Exercises and Contingency Response Operations* and AFTTP 3–32.42 *Contingency Firefighting Operations*[130] Regulations do state that locations with "occasional" take off and landings do not require fire and emergency services (FES).[131] The waiver authority for firefighting capability rests with the theatre Joint Forces Air Component Commander (JFACC) or MAJCOM/A3.

Figure 19. Operation Eagle Claw aftermath[132]

Picture of a burned EC-130 and H-53 at a FARP location during Operation Eagle Claw in 1980. The fire caused eight U.S. fatalities.

[130] Department of the Air Force, *Aircraft Fire Protection for Exercises and Contingency Response Operations,* AFPAM 32–2004 (Washington, DC, Department of the Air Force, 2014); Department of the Air Force, Contingency Firefighting Operations, AFTTP 3–32.41 (Washington, DC: Department of the Air Force, 2016).

[131] AFPAM 32–2004 *Aircraft Fire Protection for Exercises and Contingency Response Operations* defines occasional as no more than 4 fighter type aircraft or 2 heavy type aircraft takeoff and landing in 7 days.

[132] Source: https://www.socom.mil/Pages/USSOCOM-celebrates-its-30th-anniversary.aspx

Table 15. Levels of fire and emergency services[133]

Aircraft Type		Optimum Level of Service		Reduced Level of Service		Critical Level of Service		Inadequate Level of Service	
Aircraft	AF Vehicle Set	OLS - Firefighters	OLS - Gallons Q1+Q2+Q3	RLS - Firefighters	RLS -Gallons Q1+Q2	CLS - Firefighters	CLS - Gallons Q1	ILS - Firefighters	ILS - Gallons
A-10, C-21, F-15, F-16, F-22, F-35, F-117, T-37B, BQM-34, MQ-1A/B, T-38, AT-38, MQM-107, T-6A, UV-18, QF-4, CV-22, UH-1N, C-38A, T-1, RQ-4, and C-12	1	14	2,500 - 1,340	13 - 8	1,339 - 513	7	512 - 325	6 or below	324
C-20	2	14	4,000 - 2,760	13 - 8	2,759 - 1,316	7	1,315 - 752	6 or below	751
C-9, C-32, C-37, C-40, C-130, E-3, E-8, T-43, MH-53 and RC-135	3	14	5,000 - 4,880	13 - 8	4,879 - 3,027	7	3,026 - 1,322	6 or below	1,321
B-1, B-2, B-52, C-17, KC-46 and KC-135	4	16	8,000 - 7,780	15 - 8	7,779 - 4,364	7	4,363 - 1,732	6 or below	1,731
E-4 (747), KC-10 and VC-25	5	17	10,000 - 9,570	16 - 8	9,569 - 6,292	7	6,291 - 2,330	6 or below	2,329
C-5	6	18	13,000 - 12,626	17 - 8	12,625 - 7,508	7	7,507 - 2,589	6 or below	2,588
* Firefighter numbers are on a per shift basis									
** Below Optimum Level of Service – Aircrew Awareness (NOTAM)									
** Below Reduced Level of Service – Mission Commander or OG/CC approval									
** At or Below Critical Level of Service – Waiver approval as specified in paragraph 7.1									

Table 15 applies to fire-fighting requirements for short-term, small scale operations lasting less than 120 days. Firefighting requirements may be excluded if less than four takeoffs and landings are made within seven days, or if waived by the JFACC[134].

E. SPECIALIZED EQUIPMENT FOR MAINTENANCE AND LOADING WEAPONS.

1. Weapons loading

Reloading A-10 munitions at a MOB or FOL does require some specialized equipment. Mission planners must consider expected mission requirements, mission duration, available logistics capacity, and FOL capability in determining the fuel and weapons requirements at the FOL. Taking on fuel only, requires no additional maintenance or equipment support. Reloading weapons will require at least six A-10 maintenance personnel and some specialized equipment.[135] Longer duration operations will require more personnel and more equipment.

[133] Source: Department of the Air Force, *Aircraft Fire Protection for Exercises and Contingency Response Operations*, 4.

[134] Department of the Air Force, *Aircraft Fire Protection for Exercises and Contingency Response Operations*, 5.

[135] Kyle Rykaczewski, *FOL Operations: A Checklist for the Weapons Officer* (student paper, USAF Weapons School, 2014), 5. Rykaczewski lists a 3-person weapons load crew, 1 weapons expeditor, 1 crew chief at the loading locations and 1 crew chief at the refueling location as the minimum maintenance package (6 people total).

Reloading the GAU-8 Avenger, the A-10s 30 mm cannon, requires a GAU-8 Ammunition Loading System (ALS) and ammunition cans loaded on an MHU-141 munitions trailer. An ALS is shown in Figure 20. Each loaded trailer can support 2 full gun reloads or 4 half gun reloads. For planning purposes, the cargo weight requirement to support a gun reload is 17,500 lbs. Adding an Advanced Precision Kill Weapons System (APKWS) reloading capability bumps the weight up to 19,000 lbs.[136] As demonstrated in exercises, a single MC-130 can support this cargo requirement.[137] Reloading 500 lb freefall munitions or AGM-65s require additional bomb lifts and munitions trailers. See Table 16 for A-10 equipment basic weight and dimensions of equipment required for weapons reloading.

Figure 20. GAU-8 ALS, required for A-10 gun reloads[138]

[136] Rykaczewski, *FOL Operations: A Checklist for the Weapons Officer*. These numbers assume all equipment and munitions are transported to the FOL via aircraft. Weight and pallet requirements can be reduced if equipment and munitions are prepositioned at or near the FOL.

[137] Specifically, Advanced Guard 2014 demonstrated this. It has been exercised and verified several times since, including 303 FS led exercise in 2016.

[138] Source: http://users.vermontel.net/~tomh/images/AIRCRAFT/USAF/TYPES/ATTACK/A10/A10_ALS_13Jan88.jpg

Table 16. Basic cargo planning data for A-10 weapons loading equipment[139]

ITEM	Length (in)	Width (in)	Weight (lb)
MJ-1 Bomb Lift Truck	145	68	4160
MHU-83 Bomb Lift Truck*	177	89-113	7320
GAU-8 ALS	191	77	2800
MHU-141 Munitions Trailer**	126	89	2900
* Required for AGM-65 loading **Unloaded trailer weight			

Of note, the Air Force does not train to loading heavy weapons (500 lb bombs and AGM-65s) without the use of bomb lift trucks. If the Air Force adopted manual weapons loading techniques similar to Navy carrier loading operations paired with manually operated bomb lift devices, it could greatly reduce the cargo capacity requirement for munitions loading.

2. Liquid Oxygen

Most A-10s require liquid oxygen (LOX) to supply pilots with adequate breathable oxygen in flight. Without adequate oxygen provided by LOX pilots are susceptible to hypoxia, especially when flying in the medium altitude environment.[140] LOX can be difficult transport and difficult to obtain away from a MOB. An A-10s LOX supply can be depleted in three days of flying operations. Mission planners should consider three days as the maximum time an A-10 can operate away from a location MOB without LOX available.[141]

Limited number of A-10s in the current inventory were converted to an on-board oxygen generating system (OBOGS). Jets outfitted with OBOGS do not require LOX servicing and can potentially operate away from a MOB longer than a non-outfitted jet. Recommend the AF invest in outfitting more A-10s with OBOGS to increase the capability and reduce the logistical requirements of A-10 austere operations.

[139] Source: Rykaczewski, *FOL Operations: A Checklist for the Weapons Officer*, 9.

[140] Medium altitude tactics are designed to fly above small arms and small caliber AAA threats.

[141] Rykaczewski, *FOL Operations: A Checklist for the Weapons Officer* referencing a recommendation from A-10 maintenance production superintendent.

IV. CHALLENGES

There are challenges and risks that accompany basing airplanes at forward operating locations. None of the challenges are insurmountable and most can be mitigated through proper planning, preparation, and rehearsal. Whether the US Air Force is providing air support to troops thousands of miles from a main operating base, or assets need to be dispersed to avoid attack during a major conflict, the benefits can greatly outweigh the risks. The following list of challenges and risks is not exhaustive nor all inclusive, but rather covers some of the major contingencies specific to operating from a FOL.

A. AUSTERE BASE ATTACK

1. Challenge

Austere bases may lack significant dedicated security forces. Each location and tactical environment will have its own unique security challenges and specific security measures is beyond the scope of this paper. The basic assumption is that the host unit or base will provide adequate security at the FOL, however, there are some mitigating factors aviation units can consider.

2. Mitigation

Putting forward deploying maintenance personnel through additional combat arms and weapons qualification training can help better prepare for a base attack. Maintenance personnel must train to performing maintenance while donned in a full Kevlar kit and carrying a weapon.[142] Additionally, maintenance personnel should cross train between specialties to add some redundancy to maintenance functions. (e.g. training a weapons troop how to service engine oil)

Consider the use of Phoenix Raven security forces. The USAF Phoenix Ravens are specifically trained to protect Air Mobility Command (AMC) aircrew and airplanes in austere environments. These high demand, low density personnel can help provide base

[142] The 442 AMXS at Whiteman AFB developed recommendation for maintainer Kevlar kit configurations. Contact 442 AMXS for more information.

and aircraft security and identify considerations for security personnel not accustom to protecting large vulnerable aircraft. Additionally, Air Combat Command (ACC) should consider sending select security forces personnel through the Phoenix Raven training course to provide personnel specifically trained to protect fighter aircraft in austere locations.

B. MINIMUM MANNING

1. Challenge

The finite amount of personnel sustainment resources (e.g. food and lodging) at a FOL combined with limited transportation resources often necessitates passenger manifests are reduced to the bare minimum for mission accomplishment. A-10 operations and maintenance personnel may not have the available manpower they typically enjoy at a MOB. Lower levels of manpower limit the ability to surge operations if required, or continue planned production levels in the event of injury, illness, or casualty.

2. Mitigation

Conducting joint cross servicing training and familiarization can provide a force multiplier and promote operational resiliency in an austere environment. Recurring joint training exercises (e.g. Jaded Thunder, MLAT, Emerald Warrior) focus almost exclusively on operations. Adding a cross familiarization or maintenance integration portion to these exercises could be beneficial to a deployed environment. Teaching an Army Ranger how to operate a bomb lift truck, an Army AH-64 mechanic how to load rockets on an A-10, an MC-130 crew chief how to service LOX, or an A-10 mechanic how to change an MRAP tire could greatly increase redundancy, enables operational resiliency, and can reduce the logistical footprint required to operate at a FOL.

Conducting jet familiarization at exercises or entering into formal cross-servicing agreements can add flexibility and extra man power while operating away from MOBs in a coalition environment as well. In the past, NATO focused on setting up a host of servicing

agreements and multinational maintenance exercises.[143] Most cross-servicing exercises and agreements ended in 2007, but have reemerged as NATO faces a more aggressive threats to its east.[144] The basic construct would allow a four-ship of US F-16s could land in Campia Turzii Airbase in Romania, be fully serviced with fuel and weapons by Polish maintainers, then take off to support a NATO combat mission. Those same maintainers could then service a four-ship of Spanish Eurofighters 30 minutes later. To complete this, the Polish maintainers need to be trained in servicing F-16s and Eurofighters and a cross-servicing logistical agreement must be in place to establish who "pays" for the gas and weapons. Unfortunately, unlike the F-16, Eurofighter, and Joint Strike Fighter, the US is the sole operator A-10s so there isn't a resident servicing knowledge base already present with allied nations. This means the A-10 community needs to make a conscious effort to build this knowledge base in NATO.

C. "HARD-BROKE" JET

1. Challenge

Having a hard-broke jet (a jet that requires significant maintenance before it is flyable), in an austere environment with minimal maintenance support is a significant risk to FOL operations. A-10s are extremely reliable, but like any aircraft, can break unexpectedly. It is unacceptable to have a jet broken in the desert for an extended period of time. There are extensive mitigating actions units can take to reduce the likelihood of a hard-broke jet.

2. Mitigation

Limit or eliminate engine shut downs while in an austere environment. A jet that is running rarely hard breaks. Shutting down jets increases the likely hood of a hard-broke

[143] NATO exercises like Exercise Ample Train in 2001 focused on familiarizing maintenance personnel on servicing requirements of each participants airplanes. According to NATO "The aim of Exercise Ample Train 2001 is to allow ground crews to acquire experience in aircraft cross-servicing so that aircraft from any of the member countries participating in the aircraft cross-servicing programme can be maintained and continue their missions."
https://www.nato.int/cps/su/natohq/news_18720.htm?selectedLocale=en

[144] Air Operations Branch JAPCC, Joint Air Power Competence Centre, accessed November 10, 2018, https://www.japcc.org/portfolio/aircraft-cross-servicing-reactivation.

jet. If an engine does not start, the jet isn't flying. **In an austere environment refueling and weapons loading should be completed with engines running to the max extent.** Eventually engines need to be shut down for basic servicing. Around 12 hours is about the maximum duration an A-10 engine should be allowed to run before shutting down and servicing oil.

Units must derive minimum equipment subsystem list (MESL) specific to FOLs. In an austere environment, if a jet has two good engines and hydraulic systems, it might not be fully mission capable, but it is likely flyable. Peace time or even MESLs used to fly at the MOB should not apply. As an example, in the A-10, which has 3 radios, the ARC-164 UHF radio is must be operational for the jet to be considered flyable. The ARC-164 is the only radio of the 3 that can operate on battery power only. It is required to radio for help during ground emergencies or with certain electrical malfunctions. While an inoperative ARC-164 will keep a jet grounded for a training mission, it should not keep a jet grounded at a FOL.

Jet maintenance go/no go decisions must be pushed down to the pilot and on scene maintenance team. Decisions that typically get routed to O-6 levels for approval must stay at the local level at an FOL. Decisions made at the local level can happen quicker, with more situational awareness, and do not require communication reach back to a home headquarters. This should fall in line with current USAF efforts to empower squadron commanders. US Air Force Chief of Staff, General Goldfein, stated empowering squadron leadership and focusing on mission command is key to aligning Air Force culture and command and control with the National Defense Strategy.[145]

A maintenance recovery team (MRT) should be kept on call with the appropriate transportation ready to rapidly deploy in response to hard broke jet. The MRT must have access to the required spare parts and maintenance specialists to facilitate the rapid repair and recovery of a hard-broke jet at a FOL. For extreme distances between a MOB and FOL

[145] Robert Barnett, "Revitalizing squadrons, Air Force, outlines progress," US Air Force, August 8, 2018, https://www.af.mil/News/Article-Display/Article/1598301/revitalizing-squadrons-air-force-outlines-progress/

mission, planners could consider deploying an MRT and mission ready spare package (MRSP) to a secure forward area ready to respond to a FOL if required.

D. COMMAND AND CONTROL

1. Challenge

FOLs with limited communications capabilities or advisories with robust communications jamming capabilities challenge traditional centralized command and control of Air Force assets. Directing sorties via the Air Tasking Order is not optimal and limits flexibility while conducting distributed operations. Additionally, supporting SOF mission sets from a FOL could require increased aircraft flexibly beyond the 72-hour ATO cycle to accomplish the mission. Currently an ATO tasking dictates most aspects of an air mission to include, take off and land times, target(s), refueling times, and weapons loadout.[146]

2. Mitigation

The dynamic nature of SOF missions, especially with potentially limited communication reach back to HHQ, necessitate execution decisions to be pushed to the lowest practical levels. For distributed operations, the AF should implement mission command comprised of a clear commander's intent, broad mission orders, and decentralized execution. Mission orders are orders with a clear commander's intent, but allow the appropriate amount of flexibility on how to execute the mission to achieve success. As General Homs stated in 2018, the Air Force needs to empower young leaders to make command decisions in order to carry out commander's intent. [147]

[146] See Air Force Doctrine Volume 3 *Command, Annex 3-0 Operations and Planning* https://www.doctrine.af.mil/Portals/61/documents/Annex_3-0/3-0-D29-I-OPS-The-Tasking-Cycle.pdf. For more information on the ATO process.

[147] Tirpak, "The Air Force's 'Forever War' is its Toughest Pill to Swallow,"

Mission orders could be as vague as:

- Provide ODA 1234 with CAS from X Date/Time to Y Date/Time.
- Prevent enemy armored vehicles from crossing X Bridge from X Date/Time to Y Date/Time.
- Provide Alert CSAR with 30 min response to TGT A from X Time to Y time.

The unit then has the flexibility to determine how to best support the assigned mission, when to fly, and what ordnance to carry. This level of decentralized execution is required for distributed operations.

E. WEATHER

1. Challenge

Inclement weather can pose a significant risk to FOL operations. Austere FOL locations can lack the offboard navigation equipment and published instrument approach procedures available at MOBs. In order to fly an approach to an airfield in instrument meteorological conditions (IMC) a published department of defense (DOD) or approved commercial approach procedure must exist.[148] Creating an approved DOD approach is a lengthy process that requires a TERPS team on the ground to conduct an airfield survey.[149]

Fighter aircraft are not approved to fly GPS approaches. Instrument approaches must be flown using a TACAN, ILS, or both. This equipment is likely not available at FOLs and is not practical to install and certify them for temporary FOL operations. Therefore, all fighter approaches into FOL must me made under visual metrological conditions (VMC). AFI 11- 202 volume 3 *General Flight Rules* defines VMC as weather

[148] Department of the Air Force, *Instrument Flight Operations*, AFM 11-217 Vol 1 (Washington, DC: Department of the Air Force, 2010), 92.

greater than 1500-foot ceilings and three statute mile horizontal visibility.[150] Terrain and obstacles in vicinity of the FOL may increase ceiling and visibility requirements for safe takeoff and landing operations.

2. Mitigation

- Consider VMC weather in the mission GO/NO GO criteria.
- Include an Air Force Special Operations Weather Technician (SOWT) at the FOL location. SOWTs are Air Force special operators that specialize is metrological and environmental analysis and forecasting.[151]
- A-10 mission planners should plan for weather let down procedures in vicinity of the FOL. Weather let down procedures allow a pilot do descend through IMC conditions at achieve VMC conditions prior to landing.
- A-10 mission planners should create 3-D glidepath GPS approach points enhance pilot situational awareness and aid runway identification in marginal weather.[152]

F. WET RUNWAY

1. Risk

Standing water on a runway can cause dangerous hydroplaning conditions during aircraft takeoff and landing operations. Hydroplaning can lead to loss of aircraft control at high speeds. Conventional runways are constructed with a crown in the middle to quickly shed rainfall and prevent standing water on the runway. Operating from an unconventional

[150] Department of the Air Force, *General Flight Rules,* AFI 11-202 Vol 3 (Washington DC: Department of the Air Force, 2016), https://static.e-publishing.af.mil/production/1/af_a3/publication/afi11-202v3/afi11-202v3.pdf, 49.

[151] See https://www.airforce.com/careers/detail/special-operations-weather-technician for more information on SOWT capabilities.

[152] Recommendation from "Unimproved Surface Ops" (course academics, A-10C Weapons Instructor Course, Nellis AFB NV, 2014)

runway surface (e.g. dirt, highways, and roads) likely means the surface may not be optimized to disperse water in the event of rainfall.

If operating from a dirt runway, recent rainfall can render a dirt strip unusable for significant periods of time. The rain decreases the load bearing capacity of the dirt runway, or standing water can submerge the runway. For example, A-10 training operations on Delmar Lake (a dry lake bed near Nellis AFB Nevada) can be suspended for a week or more following heavy rain fall.[153]

2. Mitigation

Consider recent weather and its effect on runway conditions in mission GO/NO GO criteria. Often weather in the target area is considered, but weather in and around the aircraft point of departure is an afterthought, especially if the aircraft depart from a location different from the ground unit.

Allow CCT personnel ample time on the ground to assess runway conditions and adjust the landing location/surface as required. Consult the CCT assigned to the mission for an expected timeline to clear a new field. As a rule of thumb allow a CCT team 30 minutes to assess a prepared surface (a concrete runway that is currently used or abandoned). If operating from a semi-prepared surface, allow the CCT team 4 hours before the first fighter aircraft arrive. Four hours is required to conduct soil samples to determine the load bearing capacity of the surface.[154]

Utilize all means available to gather real time imagery/intelligence of runway conditions if utilizing on unoccupied FOL prior to mission execution. The means and methods of doing so are beyond the scope of the paper. Mission planners must keep in mind, especially when deploying to an unoccupied FOL with a semi-prepared surface, the effects of heavy rain fall on a runway can last for weeks.

[153] Tim Geist, personal communication, May 1, 2107.

[154] Jimmy Larsen, personal communication, September 4, 2018

G. FOREIGN OBJECT DAMAGE (FOD)

1. Challenge

Rocks, trash, birds, and other debris when ingested into an aircraft engine can have devastating effects. The high placement of A-10's turbofan engines above the ground make it less susceptible to FOD than any other fighter aircraft in the US inventory. Other fighter aircraft with lower air intakes are susceptible to "pulling" FOD causing items off the ground. Typically, an A-10 engine doesn't create a strong enough vacuum to ingest objects that are laying on the ground. The A-10 is susceptible to items blowing in the wind, items blown up by other aircraft engine blast, or items sitting on top of an elevated surface increase the risk of ingestion.

Objects such as shrapnel, bullet casings, or large rocks can damage tires as a 40,000-pound aircraft rolls over it. Aircraft tires must be free of defects to withstand the high speeds of takeoffs and the high impacts of landings. Changing a tire, if one is even available in an austere environment, can be a daunting, laborsome task.

2. Mitigation

In accordance with AFI 13-217 *Drop Zone and Landing Zone Operations*, the runway environment should be clear of rocks greater than one and half inches, shrapnel or metal in and around the runway and FARP area. Conducting a rapid "FOD sweep" periodically or after events such as a base attack or heavy aircraft departure can help identify and remove hazardous objects.

Keep helicopter ingress and egress routes away from FARP locations, and ensure aircraft taxi routes do not blow FOD into the FARP area. Helicopters hovering over fixed wing aircraft create FOD hazards. Large jet engines from aircraft like C-17s can blow FOD causing debris for hundreds of feet. Rocks and debris that would have stayed on the ground can be thrown up to engine level. Operating from semi-prepared surfaces increases this risk.

If a strong wind is creating a lot of potential FOD, consider shutting down engines during FARP operations. Ideally, all ground operations should be conducted with the

engines running in order to reduce the risk of an engine “no-start” or major malfunction during start-up. However, in some windy situations, it may reduce risk to shut engines down.

This is not an exhaustive list of the challenges and risks of operating aircraft from a FOL, rather it covers some of the specific challenges specific to operating an A-10 away from a MOB. General challenges of operating a FOL in an austere location, potentially under constant threat of attack from the enemy require consideration. Challenges such as diplomatic clearances, mission approval authorities, host nation support, logistics, and dealing with casualties must be addressed but are beyond the scope of this paper. Each of the challenges addressed can be sufficiently mitigated with the proper planning, training, and execution. In the end, it’s about supporting the end user with fire support. The benefits of being able to provide persistent lethal aerial fires in any environment, untethered to a MOB, provides the joint force a valuable tool to fight tomorrow’s enemy.

V. CASE STUDY: NIGER

A. BACKGROUND

If the U.S. Air Force is committed to fighting the war and terrorism, providing CAS and ISR support to forces in central Africa is likely to be required in the future. The US does not have the basing infrastructure in and around Africa to operate exclusively from MOBs. The U.S. Air Force must leverage Forward Arming and Refueling Point (FARP) operations from austere locations in order to effectively support Special Operations Forces (SOF) in central Africa.

The following is a hypothetical situation, but possesses similarities to Navy-SEAL-led hostage rescues recently conducted in Yemen and Somalia.[155] The proximity Yemen and Somalia to Camp Lemonier, Djibouti provided an easy MOB staging area for assault forces. If these rescue attempts took place in Central or West Africa, against a well-armed enemy, the mission result might have been different. This scenario highlights some of the advantages the adaptive basing capabilities of the A-10 brings to the joint force. For available air support options, this scenario draws on typical forces deployed to AFRICOM and CENTCOM over the past few years.

> The US confirmed through various intelligence sources that Boko Haram captured 15 Doctors Without Borders workers and are being held at a remote compound on the Nigeria, Niger border. IMINT shows the compound is guarded by 30-40 individuals and multiple defensive fighting positions (DFPs) with heavy guns up to 23mm. Intelligence indicates the insurgent group also possesses MANPADS and 50-watt GPS jammers obtained from Libya stockpiles.
>
> A US special operations team conducting operations in Somalia is tasked to execute the hostage rescue. Intel suggests the hostages will be moved to a new, unknown location within the week. The closest staging base is Niger Airbase 201 outside of Agadez, Niger roughly 250 NM away. The CONOP calls for 2 CV-22s to insert the team via offset infill then extract the team and hostages from an LZ close to the compound. Hostages will be transloaded to a C-17 at a temporary FOL 20 miles from the

[155] In November/December 2014, Navy SEALs conducted 2 rescue attempts in central Yemen. 8 hostages were rescued, two were killed during the second rescue attempt. In January 2012 Navy SEALS conducted a hostage rescue in Somalia, freeing two hostages from Somali pirates.

objective to facilitate transporting the hostages to Landstuhl Regional Medical Center in Germany while a medical team onboard the C-17 provides immediate assistance. Based on the threat, the assault force (AF) determines airborne fire support is needed to maintain relative superiority throughout the mission. Based on weather, lunar illumination, and a potential hostage relocation, the best chance for a successful rescue is in 4 nights from now. What options are available for close air support?

- Armed MQ-9s are currently flying from Niger Airbase 201. MQ-9s carrying a mix of AGM-114 hellfire and 500 lb guided bombs are available. Based on the assessed enemy threat to the assault force and lift assets, additional fire support is needed.

- Currently there are no Navy aircraft carriers deployed to the region, the closest is currently off the coast of Oman nearing the Straits of Hormuz[156]

- Several B-1s are deployed to Al Udeid Air Base, Qatar. From Qatar to southern Niger is approximately 2500NM. With enough tanker support (approximately 220,000 lbs of fuel offload) the B-1 can provide approximately 5 hours of coverage during the 16-hour mission.[157] With the appropriate waivers and tanker support the mission could provide additional time on-station. The station time meets mission requirements, however a limited ability to flex on-station time with mission timeline and the lack of a direct fire weapon and lack of rotary wing escort capability does not meet mission requirements.

- F-16s based at Aviano Air Base, Italy are 2000NM away. The distance is too great to launch from home, but could forward deploy to Sigonella Naval Air Station, Sicily and launch from there. Sigonella is 1500 NM from the target area. Flying a 10-hour mission with dedicated tanker support, F-16s could provide approximately 3 hours of coverage.[158] Flying combat missions from Sicily on 3 days' notice could be challenging due to home station readiness, the diplomatic approval process, and flying across combatant command regions.

- At least one USAF fighter unit (F-22/F-15E/F-16) is deployed to Arabian gulf area. Repositioning these aircraft to the closest suitable African base Camp Lemonnier, Djibouti (2000NM) is still too far of a distance to conduct the mission.

[156] According to https://worldview.stratfor.com/ carrier strike group locations as of 11 Oct 2018.

[157] B-1 data computed using flight planning software, provided by Maj Chris Townsend.

[158] Assumes 400T cruise speed enroute, adequate tanker support and a 12-hour duty day.

- An A-10 unit is currently deployed to Kandahar Airbase, Afghanistan. They can operate from Niger Airbase 201 in Agadez or other FOLs in the region and could be in place 2 days after notification with the proper logistical and tanker support.

- AC-130s deployed to CENTCOM cannot operate from the semi-prepared surface at Niger Airbase 201, and the presence of AAA, MANPADs, and GPS jammers exceeds the commander's acceptable level of risk (ALR).

The WARNO is given and four A-10s loaded with two GBU-54s, one AGM-65, seven APKWS depart Kandahar to Djibouti flown by ferry pilots. The four A-10 mission pilots and ten A-10 maintainers with an MRSP, ALS, 30mm ammunition, depart Kandahar on an MC-130 going to Djibouti. Day two, the MC-130 departs Djibouti enroute to Agadez with the four mission pilots and assault force, six A-10 maintainers, and an STS team. Day three is spent finalizing mission details and conducting integrated reversals.

The mission is a go for period of darkness (POD) day four. Four A-10s arrive at Agadez flown by the ferry pilots from Djibouti and conduct shutdown operations to service fuel and oil, spending about two hours on the ground. At H-1 hour, four A-10s, two CV-22s, and an MC-130, depart Agadez's 7000' semi-prepared surface while an armed MQ-9 maintains overwatch on the compound. A-10s provide escort to the CV-22s inserting the team, while the MQ-9 maintains overwatch of the objective compound. The offset infill is uneventful. Two A-10s remain on station, providing overwatch of the AF traveling on foot to the target while maintaining outside audible signature.

The two other A-10s escort the CV-22s to the FOL location, land, refuel at the FARP, and wait for the next mission trigger (AF actions on the objective). The two A-10s on the ground takeoff to arrive at the target compound ten minutes before the AF arrives. As the AF establishes positions, the MQ-9 and four A-10s conduct a coordinated, simultaneous attack on the enemy DFPs and heavy machine gun locations. The A-10s engage enemy fighters with 30mm and APKWS laser guided rockets multiple times under control of the JTAC. The attacks go smooth, the JTAC and aircrew rehearsed them several times the day prior. Once hostile activity subsides, two A-10s depart for the FARP, quickly taking on fuel and weapons in order to support the exfil.

Upon exfil, the MQ-9 and A-10s again conduct preplanned strikes immediately prior to the CV-22s entering the landing zone. The well-timed attack silences the enemy activity and neutralizes the threat to the HLZ. The CV-22s, AF, and hostages depart for the transload site. Two A-10s take on

> fuel at the FARP while two others provide overhead security until the transload is completed. All assets return to base and the FARP is collapsed five hours after it was opened. The mission is a success, the hostages are saved. A few tire ruts in the middle of a dry lake bed serve as the only remnants of the mission. By day seven, two days after the mission, the A-10 pilots, maintainers, and jets are back in Kandahar, ready to conduct missions against the Taliban.

The "tyranny-of-distance" the rescue team faces to conduct this mission in Niger combined with an enemy more heavily armed than the Yemeni rebels or Somali pirates of the previous hostage rescues makes this a complex and potentially high-risk mission. Effective air support, both ISR and Fires was required to mitigate the risk to the assault force. Deploying the A-10s forward, leveraging their ability to operate from semi-prepared surfaces, provide lift escort, and FARP in an austere location enabled this mission to be successful without undue risk to force. The A-10s were able to leverage some key benefits outlined in Chapter II:

- The A-10s were able to deploy forward with a minimal maintenance package almost immediately after the WARNO was given. There were not unnecessary delays in waiting for airfield infrastructure upgrades, extra logistical support for a full unit of maintainers, or waiting for adequate tanker support to arrive. By sending just four jets, and a few maintainers and pilots, it would have little effect on flying operations in Kandahar.

- By sending the mission pilots forward, they were able to conduct integrated mission planning and rehearsals with the supported force. A detailed understanding of the mission, and planning with the JTAC, allowed them to conduct preplanned strikes at the appropriate times to allow the AF to maintain relative superiority. These types of strikes are difficult to pick up on the fly without planning and rehearsal.

- With the availability of the FARP 20 miles from the objective, the A-10s were able to adjust their air support to the timeline of the mission. Four A-10s were on station during the critical times of the mission (infil, AF actions on objective, exfil) to provide maximum support to the assault

force. If the mission timeline changed (e.g. overland movement to objective from infil point takes longer than expected, needing more time on objective for SSE, hostages need to be moved to exfil point via litter) the A-10s could easily adjust their timeline to best support the assault force.

- This mission turned out to be more kinetic than expected. The A-10s were able to quickly reload weapons at the FARP to ensure adequate weapons were on station. If this mission was only supported by tankers conducting air-to-air refueling, this would not have been possible. Unlike recent conflicts in Syria, Iraq, or Afghanistan, there were not an abundance of fighter aircraft available to RIP the A-10s with a low weapons or fuel state.

- Opening and closing the FOL and FARP in one POD did not allow the enemy sufficient time to discover and stage an attack on the location and did not telegraph the intent and timing of the US to conduct the rescue mission. Forward staging assets for multiple days would have likely sent warning signals to the enemy and made US assets more vulnerable to attack.

This case study illustrates just one type of mission, in one region of the world that leveraging A-10 adaptive basing capabilities could benefit the SOF community and the joint force. Similar scenarios could be applied to most current and future AORs, with potentially higher threats and higher costs of mission failure. Conducting a rescue operation far from a MOB poses some significant challenges that the Air Force is potentially unable or unprepared to adequately support. If this operation was supported with an MQ-9 only or an MQ-9 and B-1 flying out of Persian Gulf, the assault force may not have possessed air support it needed to conduct a successful rescue operation at an acceptable level of risk and ultimately risking mission failure. Operating fighter aircraft from temporary FOLs, with a dirt runway, during one POD, in the middle of the desert is not always the optimal solution, but in this scenario, it enabled mission success when few other options were available.

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VI. CONCLUSION

Forward deploying A-10s to austere locations, leveraging flexible and adaptive basing procedures, and conducting ICTs by rearming and refueling with engines running provides a lethal tool to the joint force. The adaptive and untethered basing construct provides a rapidly deployable, flexible, survivable, and lethal fires platform capable of carrying out broad mission type orders to fulfill commander's intent. The A-10 is capable of meeting and exceeding the intent of the National Defense Strategy to "transition from large, centralized, unhardened infrastructure to smaller, dispersed, resilient, and adaptive basing" to posture for the global strategic environment in support of conventional and special operations forces.[159]

A. THE BENEFITS AND RISK OF OPERATING FROM A MOB

The added benefits of integrated mission planning, rapid mobilization capability, mission flexibility, and tactical unpredictability of adaptive basing clearly outweigh the challenges and risks. Advances in commercial technology and military weapons systems make main operating bases increasingly vulnerable to enemy attack. Adaptive basing combined with full FARP operations provides US forces the ability to project forward into traditionally denied environments, operate in areas far from existing MOBs, reduce reliance on tanker support, remain unpredictable to enemy forces, disperse equipment and personnel, and reduce reaction time and increase on-station times.

B. THEATERS, MISSIONS, AND OPLANS THAT BENEFIT FROM ADAPTIVE BASING AT FOLS

Most current and future operational areas can derive benefits from a flexible basing posture. In the WPTO, it can mitigate China's extensive S/S missile arsenal. In Eastern Europe, it can allow fighters to project forward further from tanker orbits pushed hundreds of miles west due to advanced surface-to-air missile systems. In Korea, it adds resilience and redundancy in case Osan or Kunsan become unusable. In Africa, it alleviates airplanes

[159] Mattis, *National Defense Strategy: Unclassified Summary*, 6.

having to transit thousands of miles to conduct missions far from Camp Lemonnier. In future, unknown locations, it allows forces to project forward immediately and not wait for a MOB to be acquired or constructed.

C. CURRENT CAPABILITY OF THE A-10 ENTERPRISE TO OPERATE IN AUSTERE ENVIRONMENTS

At this time, the maintenance practices, operational training, and Air Force regulations do not fully support the capability and flexibility of adaptive basing. The 303rd Fighter Squadron is the only A-10 squadron currently trained and qualified to conduct full scale FARP operations in an austere environment. With a few adjustments to training plans, exercises, and regulation changes the rest of the A-10 enterprise and Combat Air Forces (CAF) can be ready to meet General Mattis' National Defense Strategy intent.

D. RECOMMENDATIONS FOR FUTURE ACADEMIC RESEARCH.

If the Department of Defense peruses adaptive and agile basing practices to combat current and future advisories more research should be done to advance the capability. Future topics could include: What are the desired design traits of future austere capable aircraft? What future platforms and capabilities should ACC and/or AFSOC procure to meet the intent of the NDS? How can the light attack aircraft program (AT-6 or A-29) advance adaptive basing capabilities? How can the Air Force effectively force package from a distributed posture? How can the Air Force exercise command and control from a distributed force posture?

Ultimately, the A-10 community is committed to providing the best possible fire support to the 18-year-old private doing his part in a major combat operation, a special operator putting his boot on the neck of the adversary, or an aviator behind enemy lines trying to evade capture. Leveraging the adaptive basing capabilities of the A-10 provides the joint force with an effective tool to employ against tomorrow's enemy…no matter where in the world that might be.

APPENDIX. LIST OF RECOMMENDATIONS

1. Air Force Regulations

- Maintenance Technical Orders-Update USAF maintenance procedures to include full integrated combat turnarounds (ICTs), conducting maintenance with NVGs, reloading weapons with engines running, and simultaneous wing loading procedures.
- Rewrite AFI 11-235 *Forward Area Refueling Point Operations* to include considerations and procedures for loading weapons at FARP locations.
- Push maintenance and mission go/no-go decisions down to the lowest practical levels to enable decisions to be made locally at austere locations.
- Develop MESLs specific to FOLs.

2. Air Force Training

- Revamp maintenance personnel training focused on austere operations to include additional weapons qualifications, operating with NVGs, performing maintenance without artificial lighting, operating lifts and machinery on semi-prepared surfaces, cross training between maintenance disciplines, manually loading weapons similar to Navy carrier practices.
- Develop integrated operations and maintenance training programs that reinforce the skills needed to operate and survive in an austere environment.

- Build a force of ACC owned security forces personnel specifically trained to protect aircraft way from MOBs. The program should mirror AMC's Phoenix Raven program.

- Update unit Rap Tasking Messages (RTM) and Designed Operational Capability (DOC) statements to include an adaptive basing capability for select units and define the adaptive basing qualification and requirements.

- Continue to develop and maintain pilot austere takeoff and landing qualifications IAW A-10 Upgrade Syllabus.

3. Joint Operations

- Plan and execute joint full mission profile training with challenging scenarios similar to those outlined in Chapter II or the scenario in Chapter V.

- Develop operational plans that leverage the advantages of adaptive basing and FW FOL operations as appropriate.

- Identify the contingency locations capable of FW fighter operations and develop a rating scale similar to AMC's Giant Report to identify those locations. See Air Mobility Command Instruction 11-211 *Flying Operations: Destination Airfield Suitability Analysis* for more details on the Giant Report or Global Decision Support System (GDSS)/Airfield Suitability and Restrictions Report (ASRR).

- Update airfield and runway planning documents to include considerations, requirements, and realistic capabilities for FW fighter operations at FOLs.

- List “adaptive basing capability” on unit deployment tasking messages as a requirement for deploying units.
- Streamline the ability to operate across Combatant Command boundaries to leverage assets and locations outside or existing COCOMMs.
- Conduct maintenance cross servicing exercises and familiarization between services and coalition partners

4. Desired A-10 upgrades specific to austere operations

- Upgrade additional jets with OBOGS.
- Add a parking brake.
- Explore options to reduce engine oil consumption or increase oil capacity to extend the available fight-time between required engine shutdowns to service oil.
- Purchase/acquire additional combat capable fuel tanks for A-10s.

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