ARMY TACTICAL MISSILE SYSTEM AND FIXED-WING AIRCRAFT CAPABILITIES IN THE JOINT TIME-SENSITIVE TARGETING PROCESS

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE
General Studies

by

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2006

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **16 JUN 2006**	2. REPORT TYPE	3. DATES COVERED

4. TITLE AND SUBTITLE **Army tactical missile system and fixed-wing aircraft capabilities in the joint time-sensitive targeting process.**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) **Henry Rogers, III**	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army Command and General Staff College,1 Reynolds Ave.,Fort Leavenworth,KS,66027-1352**	8. PERFORMING ORGANIZATION REPORT NUMBER **ATZL-SWD-GD**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**1**	**98**	

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

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ABSTRACT

ARMY TACTICAL MISSILE SYSTEM AND FIXED-WING AIRCRAFT CAPABILITIES IN THE JOINT TIME-SENSITIVE TARGETING PROCESS, by Major Henry T. Rogers III, 198 pages.

Joint publications list fixed-wing aircraft and Army tactical missile system (ATACMS) as the two preferred weapon systems for engaging time-sensitive targets (TSTs), but do not give specific considerations. This thesis comprehensively lists the capabilities and limitations of ATACMS, guided multiple-launch rocket system (GMLRS) Unitary, and fixed-wing aircraft in the six phases of the F2T2EA process: find, fix, track, target, engage, and assess. The Target Phase assessment includes deconfliction, effectiveness, responsiveness, range, accuracy, threat, and risk of employment factors. TST operations from the major combat operations of Operation Iraqi Freedom give a historical account of the performance of both weapon systems.

A capabilities analysis of fixed-wing aircraft and Army rockets and missiles provides the foundation for an attack guidance matrix that helps TST planners choose the best weapon system for a given tactical scenario. Fixed-wing aircraft employing joint direct attack munition (JDAM), laser-guided bombs (LGBs) and cannon, can engage a much wider variety of targets and their sensors are useful in the other five phases. ATACMS and GMLRS Unitary are more survivable and have the potential to be more responsive. A joint TST process needs both weapon systems, but TST planners should expect fixed-wing aircraft to engage the majority of TSTs.

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ACRONYMS

ACM	Airspace Coordination Measure
AGM	Air-to-Ground Missile
ASOC	Air Support Operations Center
ATACMS	Army Tactical Missile System
BDA	Battle Damage Assessment
BHA	Bomb Hit Assessment
BLU	Bomb Live Unit
C2	Command and Control
CA	Combat Assessment
CAS	Close Air Support
CD	Collateral Damage
CDE	Collateral Damage Estimation
EO	Electro-Optical
F2T2EA	Find, Fix, Track, Target, Engage, and Assess
FSCM	Fire Support Coordination Measure
GBU	Guided Bomb Unit
GMLRS	Guided Multiple Launch Rocket System
GPS	Global Positioning System
HARM	High-Speed Antiradiation Missile
INS	Internal Navigation System
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
JDAM	Joint Direct Attack Munition

JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JP	Joint Publication
LGB	Laser-Guided Bomb
MGM	Mobile, Guided Ground-to-Ground Missile
MLRS	Multiple Launch Rocket System
OIF	Operation Iraqi Freedom
PAH	Platoon Air Hazard
PID	Positive Identification or Positively Identify
ROE	Rules of Engagement
ROZ	Restricted Operating Zone
SDB	Small Diameter Bomb
SEAD	Suppression of Enemy Air Defenses
SOF	Special Operations Forces
TAH	Target Air Hazard
TST	Time-Sensitive Target
TV	Television
UAV	Unmanned Aerial Vehicle
US	United States
WMD	Weapons of Mass Destruction

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CHAPTER 1

INTRODUCTION

> It is firepower, and firepower that arrives at the right time and place, that counts in modern war.
>
> B.H. Liddell Hart, *Thoughts on War*, 1944

Background

Executing attacks against time-sensitive targets (TSTs) is a mission that will only gain in importance as the United States (US) continues its Global War on Terrorism. In Phase I of Operation Iraqi Freedom (OIF), the Combined Forces Air Component Commander and Commander, US Central Command categorized TSTs as leadership, weapons of mass destruction (WMD), and terrorists. Fixed-wing aircraft executed 156 interdiction missions against these targets using a special time-sensitive targeting process. The air component flew an additional 686 missions against “dynamic targets” using this same process (Mosely 2003, 9). The Army also executed TST missions. V Corps fired 109 Army Tactical Missile Systems (ATACMS) in support of the Combined Forces Land Component Commander against “immediate” targets (Kirkpatrick 2003, 13). Engaging TSTs as a joint mission provides a unity of effort across the joint battlespace and each service offers capable weapons systems.

The ability to engage TSTs rapidly and effectively is critical in today’s contemporary operating environment. TSTs characteristically have small vulnerability windows. In order to engage a TST successfully, a weapon system must be accurate, responsive, achieve the desired weapons effects, and minimize collateral damage (CD). Having weapon systems from all services available to the TST process maximizes the joint force's ability to engage these targets in minimum time with the desired weapons effects.

A joint time-sensitive targeting team must consider all assets available when matching weapon systems to targets. Each TST-capable weapon systems has specific advantages and disadvantages based on a given scenario. Unfortunately, joint publications (JPs) and other references provide only general guidance for selecting the best weapon from available joint forces assets. The purpose of this thesis is to provide a joint TST team with an accurate capabilities analysis of joint weapon systems that are most likely to engage TSTs. A TST team can then incorporate this information into an attack guidance matrix that will help them select the best weapon system for engaging a target.

Research Question

Are ATACMS better suited than fixed-wing aircraft for engaging time-sensitive targets?

As weapons systems become more accurate and versatile, fixed-wing aircraft and Army rockets and missiles provide increasingly more options for joint TST planners to choose from. The Army fires the ATACMS missile from a multiple launch rocket system (MLRS). The ATACMS missile updates its guidance via global positioning system (GPS) and can be fitted with cluster munitions or a unitary warhead. Recently, the Army introduced the guided multiple launch rocket system (GMLRS), which has a unitary warhead rather than cluster munitions. The GMLRS Unitary rocket is also GPS-guided, but its smaller 196-pount warhead reduces CD compared to ATACMS. Additionally, the GMLRS’ shorter minimum range compliments ATACMS’ area coverage.

US fixed-wing fighters and bombers employ laser-guided and GPS-guided bombs, infrared (IR) and electro-optical (EO) missiles, and cannons. The Air Force recently introduced the guided bomb unit (GBU)-39 small diameter bomb (SDB). This 250-pound class bomb is accurate and minimizes CD compared to the next-smallest 500-pound bomb body. The combination of all fixed-wing weapons systems offers the most precise and flexible options for attacking a target.

Although the end result of an ATACMS fire or a bomb dropped from a fixed-wing aircraft may be similar, there are many variables to consider when matching weapons to TSTs. Minimizing time, essential when attacking these fleeting targets, is one of ATACMS' greatest strengths. Deconflicting airspace for an ATACMS' launch, however, may significantly delay ATACMS' response times. The fastest weapon system may not be the best, as there may be excessive costs to the overall war effort if air refueling, close air support (CAS) and interdiction sorties must temporarily clear the airspace in order to deconflict from an ATACMS fire.

Not all weapons are suited for every target. GPS-guided weapons guide blindly to coordinates received prior to launch or release and therefore have great difficulty hitting moving targets. Although GPS-guided weapons are commonly referred to as "fire and forget" munitions, a TST engagement is not complete until the weapons effects can be validated. Combat Assessments (CAs) of attacks require sensors to confirm a weapon's effects in order to determine the need for a reattack. ISR platforms, targeting pod video from attacking aircraft, and visual confirmation from attacking aircraft and or Special Operations Forces (SOF) teams are examples of sensors useful for making CAs. Unlike fixed-wing aircraft, ATACMS has no capability for assessing its attacks.

Joint publications list fixed-wing aircraft and ATACMS as the primary weapons for engaging a TST, but give only general considerations for selecting one weapon system over another (JP 3-60 2002, B-10-B-11). None of the JPs address the newly fielded GMLRS Unitary and SDB munitions. These new GPS-guided weapons give both air power and the Army somewhat similar capabilities for attacking TSTs accurately with minimal CD. Since both fixed-wing aircraft and Army surface-to-surface fires have similar capabilities, a joint TST team needs clear guidance for selecting the best weapon to match to a TST.

JP 3-60 lists six factors to consider when choosing a weapon to attack a TST: deconfliction, effectiveness, responsiveness, range, accuracy, and threat (2002, B-7-B-9). When surface-to-surface missiles and fixed-wing aircraft can attain similar levels of accuracy and effectiveness against an undefended static target, responsiveness and deconfliction become key factors. The time it takes from finding a target to achieving the desired effects depends upon the availability and location of the weapon systems and the time required for coordinating and deconflicting an attack. The initial secondary question is: Under what circumstances can ATACMS coordinate, deconflict airspace, and engage a target faster compared to fixed-wing aircraft? It is possible that although an Army missile can hit the target soonest, coordination delays may result in slower response times. TST planners must also address a tertiary question of: How do airspace deconfliction measures affect the airborne missions along an ATACMS firing line?

Since few TST scenarios have perfect intelligence, no threats, stationary targets, perfect weather, and no CD issues, the analysis should evaluate ATACMS and fixed-wing aircraft against realistic tactical scenarios. It is doubtful that one weapon system is always more desirable over the other. The next secondary question addresses the expected variables in a TST engagement that highlight each weapon system's strengths and weaknesses: How will variables such as weather, collateral damage estimation (CDE) requirements, reattacks, quality of coordinates, mobile targets, and specific impact conditions influence the weapon selection process? The answers to these questions provide the framework for an attack guidance matrix that can assist a TST team in selecting the best weapon system for an engagement. The attack guidance matrix ensures the TST team has a tool or template that quickly considers the most critical factors for planning a TST attack.

Scope

The purpose of this thesis is to give sound guidance to a joint time-sensitive targeting team, operating at the Corps and or Joint Forces Air Component Commander (JFACC) level, for selecting the best weapon system when attacking a TST. This thesis focuses primarily on ATACMS and fixed-wing aircraft. It addresses the basic factors that shape the decision-making process. If the scenarios are too limited, then the TST team has a tool that is not applicable to the majority of expected scenarios. If the analysis includes every conceivable scenario and variable, then the attack guidance matrix would be too complicated to be of use.

Although new weapons with greater ranges are in development, this thesis addresses the common weapons carried by the majority of manned fighter and bomber aircraft in the current Air Force inventory. Navy and Marine fighter aircraft have similar capabilities to the Air Force fighter aircraft and therefore any conclusions can be applied to their weapon systems as well. The Air Force employs other highly capable weapon systems that work exceptionally well for attacking TSTs such as the B-2 Spirit bomber, AC-130 gunship, and the AGM-130 GPS/TV-guided munition. A joint TST team should not expect that a B-2 or AC-130 is always available or that it can immediately re-role to a TST mission. Also, the F-15E is currently the only Air Force fighter employing the AGM-130, and this asset may not always be available. This thesis does not comprehensively address the capabilities of GMLRS Unitary since its effects are similar to ATACMS but its significantly shorter range reduces GMLRS Unitary's utility in the majority of TST scenarios.

A proper assessment of a weapon system's capabilities in the TST targeting process must include a wide range of variables that are common to most TST engagements. The following considerations are included in the scope of this thesis in order to answer the primary question: deconfliction requirements, static and mobile targets, weather, requirements for CAs, flexibility and responsiveness to execute reattacks, and time required to generate GPS-quality coordinates. Results and lessons learned from Operations Enduring Freedom and Iraqi Freedom (Phase I) validate the analytical process, though technological improvements may modify some of these conclusions.

There are many factors excluded from this thesis. Operating costs and the price of the munitions do not factor into the weapon selection process since the expected value of successfully engaging a TST is higher than the cost to attack it. Conventional air-launched cruise missiles and Tomahawk land attack missiles have similar effects as ATACMS on airspace control measures (ACMs), but they are usually too far away to offer any time advantages. Since unmanned combat aerial vehicles only have quick response times if they are in the immediate vicinity of a TST and currently do not deploy in great numbers, this thesis only addresses their sensor capabilities. TSTs are divided into the two broad categories of planned or immediate targets (*Commander's Handbook* 2002, I-5). This thesis focuses only on engaging immediate or unplanned TSTs which do not give TST teams the luxury of pre-planned ACMs or preplanned fixed-wing aircraft missions.

This thesis narrowly focuses on ATACMS and fixed-wing aircraft capabilities and limitations within the TST process. The joint time-sensitive targeting process has many other areas that are currently under debate. A few of these topics include how or where the fire support coordination line should be established, who should command and control (C2) the engagement based on where the target lies in relation to the fire support coordination line, how to best integrate ATACMS and GMLRS fires into the air tasking order, the commander's role in the TST process, and how best to use emerging C2 technologies. This thesis assumes a joint TST process, but does not attempt to dictate which service owns the TST team. Further, this thesis does not address killboxes and techniques to deconflict joint fires apart from guidance found in the current JPs. Although there are many other issues involving the TST process, this thesis focuses on proper weapon selection for a TST engagement.

Significance of Study

The answer to the primary question is very important to joint operations. If a TST team determines that Army surface-to-surface missiles are primary weapons for attacking TSTs, then joint doctrine should incorporate specific guidance to reflect this. More importantly, the JFC will apportion these assets to the TST process resulting in less firepower available for the Joint Forces Land Component Commander to use at his discretion. There is also a significant impact on available airspace when launching an ATACMS through the middle of an active battlespace. Aircraft may have to disengage from CAS, air refueling, suppression of enemy air defenses (SEAD), defensive counter-air, and interdiction missions to ensure safe passage of an ATACMS. Even though an ATACMS launch may disrupt airborne missions, the operational or strategic benefit of destroying a TST is potentially worth it. A TST team needs to know at all times which weapon systems are available, most responsive, survivable, and effective for attacking potential TSTs. Therefore, determining whether ATACMS are more desirable than fixed-wing aircraft for targeting TSTs affects the priority a TST team may place on Army missiles and rockets.

Assumptions

Most of the assumptions for this thesis involve bounding the scenario sufficiently to limit the number of considerations when comparing ATACMS to fixed-wing aircraft. Since this thesis does not address future technology, one of the biggest assumptions is that the TST team has relatively the same weapons and capabilities at their disposal as when this thesis was written. Although new capabilities will quickly emerge onto the combat scene, the current capabilities of ATACMS, J-series weapons, and laser-guided bombs (LGBs) are adequate for providing a useful framework. Based on current weapons' capabilities, this thesis assumes that munitions cannot update their target coordinates once released or fired. Further, this thesis assumes there is an ongoing air campaign that may require an ATACMS battery to coordinate and deconflict before firing through manned aircraft routes and altitudes. Also reflecting actual operations, fixed-wing aircraft with the desired weapons loadout have response times that can vary from being airborne near the target to being on two hour ground alert far away from the target. A notional enemy's air defense can engage non-stealthy fixed-wing aircraft, but cannot engage individual bombs or missiles guiding to their target.

Historically, TST teams operate within the Joint Air Operations Center or within the Air Support Operations Center (ASOC) at the Corps level. This thesis assumes that a TST team has the authority to task assets without lengthy coordination with the Joint Forces Land Component Commander or JFACC operations centers. Therefore, the TST team has tactical control and engagement authority of the ATACMS assigned it, and can retask fixed-wing aircraft in flight or assign tasking to dedicated TST ground alert aircraft.

Defining Key Terms

Time-sensitive target. JP 3-60 defines a TST as "a target of such high priority to friendly forces that the JFC designates it as requiring immediate response because it poses (or will soon pose) a danger to friendly forces, or it is a highly lucrative, fleeting target of opportunity. TSTs may be planned or immediate" (2002, VII). Since it is impossible to preplan an immediate TST mission, a commander assesses his forces available and picks the best one to engage the target. TSTs that pose a significant threat "may include multiple rocket launchers, mobile long-range surface-to-air missile (SAM) systems, theater ballistic missiles (TBMs), launchers and support infrastructure, and weapons of mass destruction (WMDs). Examples of mobile high priority targets that can have a short window of vulnerability include mobile command and control (C2), leadership targets, or a terrorist vessel in international waters that is approaching territorial waters (where timeliness of response is critical)” (*Multi-Service TTPs for TST* 2004, I-1).

Time-critical target. Time-critical targets are a subset of TSTs. Time-critical targets, specified by the JFC, require immediate engagement regardless of other operational considerations such as airspace deconfliction. The *Commander’s Handbook for Joint Time-Sensitive Targeting* states that time-critical targets are so important that “immediate destruction of the surface joint time-critical target (TCT) threat outweighs the potential for friendly casualties, collateral damage, or duplication of effort” (2002, F-2). In contrast, TSTs require an immediate response, but should allow enough time for proper deconfliction and coordination.

Precision. There is no joint definition for precision and each service defines precision differently if at all. Air Force pilots require a precision munition to guide within three meters of the intended target. This definition is not consistent across all services, as JP 3-60 states that unguided cannon artillery has a precision capability although it cannot consistently achieve the same level of accuracy (2002, B-10). For the purpose of this research, precision munitions are those weapons that can guide to within 3 meters, or 9.9 feet, of their intended target more than 50 percent of the time (Tirpak 2003, 46). Examples of precision weapons are LGBs, laser-guided rockets, TV-guided munitions such as the AGM-130, and IR/EO-guided munitions such as the Maverick missile.

Near-precision. Near-precision munitions must hit within 20 meters or 66 feet of their target more than 50 percent of the time. Although most GPS-guided munitions are usually more accurate than this requirement and often impact within the precision requirements, their average miss distance is slightly outside of the precision definition

(Tirpak 2003, 46). Accuracies for specific weapon systems are often classified, but for the purposes of this thesis all GPS-guided munitions are categorized as near-precision weapons.

Weapons Development and Capabilities

In order to appreciate the problem that today's TST team has with choosing the best weapon for engaging TSTs, one must understand how weapons systems have evolved over the last fifteen years. In January 1991, the Army fielded the mobile, guided ground-to-ground missile (MGM)-140A, also known as ATACMS Block I, just in time for Operation Desert Storm. Without GPS, the Block I's internal navigation system (INS) guidance was not very accurate. Its max range of 100 nautical miles meant it could only attack close targets compared to much longer fixed-wing ranges. Finally, a payload of 950 M74 antipersonnel/antimateriel bomblets, dispersing over a 600 feet by 600 feet area (3600 square feet), made it a poor choice for surgical strikes or for minimizing CD. During all of Operation Desert Storm, the Army fired only thirty-two ATACMS missions (Directory of US Military Rockets and Missiles 2003).

Two newer variants of ATACMS saw action in 2003 as part of OIF Phase I. The MGM-140B ATACMS Block IA has GPS-aided guidance and carries a lighter payload, increasing its range out to 185 statute miles, or 162 nautical miles. Because it is more accurate, Block 1A's 275 antipersonnel/antimateriel bomblets achieve the same effects against a point target as the Block 1's 950 bomblets (Directory of US Military Rockets and Missiles 2003). Thirty-eight ATACMS Block IAs were fired in OIF (Wallace 2003). The Army fitted a unitary warhead to the ATACMS Block IA in March 2002 resulting in the MGM-140E ATACMS Block IVA. In August 2003, this missile was renamed the

MGM-168A (Directory of US Military Rockets and Missiles 2004). Its 500-pound unitary warhead combined with an upgraded GPS/INS guidance package gives the ATACMS Block IVA a near-precision capability that is on par with a basic 500-pound GBU-38 joint direct attack munition (JDAM).

In September 2005, the Army fielded the GMLRS Unitary. It incorporates a GPS-guided 196-pound unitary warhead that is capable of striking a target up to 70 kilometers away (Spacewar 2005). US soldiers in Iraq successfully fired over fifteen of these new rockets in September 2005. The munitions destroyed their targets and caused very little CD (Carden 2005). Although GMLRS Unitary rockets and ATACMS Block IVA offer a responsive, all-weather, near-precision capability to the TST process, they have no delayed fusing options. The warheads have contact-only fuses which limit their versatility for varying weapons effects. Targeteers may desire a munition that can delay its detonation until subterranean or until reaching a specific floor within a building. Also, hardened targets require delayed fusing in order to first penetrate the protective layers before detonating.

US fixed-wing air power also benefited from new technology since Operation Desert Storm. Manned fixed-wing aircraft from the Air Force, Navy, and Marines achieved precision strike in Operation Desert Storm through LGB technology that is still in use today. Pilots use IR/EO targeting pods to locate and identify targets, then fire a coded laser at the same point. A general-purpose freefall bomb fitted with a laser guidance kit guides to the reflected laser energy. An LGB has no INS or a GPS receiver and therefore cannot guide to a set of coordinates. LGBs fly an unguided trajectory until acquiring the coded laser energy reflected by the target. If an LGB never acquires the laser energy it will usually miss a small target. An LGB can effectively attack moving targets since it guides on reflected laser energy that the aircrew controls and adjusts real-time throughout the attack. A targeting pod tracks and illuminates one target at a time, which limits an aircraft to attacking only one target per pass. In Operation Desert Storm, LGBs comprised only 5 percent of the total tonnage dropped, but they accounted for nearly 50 percent of targets destroyed (US General Accounting Office 1997, 145). Since 1991, US technology has continued to update targeting pod capabilities. Almost every fighter in the Air Force inventory and even some bombers carry targeting pods. The latest targeting pods have both TV and IR sensors with much better clarity and zoom capabilities compared to ten years ago.

Laser-guided munitions are very accurate, but they are not all-weather weapons. The laser designator, usually the same aircraft dropping the bomb, desires to have a clear line-of-sight to the target from acquisition until bomb impact. Thus, an LGB is not a “fire and forget” weapon, as the laser spot must remain precisely on the target in order for the bomb to acquire the laser spot and guide to it. LGBs have delayed fusing options that can be set prior to takeoff. Pilots can take off with a variety of delayed settings in order to provide a wide range of weapons effects once airborne. Additionally, some bomb structures are designed specifically to penetrate hardened targets. Just as aircraft can carry a mixed load of fuses, they can also carry a mixed load of general purpose and penetrating bombs.

Fixed-wing aircraft’s ability to accurately strike targets in all weather conditions is realized in the J-Series weapons: JDAM, wind-corrected munitions dispenser, and joint standoff weapon. A JDAM is a general purpose or penetrating bomb fitted with a

GPS/INS guidance package. All services employing fixed-wing aircraft can employ 500, 1000, and 2000-pounds class JDAM munitions, designated as GBU-38, GBU-32, and GBU-31 respectively. JDAM have airburst, contact, and delayed fusing options that help pilots achieve specific weapons effects. The wind-corrected munitions dispenser is an INS-guided dispenser capable of carrying 202 BLU-97 combined effects munitions, which have similar effects as antipersonnel/antimateriel bomblets, but with a much lower dud rate. Since the wind-corrected munitions dispenser, designated as CBU-103 when carrying the BLU-97 combined effects munitions, is an area weapon and flies relatively small distances compared to ATACMS, its INS-only guidance is more than adequate. Additionally, a pilot can adjust a wind-corrected munitions dispenser's opening altitude and spin rate in order to achieve a specific area coverage or bomblet density. Finally, an AGM-154 joint standoff weapon is a low observable munitions dispenser with wings that give it standoff capabilities greater than 30 nautical miles. It is a GPS-guided dispenser that can carry 145 BLU-97 combined effects munition bomblets (AGM-154A), which is roughly two-thirds the payload of a wind-corrected munitions dispenser. The Navy has procured the AGM-154C, which carries a 500-pound unitary warhead. The Air Force expects to field the GBU-39 SDB in Spring 2006. This 250-pound class munition is more collateral-damage friendly compared to the heavier bombs, has increased standoff ranges, has the same accuracy of other GPS-guided weapons, and can penetrate up to six feet of reinforced concrete (Ruscetta 2005).

OIF saw extensive use of guided weapons. GPS-guided and precision-guided munitions accounted for almost 70 percent of all weapons dropped in OIF (Nider 2003). ATACMS Block IVA and J-Series weapons do have limitations, however. These weapons fly to a set of coordinates which may or may not correspond to the intended target. Barring any malfunctions, the accuracy of the coordinates has the most influence on a GPS-guided weapon's accuracy at impact. Currently, releasing on coordinates passed from a third party is usually more accurate than using ownship sensors to derive a target's coordinates. In OIF, most J-series weapons guided to coordinates supplied to the aircrew by the Combined Air Operations Center. The newer targeting pods in OIF were accurate enough for a limited capability to strike targets with GPS-guided weapons. In 2004, the Air Force F-16s successfully used a Sniper targeting pod to derive coordinates accurate enough for near-precision JDAM deliveries (Henry Rogers 2004). Joint warfighters should expect that most fixed-wing fighters and bombers will have this capability within a few years.

GPS-guided weapons cannot effectively engage mobile targets. LGBs, guided air-to-ground missiles, aircraft cannon, or SOF assets can best engage mobile targets or targets without accurate coordinates. Therefore, weapons that do not depend on accurate coordinates should always be available for potential TST missions in order to prevent unnecessary delays waiting for precise coordinates. Most fixed-wing aircraft that carry a targeting pod can easily fly with a mixed load of LGBs and J-series weapons, providing maximum flexibility. Additionally, most fixed-wing fighter aircraft have an internal gun.

Army missiles and rockets and fixed-wing aircraft both have responsive and accurate weapon systems capable of engaging TSTs. This variety provides a TST team with multiple suitable weapons to choose from. Since each weapon system has unique capabilities and limitations for a given TST scenario, a TST team needs specific guidance for determining how to select the best weapon system.

CHAPTER 2

LITERATURE REVIEW

Overview

This literature review explains how fixed-wing aircraft and ATACMS fit into the Time-Sensitive Targeting process. It builds a common understanding of each system's capabilities that forms the foundation used in the analysis. Numerous JPs discuss the TST process and give general considerations for weapon selection. A proper analysis, however, requires a more complete understanding of fixed-wing aircraft and ATACMS capabilities and limitations. Although future TST engagements will certainly benefit from emerging technology, understanding the TST process in OIF adds credibility to the assumptions and the analysis. Finally, many articles and theses give insight and opinions helpful to understanding the TST process. The literature review describes the Joint TST process, discusses specific weapons systems' capabilities, addresses the historical use of ATACMS and fixed-wing aircraft in the TST process during OIF, and discusses the opinions and insights of other authors.

Time-Sensitive Targeting Process

Weapon selection for engaging a TST is a small part of the overall Time-Sensitive Targeting process. A quick overview of this process shows where fixed-wing aircraft and Army rockets and missiles play their part. There are four primary JPs that discuss the TST process: JP 3-60, *Joint Doctrine for Targeting*, dated 17 January 2002; *Commander's Handbook for Joint Time-Sensitive Targeting*, dated 22 March 2002; *Multi-Service Tactics, Techniques, and Procedures for Targeting Time-Sensitive Targets*, dated April 2004; and JP 3-09, *Joint Fires* Revised First Draft, dated 7 September 2005. The time-sensitive targeting process is a part of the Joint Targeting Cycle Phases described by JP 3-60 (see table 1).

Table 1. Time-Sensitive Targeting Process Correlation to Joint Targeting Cycle

	Joint Targeting Cycle Phases	**JP 3-60 Time-Sensitive Targeting Cycle Steps**	**MTTP Time-Sensitive Targeting Process Phases**
Correlation	I. Commander's Objectives, Guidance, and Intent	Commander's TST Guidance	Commander's TST Guidance
	II. Target Development, Validation, Nomination, and Prioritization		
	III. Capability Analysis		
	IV. Commander's Decision and Force Assignment		
	V. Mission Planning and Force Execution	DETECT LOCATE IDENTIFY DECIDE STRIKE	FIND FIX TRACK TARGET ENGAGE
	VI. Combat Assessment	ASSESS	ASSESS

Source: Air Land Sea Application Center, FM 3-60.1, MCRP 3-16D, NTTP 3-60.1, AFTTP(I) 3-2.3, *TST: Multi-Service Tactics, Techniques, and Procedures for Targeting Time-Sensitive Targets* (Fort Monroe, VA: Headquarters TRADOC, Quantico, VA: Headquarters MCCDC, Newport, RI: NWDC, Langley AFB, VA: Headquarters AFDC, 2004), I-3.

The Joint Targeting Cycle requires too much time to effectively prosecute a TST, which may have a vulnerability window of only minutes. Therefore, Phases I through IV of the Joint Targeting Cycle "collectively produce the Commander's TST guidance, which sets the boundaries for the time-sensitive targeting process" (*MTTPs for Targeting TSTs* 2004, I-2). The rest of the Time-Sensitive Targeting process occurs within Phases V and VI. JP 3-60 and the *Commander's Handbook*, both produced in 2002, describe the TST targeting cycle with the following steps: "detect, locate, identify, decide, strike, and assess (DLIDSA)" (JP 3-60 2002, B-2). *MTTPs for Targeting TSTs* and JP 3-09 are newer and list the six steps as "find, fix, track, target, engage, and asses (F2T2EA)" (2004, I-4). Where JP 3-60 and the *Commander's Handbook* do little more than list the steps of the "compressed decision cycle," *MTTPs for Targeting TSTs* describes each step of F2T2EA in detail (see figure 1). It includes all of JP 3-60's targeting cycle steps and adds additional steps specific to TSTs (2004, I-2-I-3). This thesis uses the time-sensitive targeting process found in *MTTPs for Targeting TSTs*, also referenced in the new JP 3-09, to evaluate how Army missiles and fixed-wing aircraft perform in the TST process.

Army missiles and fixed-wing aircraft play their biggest roles in the Target and Engage Phases of the TST process. Unlike ATACMS, fixed-wing aircraft have sensors that can contribute to the other phases. The Find Phase and makes use of any sensor that can detect a potential TST. This includes all sensors from SOF on the ground to traditional ISR assets in the air such as UAVs, the U-2, and satellites. This list also includes fixed-wing aircraft with air-to-ground radar and targeting pods. In OIF, for example, F-16s and F-15Es were tasked with strike coordination and reconnaissance missions where pilots primarily used their targeting pods to find targets (McGee 2005, 17).

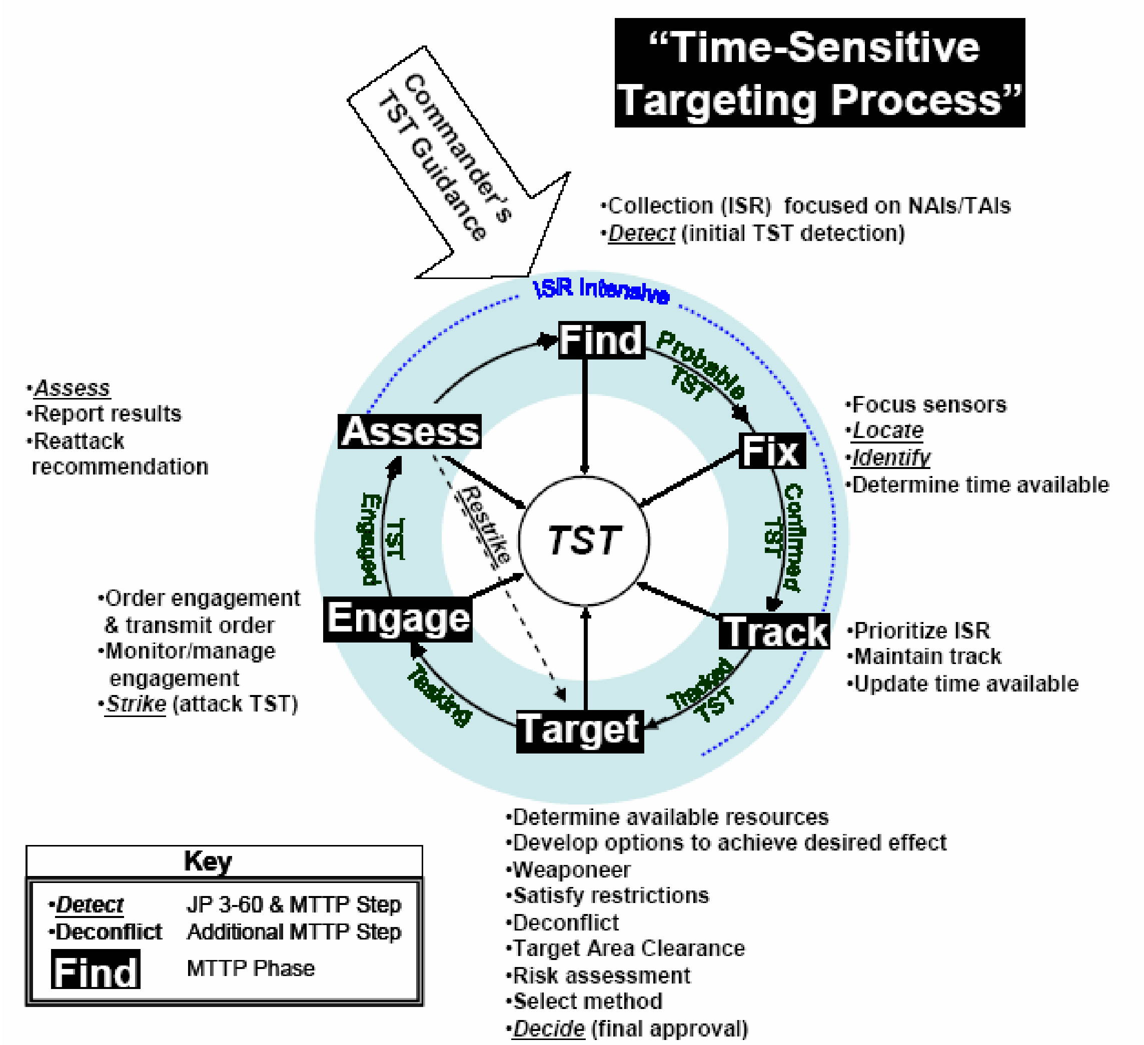

Figure 1. Time-Sensitive Targeting Process Phases
Source: Air Land Sea Application Center, FM 3-60.1, MCRP 3-16D, NTTP 3-60.1, AFTTP(I) 3-2.3, *TST: Multi-Service Tactics, Techniques, and Procedures for Targeting Time-Sensitive Targets* (Fort Monroe, VA: Headquarters TRADOC, Quantico, VA: Headquarters MCCDC, Newport, RI: NWDC, Langley AFB, VA: Headquarters AFDC, 2004), I-4.

The Fix Phase focuses sensors to identify, classify, and confirm that a potential target meets TST criteria. *MTTPs for Targeting TSTs* states "optimally, ISR assets should provide both operators and intelligence analysts with the capability to identify stationary and mobile targets, day or night, in a timely manner in all weather, all terrain, camouflage, concealment, deception (CCD) environments to the degree of accuracy required by the engaging weapon systems" (2004, I-6). The Track Phase coordinates sensors to maintain continuous track of a target until the desired effect on the TST is confirmed. If the track is lost, the Find and Fix Phases most likely have to be re-accomplished (*MTTPs for Targeting TSTs* 2004, I-5-I-6). Fixed-wing aircraft complement traditional ISR assets in the Fix and Track Phases by providing additional sensors to help identify and maintain track of TSTs.

The Target Phase focuses on the primary thesis question. This phase matches weapons to desired effects and includes many time-consuming tasks that TST planners must accomplish before selecting a weapon system. In addition to weaponeering the attack and choosing the most appropriate weapon, *MTTPs for Targeting TSTs* states that the Target Phase must consider "collateral damage (CD) guidance, WMD consequence of execution (COE), rules of engagement (ROE), law of armed conflict (LOAC), no-strike list (NSL), restricted target list (RTL), component boundaries, fire support coordinating measures (FSCMs), etc." (2004, I-6-I-7). Additionally, planners must assess weather, potential for fratricide, cost of diverting and or deconflicting assets, target coordinate accuracy, attack restrictions, target area threat, the availability of supporting assets such as tankers and SEAD aircraft, and the availability of the desired weapon system itself. TST planners can begin to assess these considerations in the early phases and complete them in parallel to reduce time (*MTTPs for Targeting TSTs* 2004, I6-I-7).

The Engage Phase begins after TST planners match the weapon system to the approved TST. Orders must be passed to, received, and understood by the selected weapon system. The C2 assets monitor and assist the engagement while the weapon system focuses on achieving the desired effects on the target. Once the engagement is complete, the Assess Phase ensures that the attack achieved the desired effects. "[Combat] Assessments of TST engagements are conducted to provide quick results and to allow for expeditious reattack recommendations, and therefore likely will not be as rigorous as traditional CAs" (*MTTPs for Targeting TSTs* 2004, I-7-I-8).

Considerations For Attacking TSTs

JPs offer limited guidance for matching a weapon system to a TST. JP 3-60 states that a TST team should consider deconfliction, effectiveness, responsiveness, range, accuracy, and the threat. It also states that the JFC may provide guidance to assist component commanders in choosing their best weapon for engaging TSTs, and suggests using an attack guidance matrix to expedite decisions (JP 3-60 2002, B-8-B-9). Unfortunately, JP 3-60 does not provide a template or give an example of an attack guidance matrix. *The Commander's Handbook for Joint Time-Sensitive Targeting* also lists six considerations for attacking TSTs, replacing deconfliction with "associated risks of employment" (2002, IV-2). Combining these two lists results in the following seven considerations: deconfliction, effectiveness, responsiveness, range, accuracy, threat, and associated risks of employment.

Deconfliction

Deconfliction involves the coordination between friendly forces to prevent mid-air collisions and fratricide. A detailed knowledge of the friendly positions on the ground combined with clear deconfliction procedures in the air helps prevent fratricide. ACMs, FSCMs, and real-time positive control deconflict aircraft from ATACMS, MLRS, and from each other. These coordinating measures have the potential to delay a launch until the airspace is clear, deny entry into the airspace until coordinated, or require attacks along a specific axis. *MTTPs for Targeting TSTs* states that an ATACMS' flight characteristics differ from cruise missiles or MLRS rockets allowing for more simplified airspace deconfliction and coordination. "The high angle of launch and impact, along with a very high altitude flight path, does not require large amounts of airspace to be deconflicted prior to firing" (*MTTPs for Targeting TSTs* 2004, E-8).

Units firing ATACMS deconflict their missile trajectories through the use of Platoon Air Hazards (PAH) and target air hazards (TAHs). The PAH is a preplanned volume of airspace extending horizontally and vertically around ATACMS launchers (see figure 2). A PAH is doctrinally a 3-by-3 kilometer horizontal box around the ATACMS site, and the altitude varies based on the type of ATACMS being fired. A similar volume of airspace called a TAH helps deconflict the target area (see figure 3). The exact size of the TAH depends on the munition and the range to the target. The Battlefield Coordination Detachment, located at the Joint Air Operations Center, should ensure that the PAHs and TAHs are deconflicted and integrated with the air tasking order. These airspaces often integrate into the airspace control order in the form of a restricted operating zone (ROZ). The dimensions and activation times will appear on the airspace control order so aircrew can deconflict when planning their missions (ST 6-60-30 1999, 17, 20).

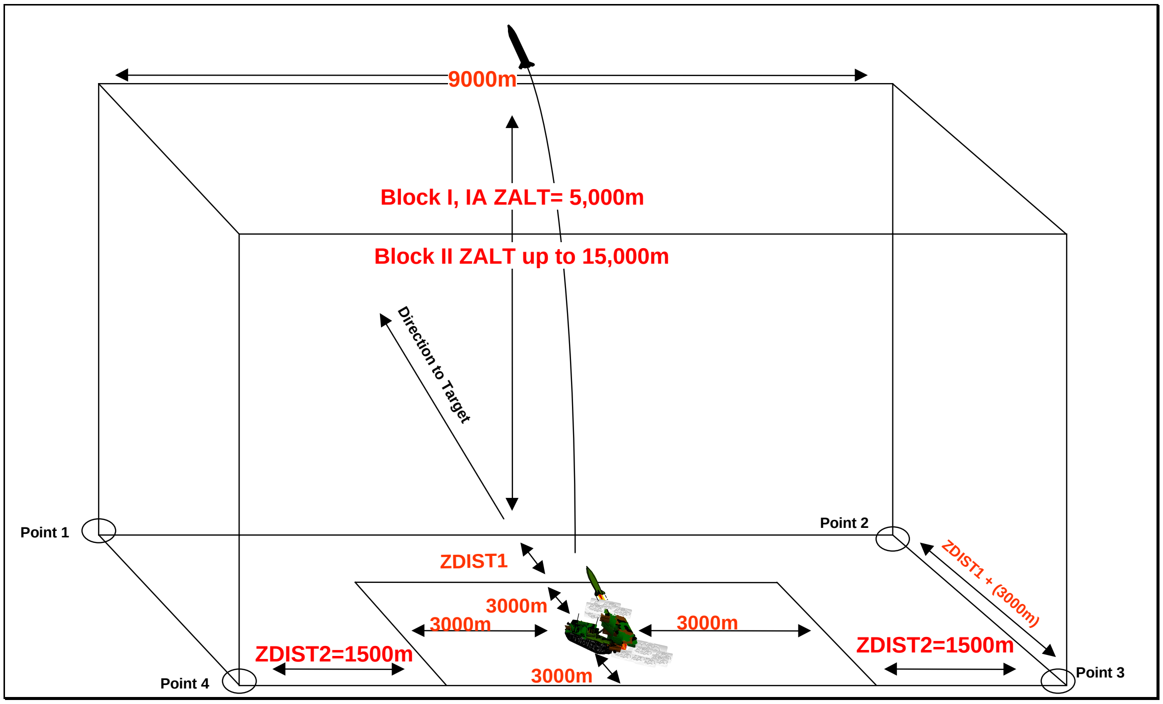

Figure 2. Army Tactical Missile System Default Platoon Air Hazard
Source: US Army Field Artillery School, ST 6-60-30, *The Army Tactical Missile System (Army TACMS) Family of Munitions (AFOM): Tactics, Techniques and Procedures (TTP)* (Fort Sill, OK: Government Printing Office 1999), 20.

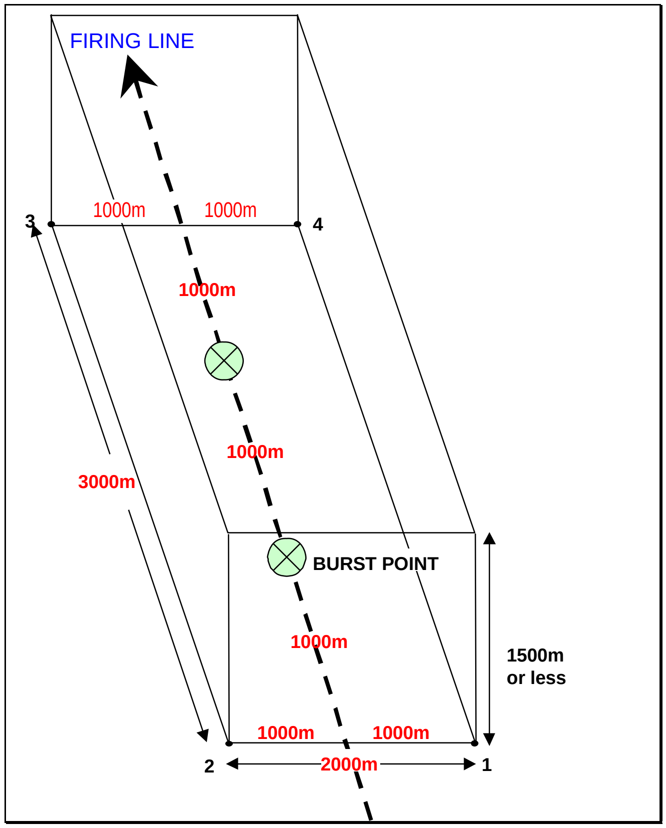

Figure 3. Army Tactical Missile System Default Platoon Air Hazard
Source: US Army Field Artillery School, ST 6-60-30, *The Army Tactical Missile System (Army TACMS) Family of Munitions (AFOM): Tactics, Techniques and Procedures (TTP)* (Fort Sill, OK: Government Printing Office, 1999), 21.

The ATACMS missile location message generates the flight profile of an ATACMS from the PAH to the TAH. It provides a list of eight coordinates that define the missile's trajectory. This flight trajectory creates no ROZ, is not deconflicted with the air tasking order, and requires real-time flight path deconfliction between the PAH and TAH prior to launch. ST 6-60-30 states, "The trajectory of [ATACMS] variants is for the most part above the normal flight altitudes of attack aircraft operating behind friendly lines, and in designated target areas" (1999, 21). The notional altitude of an ATACMS Block IA PAH is 4,600 meters or 15,100 feet. This is not sufficient as aircraft routinely fly above 15,000 feet. The notional TAH for ATACMS Block IA only goes up to 5,000 feet (ST 6-60-30 1999, 21). Real time deconfliction prior to an ATACMS launch or higher PAHs and TAHs are necessary as the notional PAHs and TAHs do not adequately deconflict an ATACMS trajectory from aircraft above them.

The Time-Sensitive Targeting process expects to real-time deconflict airspace prior to an ATACMS launch against a TST. Although an ATACMS unit may have a permanently activated PAH ROZ on the airspace control order, an emerging TST does not have a previously coordinated TAH so TST planners expect to always deconflict part of an ATACMS fire. Establishing a PAH ROZ is still beneficial to the TST process. It helps simplify planning, maximizes an ATACMS' responsiveness, and gives all service components visibility to its location via the air tasking order and airspace control order. The disadvantage of a standing PAH ROZ is that, regardless of whether the ATACMS fires or remains silent, its ROZ continuously restricts airspace that could be used by other assets.

Effectiveness

The capability and flexibility of a weapon system determines its effectiveness. The basic question is, Can the weapon achieve the desired effects? The target area environment and the target itself dictate which weapon can most effectively engage a TST. Urban targets may require that a bomb bury itself beneath the surface before detonating in order to reduce collateral damage. Hardened targets require a munition to penetrate a protective barrier before detonating. GPS-guided weapons are generally ineffective against mobile targets. TST planners must also consider the size of a warhead's blast and any specific impact azimuth or impact angle requirements. Further, the ROE may require Positive Identification (PID) of the target prior to weapons release. Although area coverage submunitions can compensate for some coordinate inaccuracy or for moving targets, they do little to minimize collateral damage. Finally, some TSTs may require SOF direct action (JP 3-60 2002, B-8). TST planners must have detailed knowledge of the capabilities of each weapon system in order to select the most effective asset against a TST.

Responsiveness

Responsiveness determines how quickly a weapon can engage a TST. This is a critical factor in the TST process due to small windows of vulnerability normally associated with TSTs. Responsiveness measures the time it takes from initiating the strike order to weapon impact or effects. This includes the time required to communicate with the attacking weapon system and the time required to deconflict the airspace. A weapon system's responsiveness also includes its ability to operate in the target area. Poor weather conditions, for example, may prevent the employment of cannon or LGBs.

Range and Accuracy

Army missiles and rockets have fixed maximum ranges, while fixed-wing aircraft have variable ranges based on their configuration and the availability of air refueling. A weapon system's accuracy is also relatively constant, although personal pilot ability and proficiency directly affect cannon and unguided bomb attack accuracy. GPS-guided weapons are near-precision weapons and are very capable at guiding to their given coordinates.

Threat and Associated Risks of Employment

The target area threat may prevent manned fixed-wing aircraft from getting close enough to the TST to deliver their weapons without excessive risk from enemy defensive systems. If an ATACMS is out of range or cannot achieve the desired weapons effect, low observable stealth aircraft or conventional aircraft with dedicated SEAD assets can potentially reduce the risk to acceptable levels. Associated risks of employment refer to a weapon system's ability to minimize collateral damage and the risk of fratricide. Other employment risks include the cost to the air campaign of diverting aircraft away from assigned missions and the cost of not attacking a preplanned target in order to retask an asset to engage a TST.

Limiting collateral damage is a significant constraint when selecting a weapon system. CD is the “unintended physical damage to noncombatant persons or property occurring incidental to military operations” (*MTTPs for Targeting TSTs* 2004, IV-5). It is always an important consideration as excessive CD can have negative strategic consequences. *MTTPs for Targeting TSTs* states “satisfying published TST restrictions can be a time consuming process that has the potential to delay TST engagement approval significantly if coordination, target development, and planning are not conducted as early as possible in the time-sensitive targeting process” (2004, V-5). In some cases, the shooter may be authorized to make an initial CD estimate. A pilot would simply sanitize the area around the target to ensure no civilian structures or personnel are located within “XX” feet from the expected point of impact--“XX” determined by weapon and fusing type. Although rudimentary, this type of CD risk assessment greatly expedites the Target Phase.

Target areas in urban terrain may require additional coordination and time to complete CDE. “Precise location (mensuration) of urban area targets is essential for lethal weapon targeting and for CDE accomplishment, possibly an extremely time-consuming process (e.g., often, larger yield weapons cannot be used to make up for imprecise target coordinates)” (*MTTPs for Targeting TSTs* 2004, V-6). It is also more difficult to maintain certainty of friendly and noncombatant forces in urban areas, compounded by small target windows of vulnerability. Finally, urban areas can restrict certain weapons in order to minimize CD (*MTTPs for Targeting TSTs* 2004, V-5-V-8). For example, high yield, freefall munitions, or weapons without delayed fuse settings may be restricted from employment in urban areas.

MTTPs for Targeting TSTs includes a TST Checklist in Appendix C that covers all six phases of the TST process, but it does not include a comprehensive list of considerations for selecting the best weapon system for a TST engagement. The Target Phase checklist eventually covers most of the aforementioned considerations, but it is not conducive for selecting the best weapon the first time. For example, the checklist does not consider the threat, potential for collateral damage, or the potential for fratricide until after matching the weapon to the target and requesting a re-role or assignment of forces (*MTTPs for Targeting TSTs* 2004, C-9).

Weapons Comparison

The JPs list advantages and disadvantages of surface-to-surface systems, cruise missiles, rotary-wing aircraft, fixed-wing aircraft, and SOF in relation to the TST process. JP 3-60 identifies surface-to-surface systems and fixed-wing aircraft as generally the best weapon systems for engaging TSTs due to their responsiveness, range, and accuracy

(2002, B-10-B-11). *The Commander's Handbook for Joint Time-Sensitive Targeting* states, "coordinated ATACMS and air attacks are USCENTCOM's [United States Central Command's] preferred methods of engaging joint TSTs" (2002, B-2). *MTTPs for Targeting TSTs* identifies the same weapon systems, but includes more details and specifically lists advantages and disadvantages of each weapons system. *MTTPs for Targeting TSTs* states the following about manned fixed-wing aircraft:

> c. **Manned Aircraft**. Due to their range, speed, and flexible weapon selection, manned aircraft are well suited to attack TSTs. Because the aircrew can provide "eyes on" during the attack, manned aircraft are of particular advantage when attacking mobile targets or when exact target coordinates are unavailable. However, a permissive threat environment or SEAD may be required to avoid unacceptable risks to aircraft and aircrews. Rapid deconfliction of airspace can be a challenge in a congested environment. Manned aircraft possess both day and night capability, but are weather-dependent and fuel dependent. (2004, E-9)
>
> (2) Fixed-Wing Aircraft. The ability of fixed-wing aircraft to move long distances in relatively short times, along with their component coordination and control capabilities, provides the force with the flexibility to quickly mass throughout the battlespace. Weapon payloads (to include nonlethal systems such as jammers) can be adjusted to suit the mission, and with air refueling they are capable of extended loiter times. If needed, these assets can be quickly diverted in-flight to a new target as long as suitable communications links are available. (2004, E-9)

Weather can significantly effect LGB, Maverick and cannon employment, but has little effect on GPS-guided munitions employment. Overall, *MTTPs for Targeting TSTs* lists fixed-wing aircraft advantages as having range, rapid response times, and accuracy. Disadvantages include inclement weather flying restrictions and vulnerability to enemy fire (2004, E-9).

The JPs do not address the Army's near-precision GMLRS Unitary rocket or the GPS-guided ATACMS Block IVA unitary missile. Including the latest weapons capabilities, Army rocket and missile advantages include accuracy, all-weather capability, rapid response time, and wide area coverage. Their disadvantages include limited effectiveness against hardened or moving targets, high antipersonnel/antimateriel submunition dud rates, and airspace deconfliction requirements (*MTTPs for Targeting TSTs* 2004, E-8).

The JPs value the rapid response time and accuracy of both fixed-wing aircraft and Army rockets and missiles. They give the nod to fixed-wing aircraft when engaging hardened and mobile targets, targets beyond the 162 nautical mile maximum range of ATACMS, and during times of congested airspace. The JPs give the advantage to ATACMS when attacking a TST in a high-threat area and in inclement weather.

Time-Sensitive Target Process in Operation Iraqi Freedom

OIF Phase I provides an excellent case study of the TST targeting process. Where doctrine can be nebulous, actual TST missions engaged by ATACMS and fixed-wing aircraft in OIF give hard data concerning the responsiveness and effectiveness of these weapon systems in a relatively current technological state.

In OIF, the Combined Forces Air Component Commander flew a total of 842 missions against dynamic and time-sensitive targets using the F2T2EA process (Mosely 2003, 9). The Combined Forces Land Component Commander fired a total of 109 ATACMS Block I/IA as TST missions. Although the ATACMS Block IVA unitary missiles were in theater, all thirteen Block IVA fires engaged preplanned targets (Kirkpatrick 2004, 12-13). In total, the joint forces executed 951 missions in OIF using the TST process.

Minimizing collateral damage was very important in OIF and efforts to minimize CD often slowed the F2T2EA process. Lt Col McGee, an Air Force officer who worked in the ASOC for V Corps during OIF, explains:

> Essentially, the CDE matrix was a set of rules published by CENTCOM that dictated how close to a civilian structure or restricted target ordnance could be employed. There were different levels of analysis required depending on the type of target and the type of civilian structures surrounding that target. At a very basic level, there were published "no closer than" distances for given types of ordnance. If a target was closer than the specified distance to a civilian structure, a computer software program was required to further analyze the weaponeering in an attempt to satisfy the CDE restrictions. Pilots did not have access to these programs once airborne. Also, there were thousands of restricted targets throughout Iraq. These targets were off limits due to religious or civil sensitivities, or due to their importance for the rebuilding of Iraq in Phase IV. Pilots would only know which buildings were civilian, military, or restricted for preplanned missions. If they were diverted to another target in another part of Iraq, pilots would typically not have this level of detail in the cockpit. (2005, 12)

Coordinates with low target location errors are highly desirable for all engaging platforms and are required for GPS-guided weapons. ATACMS Block IA/IVA, GMLRS Unitary, and J-series weapons are only as accurate as the coordinates given to them. In OIF, high accuracy coordinates were obtained via "an on-call Raindrop team, a highly rectified (accurate) graphic, or through a targeting pod capable of generating low TLE [target location error] coordinates" (McGee 2005, 53). Raindrop fused data from multiple sources and required a trained technician to operate the system in order to determine mensurated 3-D coordinates with a very low target location error. In 2001, the Raindrop system could provide mensurated coordinates within ten minutes (Basham 2001, 29). During OIF, the process took only five minutes (McGee 2005, 41).

Army Tactical Missile System Operations in Operation Iraqi Freedom

ATACMS performed very well in OIF. The 4th Air Support Operations Group concluded that "Army ATACMS were an effective and responsive SEAD asset. The two massive V Corps/ASOC planned volleys significantly degraded the Baghdad missile engagement zone, thereby allowing efficient CAS operations in and around the city" (Kirkpatrick 2004, 12). A total of 109 ATACMS Block I/IA were fired as SEAD missions and 77 ATACMS were fired in support of the First Marine Expeditionary Force (Kirkpatrick 2004, 11-13).

The many deconfliction requirements were obstacles to integrating ATACMS into the joint battlespace. In OIF Phase I, ATACMS PAHs grew to a 7 by 7 kilometer area and extended up to 60,000 feet (3rd Infantry Division 2003). The higher altitude of these PAHs adequately deconflicted ATACMS from fixed-wing aircraft. The PAHs were always in effect, which led to the establishment of a ROZ around the MLRS positions. Although the ATACMS ROZ "was pre-established for the supposed ease of planning, this in reality only made it more difficult at the executor level. Air routes had to be planned around the MLRS position areas, including FARPs [forward air refueling points] being positioned far from the PAHs" (3rd Infantry Division 2003). Even with an established ATACMS PAH ROZ, the TAH and missile flight trajectory had to be real-time deconflicted before firing. In his article "The Miracle of Operation Iraqi Freedom Airspace Management," Wathen writes that "this deconfliction methodology uses huge amounts of airspace, a precious commodity in the already crowded battlespace. Furthermore, preplanned ATACMS launches are rare and normally originate during the

Execution Phase of the ATO [air tasking order] requiring an enormous amount of coordination to maintain a safe airspace" (2005).

The process of deconflicting airspace for ATACMS missions in OIF did not adversely affect the responsiveness of the weapons system. In Operation Desert Storm it took over an hour to process and clear the airspace for an ATACMS mission, but in OIF the average time was only seven minutes (Carter Rogers 2004, 59). V Corps determined a slightly different time, stating that "by coordinating with the ASOC, the Fire and Effects Coordination Cell (FECC) team was able to clear the airspace and the ground and the ASOC was able to divert the aircraft within 15 minutes" (V Corps 2004, 13-14).

OIF uncovered other negative aspects concerning using ATACMS in the time-sensitive targeting process. There were fewer ATACMS platoons in OIF compared to other artillery systems, and potential TST missions further limited their use. For example, the 2-4 Field Artillery unit essentially lost one third of its assets since it dedicated six of its eighteen launchers as TST shooters (3rd Infantry Division 2003). The inability for ATACMS to provide any CA of its attacks occasionally left the time-sensitive targeting process incomplete. In these cases, an asset capable of providing timely CA of the attack had left the area prior to the ATACMS launch for deconfliction purposes or had been retasked. The TST cell in OIF that initiated the engagement occasionally never received feedback from the attack. In these cases, the TST team assumed that the GPS-guided munition hit the proper coordinates and that the coordinates correctly corresponded to the desired target (Nelson 2005).

Fixed-Wing Operations in Operation Iraqi Freedom

Fixed-wing aircraft executed the majority of missions against time-sensitive and dynamic targets in OIF. Unlike ATACMS, manned fixed-wing aircraft participated in all six phases of the time-sensitive targeting process. For example, the V Corps/ASOC often tasked aircraft with targeting pods to identify and track "suspect" tracks detected by an E-8 joint surveillance target attack radar system, also known as JSTARS. Lt Col McGee writes:

> Many times, data from the national intelligence resources was not accurate enough for targeting; the geo-location was not specific enough to allow an attack. For example, an intelligence asset may find a target, but only be able to locate it within a 500-meter target location error (TLE). In these cases, the ASOC would send a SCAR [strike coordination and reconnaissance] aircraft to the general location and direct a search for a specific target type in the detected area. (2005, 22)

Fixed-winged aircraft's assortment of munitions proved very valuable in the TST Engage Phase. The complexity of targeting in an urban terrain and the lack of time available for extensive talk-ons led to the JDAM as the preferred munition against stationary targets. The all weather munition was ideally suited for prosecuting TSTs when accurate coordinates were available, but collateral damage was initially a problem for the large warheads exploding in urban areas. Only 1,000 and 2,000-pound JDAMs were available in OIF, as the 500-pound GBU-38 JDAM did not become operational until after OIF Phase 1 (Allison 2004). The buried JDAM CAS technique fixed this problem. This technique "consists of 90 degree impact JDAMs with a delayed fuse. The length of the delay fuse was based on the building height; burying the bomb deep enough to 'muffle' the detonation, but not too deep so as not to achieve the killing mechanism.

Damage to surrounding buildings was significantly reduced by using this technique" (McGee 2005, 27-28).

JDAM was a proven weapon in OIF. Unlike with ATACMS, pilots can specify a JDAM's impact parameters. Ninety-degree impact angles are normally used to help reduce vertical target location error and ensure good penetration in the case of the buried JDAM technique. If the target is a vertical such as a cave entrance for example, the pilot can specify the final attack heading, minimum airspeed, and impact angle. The GPS receiver unit location makes JDAM resistant to GPS jammers. This was proven true in OIF when a JDAM successfully destroyed a GPS jammer (F-16.net 2005). JDAM is also a true all-weather weapon. In the fight near An Najaf on 26-27 March 2003, the 3-7 CAV was surrounded by enemy troops during the sandstorm. In this two-day period of fighting, 182 CAS sorties dropped JDAM through the weather to provide "the lion's share of support" (Fontenot et al. 2003, 209). General Franks, Commander, United States Central Command during OIF, comments that "B-52s, B-1s, and a whole range of Air Force, Marine, and Navy fighter-bombers would be flying above the dense ochre dome of the sandstorm, delivering precision-guided bombs through the zero-visibility, zero-ceiling weather. I was confident that we were looking at the end of organized Iraq resistance" (2004, 503).

Fixed-wing aircraft employed many other types of weapons in OIF. In urban areas such as Baghdad, aircraft dropped LGBs with delayed fusing and fighters often employed their gun against very low collateral damage tolerant targets (McGee 2005, 27-28). Fixed-wing aircraft engaged mobile targets with Maverick missiles, LGBs, and the gun.

Compared to ATACMS, fixed-wing aircraft possessed the only capability to engage mobile TSTs.

Fixed-wing aircraft also provided a variety of non-traditional ISR sensors that were useful in all phases of the TST process. Experiences in OIF and Operation Enduring Freedom proved that it is necessary to utilize fighters' targeting pods, HARM targeting system pods, and radar warning receivers to aid in the Find, Fix, Track, and Assess Phases. Involving the shooter in the early phases, especially when the shooter can accomplish CDEs, decentralizes the process which increases responsiveness. "Operation ALLIED FORCE, recent exercises, OEF [Operation Enduring Freedom], and OIF experiences point to dramatic improvements in timeliness by decentralization of TST engagement authority and decision making to the lowest level possible" (*MTTPs for Targeting TSTs* 2004, IV-4). Performing CAs immediately after an attack, especially when using GPS-guided weapons, is critical to determine if a re-attack is required. OIF experiences showed that "keys to successful, timely assessments include . . . expedited feedback from shooters/sensors to the TST Cell and ISR Cell" (*MTTPs for Targeting TSTs* 2004, IV-3). *MTTPs for Targeting TSTs* summarizes the TST assessment process with the following:

> (1) Lack of adequate assessment following engagement can also mean that resources are unnecessarily tasked to stand by or seek possibly inoperative or destroyed targets. Combat assessment is supported by a number of sources (including the time-sensitive targeting assets themselves) most of which are used to corroborate other information. (2004, V-10)
>
> (2) In the case of decentralized execution, the time-sensitive targeting mission may require the engaging platform to provide initial combat assessment using its own sensor and intelligence resources. (2004, V-10)

Fixed-wing aircraft in OIF had varying response times when re-roled to engage a TST. Referencing the area in and around Baghdad, V Corps/ASOC prosecuted eighteen TST attacks averaging eighteen minutes per attack (Kirkpatrick 2004, 11). Lt Col McGee said "it was an easy transition to attack the TST target in a very short timeline" (2005, 62). Of the fifteen TST air strikes that Cordesman evaluated in *The "Instant Lessons" of the Iraq War: Main Report*, he noted that retargeting aircraft to new targets took "from minutes to two hours" (2003, 133).

The variety of sensors, munitions, and fuse settings found on fixed-wing aircraft potentially results in plenty of available air assets with none having the desired configuration. For example, F/A-18s carried the limited-capability NITEHAWK targeting pod that could not identify small targets from medium altitude (McGee 2005, 34). Additionally, only one F-16CJ squadron carried targeting pods and LGBs in OIF. Additionally, the remainder of the F-16CJ squadrons carried HARM targeting system signals-collection pods and no LGBs. The other F-16 variants (F-16C+, F-16CG) carried targeting pods, but with differing capabilities. Even if the TST team identified an aircraft with the desired sensors and munitions, there was no guarantee that it had the correct fuse setting. The Combined Air Operations Center fixed this problem for CAS operations by tasking enough units to ensure there were always enough airplanes in the sky with a mixture of weapons and fuses that could handle any situation. Duplicating this scenario for a potential TST engagement at an unpredictable time and place is not feasible except under the very best of circumstances, so TST planners need to coordinate for the correct sensor and weapon as soon as they identify a potential TST.

Others' Research

Many professional officers from the armed services have written theses discussing the use of ATACMS, GPS-guided weapons, and all aspects of the time-sensitive targeting process. Most authors focused on topics other than weapons selection such as airspace coordination, placement of the fire support coordination line, the commander's role in the TST process, the effects of decentralizing the TST process, and C2 concerns. Several of the authors made direct comparisons between fixed-wing aircraft and ATACMS.

Major Moskal's monograph titled "The Role of ATACMS in JFACC Planned Deep Operations" compares the capabilities of fixed-wing aircraft with ATACMS in joint fires. Although he made his assessments in 1995, many of them remain valid today. Regarding effectiveness, Major Moskal, an Air Force officer who wrote his monograph while attending the Army School of Advanced Military Studies, states that the wide variety of munitions carried by fixed-wing aircraft allows them to engage a greater variety of targets compared to ATACMS. He concluded that ATACMS is more responsive if it is already established in theater and no fixed-wing aircraft are airborne, "but this is not the case if an aircraft that is in flight can be used to service the target" (1995, 27). Finally, Major Moskal states that ATACMS require a non-hardened, stationary target with precise coordinates (1995, 27-28).

Major Carter Rogers, an Army officer who graduated from the Army Command and General Staff College in 2004, evaluated the capabilities of ATACMS, rotary-wing aircraft, fixed-wing aircraft, and cruise missiles in the TST arena. He used most of the criteria listed in the *Joint Commander's Handbook for Joint Time-Sensitive Targeting* and developed a matrix to declare one weapon system as the best for engaging TSTs. In his thesis “Army Tactical Missile System: Revolutionary Impact on Deep Operations,” Major Carter Rogers only considered the Engage Phase of the TST process and did not assess the synergistic effects of using the sensor as a shooter throughout all six phases of the TST process (2004, 49-56).

Major Carter Rogers cited Baker’s article to conclude that fixed-wing aircraft cannot provide joint, responsive fires under extreme weather conditions. Baker, an imbedded reporter in OIF, states that “a dust storm shut down Army and Air Force aviation fires, and the 2d-4th FA [Field Artillery] became the only ‘all weather’ deep strike capability in the operations area” (2003). Major Carter Rogers uses this quote to erroneously conclude that in the extreme conditions of the sandstorms, “ATACMS was the only asset that could effectively attack TSTs” (2004, 54). He further adds that fixed-wing aircraft have limited all-weather capabilities because pilots and aircrew have difficulty acquiring targets in harsh environmental conditions. This is true, but Major Carter Rogers failed to mention that ATACMS has no capability to acquire a target in “any” environmental condition.

Major Carter Rogers developed a weighted matrix to rank order weapons systems based on their effectiveness to attack TSTs. He assigned point values to each weapon system based on five of the six considerations outlined in *The Commander’s Handbook for Joint Time-Sensitive Targeting*. Absent from the list of Major Rogers’ categories is the first one listed in the *Handbook*: “effectiveness against different target types” (*Commander’s Handbook* 2002, IV-2). Major Carter Rogers scored ATACMS over fixed-wing aircraft in the two categories of “Risks” and “Limitations” based on the increased vulnerability of fixed-wing aircraft to the enemy’s air defense systems and on the fallacy of ATACMS' superior all-weather capability (2004, 56). The end result of his analysis is that Carter Rogers concludes ATACMS to be the "lethal asset of choice for attacking TSTs out to 300 kilometers" (2004, 56).

Major Kaufman, an Air Force officer who attended the Naval War College in 2003, criticizes the US military for relying too heavily upon GPS-guided weapons in his thesis "Precision Guided Weapons: Panacea or Pitfall for the Joint Task Force Commander." He cites that too much time is required to mensurate coordinates for GPS-guided weapons when troops are in contact, and that it is very difficult for GPS-guided weapons to engage mobile targets in adverse weather conditions. In reference to TST engagements, Major Kaufman states "precision or accurate weapons lack the flexibility and rapidity to destroy these forces, thus degrading the JFC's ability to utilize the concepts of operational art and the principles of war to their fullest advantage" (2003, 11). Overall, Major Kaufman criticizes the complexity required to locate, derive accurate coordinates, and employ GPS-guided weapons compared to cheaper, less-accurate unguided ones (2003, 9-17). His arguments do not account for collateral damage concerns and he fails to acknowledge the capabilities of laser-guided weapons, IR/EO Maverick missiles, and gun employment.

Joint TST planners need credible guidance of how to determine the best weapon for engaging TSTs. Joint doctrine provides an incomplete list of considerations and only a basic overview of the advantages and disadvantages of each weapon system. Past theses pertaining to weapon selection in the TST process fail to consider the uniqueness of each TST engagement, the vast array of weapons effects and sensors that fixed-wing aircraft provide, and the synergy created when the sensor is the shooter throughout all six phases of the TST process. Fixed-wing aircraft and Army rockets and missiles now have relatively the same accuracy via GPS-guided weapons with potentially similar response times. Finally, TST planners need a comprehensive attack guidance matrix capable of quickly matching a weapon to a target after considering all the factors of each unique scenario. This attack guidance matrix can be used directly or as a template in future conflicts.

CHAPTER 3

RESEARCH METHODOLOGY

The research methodology model will answer the primary question: Are ATACMS better suited than fixed-wing aircraft for engaging time-sensitive targets? The model requires three steps. The first step is a capabilities analysis of ATACMS and fixed-wing wing aircraft. Current lists of advantages and disadvantages in JPs or in other literature do not address the new and emerging technological capabilities of the competing weapon systems nor do they adequately cover all the factors TST planners must consider when matching weapons to TSTs. The capabilities analysis tersely covers the entire TST process and focuses primarily on the Target Phase. The Target Phase analysis combines the considerations found in JP 3-60 and *The Commander's Handbook for Joint Time-Sensitive Targeting* and includes additional considerations found in the Target Phase Checklist in Appendix C of *MTTPs for Targeting TSTs*. ATACMS and fixed-wing aircraft capabilities are analyzed with respect to each of the categories. This provides planners with a quick reference of the advantages and disadvantages offered by each weapon system. Information in the capabilities analysis can be applied to a specific TST engagement when determining weapon selection. Lumping all of fixed-wing aircraft's capabilities into one category appropriately answers the primary thesis question, but this general weapon system should brake down into specific airframes and weapons for use in an actual TST cell. The capabilities analysis should be updated prior to and during each conflict as it provides the foundation for step two, the attack guidance matrix.

The attack guidance matrix gives TST planners sufficient direction to select the best weapon system for a particular engagement. A flow chart that addresses all possible circumstances quickly becomes unmanageable. On the other hand, a matrix made too simple is equally useless because it omits too many required considerations. A proper attack guidance matrix, therefore, addresses all considerations common to the majority of expected TST scenarios. The matrix initially attempts to eliminate a weapon system as an unfeasible match. For example, if the target is outside the range of ATACMS, the matrix quickly eliminates ATACMS as a possible candidate. If both weapon systems can engage the target, the attack guidance matrix exposes capabilities and limitations of each weapon system with respect to the given scenario. Although this involves a certain level of art and not strictly science, the capabilities analysis provides TST planners with a solid foundation of each weapon system's capabilities.

The attack guidance matrix, like the capabilities analysis, should be updated prior to and during a conflict to ensure it represents the correct capabilities and updated ROE. Since theory and reality often produce different results, recent operations where both weapon systems were employed in high numbers provide a historical basis for how long planners should expect to wait to receive mensurated coordinates, deconflict airspace, and engage a target. It is critical for TST planners to update these assumptions as new doctrine and technology improvements will certainly adjust these times.

The final step of the analysis applies the attack guidance matrix to a few TST scenarios to determine areas where one weapon system has significant advantages over the other. It also highlights situations where both weapon systems have relative parity. There are unlimited hypothetical scenarios, and they can be tailored to highlight a weapon system's strength or weakness. An objective assessment of a few realistic scenarios is adequate, however, for determining if Army missiles and rockets are better suited than fixed-wing aircraft for engaging time-sensitive targets. The analysis of Army missiles and fixed-wing aircraft produces a capabilities analysis and an attack guidance matrix that assists TST planners in correctly and expeditiously choosing the best weapon to engage a time-sensitive target.

CHAPTER 4

ANALYSIS

The analysis follows the research methodology described in chapter 3. A capabilities analysis compares the capabilities and limitations of fixed-wing aircraft to Army missiles and rockets in all six phases of the time-sensitive targeting process. The analysis concentrates on the Target Phase and combines the considerations found in JP 3-60, *The Commander's Handbook for Joint Time-Sensitive Targeting*, and Appendix C of *MTTPs for Targeting TSTs*. Information on weapon systems' capabilities forms the foundation for answering the questions in the attack guidance matrix.

The attack guidance matrix uses the categorized information from the capabilities analysis to provide TST planners a framework for assessing each weapon against a specific TST. The matrix does not identify a single best weapon system for engaging TSTs. Instead, the matrix requires TST planners to apply the weapon systems' capabilities and limitations to a unique TST engagement. When "yes" and "no" do not sufficiently answer questions, the attack guidance matrix uses a scale of one to ten. Assessing trends after applying the attack guidance matrix to multiple TST scenarios answers the primary research question: Are ATACMS better suited than fixed-wing aircraft for engaging TSTs?

Capabilities Analysis

The capabilities analysis compares the performance of ATACMS and fixed-wing aircraft in the F2T2EA process as outlined in *MTTPs for Targeting TSTs.* Although Target Phase comparisons provide the bulk of data relating to the thesis questions, a weapon system’s capabilities in the other five phases can greatly affect the timely execution of the entire TST process.

Find, Fix, Track Phases

The first three phases of the TST process are ISR-intensive and can make use of fixed-wing aircraft’s sensor capabilities. If a shooter is also a sensor, in the case of fixed-wing aircraft employing IR/EO targeting pods, radar mapping, and or moving target indicator capabilities, the asset can greatly reduce the F2T2EA processing time. *MTTPs for Targeting TSTs* states “if a TST is detected by a shooter, it may result in the Find and Fix Phases being completed nearly simultaneously without the need for traditional ISR, and the Target and Engage Phases being completed without a lengthy coordination and approval process” (2004, I-5).

Fixed-wing aircraft sensors come in a wide variety of capabilities. A particular aircraft may not have a sensor that can meet the operation’s identification criteria requirements, so TST planners must know the capabilities of a particular asset’s sensor suite. Additionally, enemy threats, environmental conditions, and ROE constraints may limit an aircraft’s sensor capabilities. For example, a pilot flying with an older generation targeting pod who cannot descend below an ROE-imposed 15,000 foot floor may not have enough clarity in his targeting pod video to identify and maintain contact with a small target (McGee 2005, 34). On the other hand, some fighter aircraft employ targeting pods that have excellent capabilities and can derive GPS-quality coordinates without requiring the time-intensive services of a third party.

Once found, most TSTs require dedicated, and often additional, sensors to maintain continuous track of the target throughout all six phases of the TST process

(*MTTPs for Targeting TSTs* 2004, V-4). Fixed-wing aircraft can provide additional sensors and can free up low density/high demand ISR assets or SOF teams for other missions. For example, once a UAV finds a potential TST, a sensor-as-the-shooter aircraft can confirm and track the TST, freeing up the UAV for retasking to other missions. Fixed-wing aircraft can also communicate directly with SOF or Joint Terminal Attack Controllers, coordinate with other strike assets, perform limited CDEs, derive accurate coordinates, and can provide targeting and engagement suggestions. Finally, fixed-wing aircraft can expedite the Target and Engage Phases by preparing for an engagement as they assist with the Find, Fix and Track Phases. *MTTPs for Targeting TSTs* sums up the potential for fixed-wing aircraft to streamline the TST process by saying "if the platform or system selected for engagement has the resources available to identify, track, and engage the target, then tasking may be as simple as alerting it to the presence of a TST and tasking it to engage the TST" (2004, V-6). Although ATACMS batteries have no input to these phases and thus it may seem unfair to include the entire F2T2EA process in the capabilities analysis, the potential synergy of fixed-wing sensor-as-the-shooter aircraft is too great to overlook.

Target and Engage Phases

Matching attack assets to desired effects is a key process in the Target Phase. Additionally, the Target Phase includes deconflicting assets, assessing risk, satisfying restrictions, and determining engagement options. Since many of these requirements directly relate to a weapon's capabilities and effects, TST planners cannot definitively match a weapon to a TST at the beginning of the Target Phase. TST planners should consider all munitions at their disposal since a restriction or requirement may deem a particular weapon unacceptable. JPs and independent researchers agree that fixed-wing aircraft and Army missiles are generally the best TST engagement options. Every TST engagement is unique, however, and a most desirable weapon system should emerge after accounting for all the considerations that influence weapon-target pairing for a specific TST. The following categories include all of the JPs' considerations for matching weapon systems to TSTs in the F2T2EA process: deconfliction, effectiveness, responsiveness, range, accuracy, threat, and risk of employment. Evaluating fixed-wing aircraft and ATACMS in each category builds a foundation of capabilities and limitations that TST planners can apply to specific TST engagements.

Deconfliction

Fixed-wing aircraft are generally easier to deconflict from each other compared to ATACMS. Fixed-wing aircraft are accustomed to deconflicting with each other via positive control from C2 and "see and avoid" techniques. When deconflicting fixed-wing aircraft from each other, all parties can easily change their routing and altitude to ensure positive deconfliction. Compared to ATACMS, fixed-wing aircraft may occupy a greater volume of airspace around the target for a longer time. If a TST is located under a heavily-used transition corridor, for example, C2 would stay busy real-time deconflicting air traffic until the attacking aircraft were off target.

Army rockets and missiles deconflict with air assets via pre-established FSCMs, ACMs, and real-time with the Air Operations Center. In an unplanned TST scenario, an ATACMS unit may have an established PAH ROZ, but requires real-time deconfliction of the flight profile and TAH area. The time required to deconflict and authorize an ATACMS fire depends directly upon how quickly C2 can direct air assets away from the needed airspace. Moving a few transiting aircraft away from a firing line is much easier compared to relocating an air refueling orbit stacked with multiple tankers and receivers or moving CAS aircraft who are currently engaging a target.

Accurately predicting the amount of time required to deconflict airspace for unplanned ATACMS fires is situation-dependent and determining a baseline time is not realistic. Joint doctrine updates, technological improvements, and joint operations experience continues to shorten the time required to deconflict Army fires. Major Carter Rogers determined that the average time to deconflict airspace for ATACMS fires went from over an hour in Operation Desert Storm to only seven minutes in OIF (2004, 59). V Corps stated that they were able to clear the airspace within fifteen minutes (*V Corps Artillery Lessons Learned*, 13-14). Assigning a single value based on average coordinating times from previous operations, however, gives false expectations to TST planners. A real-time assessment of the current battlespace allows experienced TST planners to better predict how long the deconfliction process will take. If there are no aircraft operating near the firing line, coordinating an ATACMS launch could happen almost immediately. If many aircraft are in conflict and are executing tactical missions, timely deconfliction of Army fires may be next to impossible.

Effectiveness

The capability to achieve the desired weapons effects against a target determines a weapon system's effectiveness. In order to obtain the desired effects against a target while minimizing collateral damage, many TST engagements may require a weapon system to do more than simply find its desired point of impact. Current Army fires have little control over impact conditions and always detonate on contact. These limitations, combined with GPS-only guidance, render ATACMS and GMLRS Unitary effective against only a few target categories. They do not have the delayed fusing or reinforced warheads in order to penetrate hardened targets. A lack of delayed fusing also prevents ATACMS and GMLRS from detonating beneath the surface or on a specific floor of a multi-story building. An ATACMS' steep descent renders it ineffective against many vertical target scenarios such as cave openings. Finally, Army rockets and missiles cannot effectively engage moving targets. As with all GPS-only guided munitions, ATACMS Block IVA and GMLRS Unitary simply guide to preset coordinates. Army rockets and missiles are all-weather weapons and perform very well when assigned to stationary targets that require no delayed fusing or specific impact conditions.

Fixed-wing aircraft carry a wide array of munitions that are very capable of engaging almost any TST. Fixed-wing aircraft employ 20 millimeter and 30 millimeter cannon, cluster munitions, LGBs, IR/EO missiles, and GPS-guided munitions with 250, 500, 1000, and 2000-pound class warheads. Regarding the all-weather GPS-guided JDAM and SDB munitions, pilots and aircrew can specify their impact angles, headings, and minimum impact velocities. JDAM guidance kits can attach to general purpose and reinforced penetrating bomb bodies. Additionally, there is a wide range of fusing options that pilots set prior to takeoff and in some cases can be altered in flight. Unlike ATACMS, which have no capability against moving targets, some fixed-wing aircraft have a limited capability to engage mobile targets with GPS-guided munitions. For example, an F-16 has a visual employment mode that allows the pilot to send the JDAM to where he predicts the target will be at bomb impact, usually less than twenty seconds after release.

Fixed-wing aircraft also employ Maverick IR/EO-guided AGMs, LGBs, and a fighter's gun against TSTs. Like JDAM, LGBs also have general purpose and penetrating bomb bodies with multiple fusing options. The pilot can select his attack direction in order to meet specified impact headings. LGBs are limited compared to GPS-guided weapons in that they have many meteorological requirements for successful engagements, cannot achieve near-vertical impact angles, and do not come smaller than 250-pound class warheads. Mavericks and LGBs are much better suited for engaging mobile targets compared to GPS-guided weapons, however, as they do not require coordinates for successful employment. Finally, fixed-wing fighters can employ their gun against stationary and mobile targets with minimal collateral damage concerns.

Compared to ATACMS and GMLRS, fixed-wing aircraft can engage a much greater target set, can achieve a variety weapons effects due to their fusing options, and can meet prescribed impact conditions.

Responsiveness

Determining the most responsive weapon for a specific TST engagement depends on the assets available and how quickly they can engage a specific TST. The responsiveness of airborne fixed-wing aircraft depends largely upon how close they are to the target. Once C2 directs airborne alert or re-rolled aircraft to a TST, planners should conservatively expect fixed-wing fighters or bombers to fly to a target at around 8.5 nautical miles per minute or at 510 nautical miles per hour true airspeed. If no aircraft with the correct sensors and munitions are airborne, TST planners may have ground alert fighters at their disposal. Ground alert aircraft have a wide range response times based on their required alert status. Pilots and aircrew can have their aircraft parked next to the runway with engines on ready for takeoff or be on "two hour alert." The total response time includes the time to get airborne plus the time required to fly to the target area. TST planners should maintain the current status of all airborne and ground alert aircraft available for TST tasking, including munitions on board and the expected length of time the aircraft can remain in the target area before needing to return to base or refuel from an airborne tanker.

ATACMS is a very responsive system. Its time of flight is very fast and in a perfect world ATACMS can almost always put effects on a target faster than fixed-wing aircraft. For example, an ATACMS can hit a target 100 nautical miles away in about three minutes (Boswell 2005). If dedicated to the TST process, ATACMS can be on alert and available within minutes to the TST process. An ATACMS Block IVA always has the same warhead and instantaneous fuse setting and is not concerned with weather at the launch point, en route, or in the target area. ATACMS can always provide TST planners with a consistent but limited weapons effects capability.

Unfortunately, a weapon system's responsiveness includes more than receiving an engagement order and the time required to hit the target. ATACMS must delay their launches for airspace deconfliction which can significantly degrade its response time. Also, if ATACMS are not apportioned or otherwise directly assigned to the TST process, it could easily take over an hour for a TST team to coordinate an ATACMS engagement.

External factors can also delay fixed-wing response times. Poor meteorological conditions in the target area may preclude tasking the closest fixed-wing assets if they are not carrying GPS-guided weapons. If TST planners expect a significant delay before completing CDEs and ROE requirements, airborne aircraft available at the beginning of the TST process may not have enough fuel to wait for the engagement order. Finally, fixed-wing aircraft may require escort and or SEAD assets in order to engage a TST without accepting too much risk from the enemy's air defenses. This coordination may significantly delay an engagement and increases the risk of an asset requiring more fuel before accepting additional tasking, which potentially further delays the TST engagement.

Although response times for each weapon system depend heavily upon the current battlespace environment, TST planners can shorten the response time of both Army fires and fixed-wing aircraft by working time-intensive issues as early as possible in the F2T2EA process. TST planners can start coordination with the Battlefield Coordination Detachment for an ATACMS fire as soon as potential TSTs emerge in the Find Phase. At the same time TST planners can proactively launch ground alert aircraft, begin coordination for support assets, and include sensor-as-a-shooter aircraft early in the TST process so the aircraft are ready for immediate engagement.

Range

An ATACMS Block IVA cannot attack any target outside of 300 kilometers, or 162 nautical miles, from its launch point. GMLRS can attack targets up to 70 kilometers from its launch point, or 38 nautical miles. Most fighter aircraft can triple this number without air refueling and a bomber's combat radius is much greater. Air refueling can extend fixed-wing aircraft's range indefinitely, but most tankers will remain over protected friendly territory.

Accuracy

ATACMS Block IVA, GMLRS and fixed-wing aircraft employing GPS-guided weapons can consistently and accurately hit targets assuming the coordinates are correct. If engaging a TST requires anything beyond guiding to coordinates provided by a trusted third party, ATACMS and GMLRS come up short. Fixed-wing aircraft, however, can accurately engage TSTs when GPS-quality coordinates are unavailable. Laser-guided bombs and Maverick missiles do not require precise coordinates and fighters can employ their gun against visually acquired targets. Finally, some aircraft employ targeted pods or radar mapping equipment capable of producing real-time GPS-quality coordinates.

Threat

The enemy threat en route to and in the general area of a TST may present too great a risk for manned aircraft engagement. This is especially true in the first days of hostilities if the enemy's integrated air defense system continues to function without significant degradation, or if a TST emerges in a well-defended geographic area. ATACMS is very survivable and is a favored weapon system for attacking SEAD targets. The MLRS launcher is an armored vehicle and batteries disperse when they set up to limit detection. Army doctrine recommends that launchers maneuver immediately after firing to further decrease risk of counter-attack (FM 6-60 1996, 4-21). An ATACMS flight path increases its survivability against enemy threats. ST 60-60-30 notes that ATACMS are "generally not vulnerable to short-range, low-altitude air defense weapons. However, some potential enemies possess long-range, high-altitude air defense assets that are marginally effective against an [ATACMS] missile" (1999, 9-10).

Fixed-wing aircraft are much more vulnerable to an enemy's air defense systems compared to ATACMS and must employ supporting assets or stealth technology to minimize risk to aircrew. Low observable aircraft such as the F-117, B-2 and F-22 are designed to operate in high threat environments, but TST planners should not expect these assets to be readily available for TST missions. Conventional aircraft attacking a TST in a high threat environment may require additional SEAD and or defensive counter-air aircraft. Not all fixed-wing aircraft munitions require the aircraft to fly directly over the target. For example, the SDB is capable of accurately hitting a target 70 nautical miles away from its release point (Ruscetta 2005). Enemy air defenses generally attempt to engage aircraft before releasing their munitions, as engaging individual bombs and missiles are much more difficult.

Although fixed-wing aircraft can employ stealth aircraft or coordinated strike packages to increase their survivability in a high threat area, they remain less survivable when compared to Army GMLRS and ATACMS. If a TST emerges near a formidable ground threat and or air superiority is questionable, TST planners should consider using Army fires to maximize survivability. Since the enemy's threat level fluctuates, it is important that TST planners have a direct link with Intelligence so they can accurately assess potential threats en route to and around the target area. Also, fixed-wing aircraft have varying capabilities against an enemy's air defense. If TST planners are unfamiliar with an aircraft's or unit's capabilities regarding a specific threat scenario, they should reference a capabilities summary provided by the unit or call the unit for specific guidance.

Risk of Employment

Risk of employment refers to the second order of effects caused by a TST engagement. Considerations include a target's vulnerability window, potential for collateral damage and fratricide, the cost of diverting assets away from a planned mission or to comply with FSCMs, and any ROE restraints imposed on attacking weapon systems. Many of these considerations depend on the unique TST scenario and therefore TST planners cannot make generalized conclusions about a weapon system's effectiveness ahead of time.

A target's vulnerability window directly links to a weapon system's responsiveness. If only one system can engage the TST within the target's vulnerability window, then TST planners only have to assess the feasibility and acceptability of that one weapon system. TST planners risk missing an engagement entirely if they choose a weapon that cannot put effects on the target until it is too late.

Minimizing collateral damage and the potential for fratricide are often of paramount concern when matching weapons to targets in an urban environment. Fixed-wing aircraft's variety of munitions and fusing options provide TST planners with the greatest spectrum of capabilities to meet the desired weapons effects while minimizing the potential for collateral damage and fratricide. ATACMS Block IVA and GMLRS Unitary contact-only fuses may create too much collateral damage or prevent them from complying with ROE restrictions, as the case in many urban environments.

Retasking a fixed-wing sortie or withholding an ATACMS battery for potential TST engagements may produce undesirable second order effects. Without knowing what targets an ingressing fixed-wing aircraft is planning to attack, it is possible to degrade the total targeting effort by retasking an aircraft to hit a less-important TST. Re-assigning tanker fuel and retasking SEAD assets may prevent follow-on strike packages from executing their missions, which can affect the future engagement of multiple targets. Concerning Army fires, requiring a minimum number of missiles to remain available to the TST process reduces the available firepower for corps targeting. Additionally, delaying and diverting fixed-wing aircraft for ATACMS fires risks negative consequences if it delays part of an intricately-coordinated strike package or significantly delays CAS aircraft from engaging their targets.

When matching weapon systems to targets, TST planners must ensure that the weapon system can comply with any ROE requirements. A common ROE is to require the engaging asset to PID a target prior to engaging it. ATACMS have no capability to comply with this unless the ROE allows a third party to PID a target for a GPS-guided munition. Fixed-wing aircraft routinely train to PID targets prior to releasing their weapons. If employing GPS-guided weapons, fixed-wing aircraft can use targeting pods to indentify their target prior to release.

Assess Phase

Fixed-wing aircraft can provide immediate Battle Damage Assessment (BDA) and Bomb Hit Assessment (BHA) of attacks and then can immediately reattack if required. The F2T2EA process is complete only after a proper assessment of the engagement. Due to many TSTs' small windows of vulnerability, timely CAs are critical if reattack is deemed necessary. CAs are important because coordinates are sometimes inaccurate, a small percentage of munitions fail, and properly-functioning weapons may not achieve the desired effects. Therefore, a TST team needs immediate and accurate CAs so they can execute a timely reattack.

Fixed-wing aircraft posses two advantages over Army missiles in the Assess Phase. First, a fixed-wing aircraft is most likely able to make a CA of his own attack. Pilots can simply look outside and verify that their bombs hit the correct target and can use the magnified images from their targeting pods to gauge a weapon's effectiveness. If the first attack did not achieve the desired results, fixed-wing aircraft can immediately reattack with minimal coordination. In contrast, Army missiles must rely on a third party for their CAs. Feedback to an ATACMS unit may be very late if at all. Often a high demand/low density asset such as a Predator UAV receives another tasking before it can return and assess a strike. Secondly, if an ATACMS missed its target, the TST team has no way of knowing if it was due to bad coordinates or if the weapon malfunctioned. What can be done to ensure an ATACMS reattack will be successful? Fixed-wing aircraft that can physically see the target should be able to reattack and make real-time adjustments to compensate for inaccurate coordinates.

Fixed-wing aircraft and Army rockets and missiles provide TST planners with unique capabilities and limitations. Fixed-wing aircraft can engage more targets with the greatest range of effects, can comply with ROE restrictions, have greater range, and can engage targets without accurate coordinates. ATACMS are consistent, can be always available, and are very survivable in high-threat environments. Factors such as responsiveness, deconfliction, threat, and risk of employment depend on the current situation and TST planners must make real-time assessments of each weapon system's capabilities in these areas.

Attack Guidance Matrix

An attack guidance matrix applies the capabilities of a weapon system to a given scenario (see table 2 or Appendix A). A completed matrix may lead TST planners to the following conclusions: only one weapon system is feasible, one weapon system is preferred over the other even though both are capable of engaging the TST, neither weapon system is acceptable, or in rare cases both weapon systems are equally acceptable. TST planners must thoroughly understand a weapon system's strengths and weaknesses outlined in the capabilities analysis in order to make effective use of the attack guidance matrix. Flawed assumptions or limited understanding of a weapon system's capabilities result in erroneous conclusions. The attack guidance matrix in this thesis combines all fixed-wing aircraft sensors, weapons, and fuse settings capabilities into the one "Fixed-Wing" category. While this methodology is appropriate for answering the primary the primary thesis question, TST planners should build or update a comprehensive capabilities analysis of each individual airframe and weapon prior to an operation using only the actual assets that are available to the TST process. TST team members can reference JFIRE to look up the capabilities of joint weapon systems, sensors, and munitions.

The attack guidance matrix categorizes the TST considerations into four areas: feasibility, risk, responsiveness, and synergy. The feasibility section evaluates a weapon system's capability to physically hit a TST in its vulnerability window, achieve the desired effects, and comply with collateral damage requirements or other restrictions. Question four, "Can the weapon system achieve the desired weapons effects?" uses a scale of one to ten, with "ten" being the best. The risk section assesses the acceptability of a potential engagement. It addresses the attacking weapon system's vulnerability to the enemy's defensive systems and considers the second order effects of deconflicting airspace and retasking assets. The responsiveness section assesses each weapon system's suitability for a TST engagement. This section addresses the availability and time required for a weapon system to deconflict and engage a target. It also assesses the time required to task and organize supporting assets if required. Synergy, the final section, determines if a sensor-as-a-shooter asset can expedite the TST process and addresses a weapon system's capability to provide CA and or execute a reattack. It is possible that a SOF team identified the TST and will remain in the area to provide immediate assessment of the attack, thus reducing the synergistic effects of a sensor as a shooter apart from providing an immediate reattack option.

Table 2. Attack Guidance Matrix

	Fixed-Wing	ATACMS/GMLRS
FEASIBILITY		
1. (Y/N) Does weapon system have the range to hit the target? - Consider MLRS if min-range for ATACMS. - Check if air-refueling assets are available.		
2. (Y/N) Can weapon system physically hit the target? - Moving target? - Coordinate confidence - good enough for GPS? - Terrain obstacles		
3. (Y/N) Do target area meteorological conditions allow desired weapon system employment? - clouds, wind, thermal crossover		
4. (1-10) Can weapon system achieve desired weapons effects? - Delayed fusing, attack axis, specific impact conditions, penetration, area coverage/pattern density? - Collateral damage constraints (warhead size, fusing) - Fratricide possibility?		
5. (Y/N) Can weapon system comply with ROE?		

- PID prior to release? - 3rd party verification exception for GPS-guided weapon?		
6. (Y/N) Can weapon system engage during TST's vulnerability window?		
RISK (ACCEPTABILITY)		
1. (Y/N) Can weapon system navigate to target area with acceptable risk? - Do weapons have standoff capability? - Does weapon system need SEAD/Escort support? - Is weapon vulnerable to any threat en route?		
2. (1-10) Can weapon system engage TST with acceptable risk to soldiers and/or assets? - Is SEAD/Escort support required? - Does weather require aircraft to descend into high-threat envelope in order to engage?		
3. (1-10) Is retasking asset worth the secondary effects? - What target(s) will not get hit by retasking assets?		
4. (1-10) Will deconfliction measures have minimal impact on current operations (10 = least impact)? - How many assets must divert/delay in order to execute the mission?		
RESPONSIVENESS (SUITABILITY)		
1. (Y/N) Is weapon system available? - Consider weapon and fusing requirements - Consider retasking, airborne alert, and ground alert		
2. (1-10) How quickly can weapon system put effects on TST? - Airspace deconfliction (FSCM, ACM) - Expected time from execute order to effects - Consider assets on alert status - Initiate warning order to weapon system?		
3. (Y/N or N/A) Are additional assets available (if required)? - Consider availability and Time On Station of SEAD, Escort, and tanker assets		
4. (Y/N) Does the weapon system have adequate on-station time? - Can it remain in the target area long enough for a reattack?		
SYNERGY		
1. (1-10) Can a "sensor-as-the-shooter" increase responsiveness / decrease response time of entire F2T2EA? - Can weapon system derive GPS-quality coordinates? - Will meteorological conditions limit asset's		

capability? - Can shooter help with coordinating attack or assist in CDE? - Is ISR asset (UAV, SOF) sufficient?		
2. (Y/N) Can weapon system provide immediate BHA/BDA? - Can SOF in the area provide immediate BHA/BDA?		
3. (Y/N) Can weapon system execute immediate reattack? (target moved, bad coords, desired effect not achieved)		

Applying the attack guidance matrix to four potential TST scenarios (appendices A through D) reveals "areas of exclusivity" where each weapon system has clear advantages over the other. Fixed-wing aircraft have exclusive capabilities in the feasibility and synergy categories. They can engage a wider variety of targets, have much greater range, provide a greater variety of weapons effects, do not always require accurate coordinates, can comply with a multitude of impact conditions, and can more easily meet ROE and CD restrictions. The exclusive target sets that fixed-wing aircraft can hit include moving targets, vertical targets (cave entrance), hardened targets, multilayered targets requiring penetration prior to detonation (multistory building), targets that can only accept the lowest potential for CD, and any target without GPS-quality coordinates. ROE may further exclude ATACMS, as in urban environments that require subterranean detonations to minimize collateral damage. Fixed-wing aircraft also exclusively provide synergy to the F2T2EA process when employed in a sensor-as-the-shooter role. Their ability to assist in all phases of the TST process has the potential to significantly reduce the time from finding a target to engaging it, and then can immediately assess the attack and reattack if necessary.

ATACMS have areas of exclusivity in the risk and responsiveness categories. If the enemy's defensive systems prevent fixed-wing aircraft from engaging a TST within acceptable risk levels, then ATACMS is the only acceptable weapon. In certain situations, an ATACMS can respond quicker than fixed-wing aircraft. ATACMS is more responsive or more suitable when aircraft cannot respond quickly to an engagement order, when the second order effects of re-tasking an aircraft is too great, or when no aircraft with proper munitions and fusing options are readily available. If properly apportioned to the TST process, ATACMS can remain available indefinitely, ready to fire as soon as they receive an order.

The results of the attack guidance matrix are not always black and white. Assessing a few scenarios with the attack guidance matrix reveals a few "it depends" areas where the scenario itself determines the best weapon system for engagement. For example, ATACMS and fixed-wing aircraft can equally engage simple stationary targets with accurate coordinates, no specific attack requirements, no CD constraints, and are within range. At best ATACMS and fixed-wing aircraft tie for feasibility, but complex scenarios and additional engagement restrictions quickly highlight the aforementioned strengths of fixed-wing aircraft.

When both weapon systems are equally feasible and there is no serious enemy threat to fixed-wing aircraft, TST planners must carefully assess the risk and responsiveness categories. In these scenarios, the acceptability and suitability of each weapon system determines which weapon system is best for an engagement. Response times for each weapon system vary based on their availability and the expected time to deconflict airspace, transmit and receive engagement orders, and coordinate for supporting assets. C2 structures that are unique to each theater, emerging technology, and evolving doctrine make predicting response times for a future operation impossible. No scientific equation can accurately predict a weapon system's responsiveness in a complex scenario. Therefore, TST planners must combine doctrine, historical averages, exercise data, and experience into reasonable predictions for a weapon system's response time for a given scenario. As an operation progresses, TST planners can adjust their predictions based on recent experience and familiarity with that particular operation's TST process.

Assessing a weapon system's risk for a TST engagement also depends primarily on the specific scenario. Without any experience or a thorough knowledge of the current tactical situation, it is difficult for a TST planner to correctly assess the second order effects of deconfliction measures or of retasking aircraft away from their primary missions. Close coordination with the Air Operations Center and or ASOC should help a TST team see the bigger picture and help them understand the second order effects of a particular course of action.

The capabilities analysis and attack guidance matrix helps TST planners apply the capabilities and limitations of a weapon system to a specific tactical scenario. Although one weapon system should emerge as a better option for engaging a TST, it is possible that TST planners determine that no weapon system or both weapon systems should engage a TST. For example, TST planners may decide not to engage a TST if it is out of the range of ATACMS and the threat is too great to risk fixed-wing operations. On the other hand, TST planners may see the value of tasking both ATACMS and fixed-wing aircraft to the same TST. Since fixed-wing aircraft exclusively provide so many capabilities beyond those of ATACMS, TST planners may adopt a technique of always tasking fixed-wing aircraft to support an ATACMS engagement when the risk allows. Initially execute an ATACMS fire in order to achieve effects on the target in minimum time, and then have fixed-wing aircraft follow up for an immediate CA and be in a position to reattack if necessary. Involving fixed-wing aircraft in an ATACMS engagement can free up high-demand/low density ISR assets sooner without losing CA capabilities. Finally, if the initial ATACMS attack missed was unsuccessful, fixed-wing aircraft can reattack until achieving the desired effects.

The analysis answers the secondary and tertiary questions as outlined in chapter 1. The capabilities analysis details each weapon system's strengths and weaknesses as they apply to the six steps of the TST process. In the Target Phase, it focuses on the considerations for matching weapon systems to TSTs: deconfliction, effectiveness, responsiveness, range, accuracy, threat, and risk of employment. This thorough understanding of each weapon system's capabilities builds the foundation for the attack guidance matrix. The attack guidance matrix provides a quick checklist for TST planners to assess a weapon system's capabilities in a specific scenario. Finally, applying the attack guidance matrix to several TST scenarios reveals areas where one weapon system consistently has an advantage over the other or where the tactical scenario itself determines the most desirable weapon system.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The purpose of this thesis is to determine if Army rockets and missiles are better suited than fixed-wing aircraft for engaging time-sensitive targets. JPs and other authors agree that ATACMS and fixed-wing aircraft are generally the best two weapon systems for engaging TSTs. Unfortunately, they discuss only general considerations for selecting the best weapon. Most comparisons only assess the weapon-to-target matching process and do not evaluate a weapon system's capability to influence the entire F2T2EA process. Therefore, this thesis answers the primary question by making a detailed capabilities analysis that addresses all six phases of the TST process, develops an attack guidance matrix that highlights each weapon system's strengths and weaknesses in a given TST scenario, and then applies the matrix to realistic TST scenarios. These processes reveal areas where one weapon system consistently has an advantage over the other or where the tactical scenario itself determines the most desirable weapon system for engagement.

Fixed-wing aircraft are usually better suited than Army rockets and missiles for engaging TSTs. Although TST planners must evaluate each scenario separately, the analysis reveals a few areas of exclusivity or "rules of thumb" that make each weapon system the most desirable choice in certain TST scenarios.

Fixed-wing aircraft can achieve the desired weapons effects against many more targets compared to ATACMS. ATACMS must receive GPS-quality coordinates from a third party and can only engage stationary targets with antipersonnel/antimateriel bomblets or a contact-only fused 500-pound warhead. ATACMS cannot engage mobile targets, penetrate hardened targets, attack a TST with poor-quality coordinates, detonate subterranean, use smaller or bigger warheads to achieve specific weapons effects, or meet specific impact headings and angles. These limitations quickly render ATACMS a less-feasible engagement option. Also, fixed-wing aircraft can participate in all six phases of F2T2EA. Using their multiple sensors, fixed-wing aircraft can expedite the TST process, provide a timely CA of an attack, and can immediately reattack if necessary.

There are two scenarios where TST planners would exclusively choose ATACMS over fixed-wing aircraft. The first is when enemy air defense systems create too much risk for fixed-wing aircraft operations and GPS-quality coordinates are available. The second scenario is when fixed-wing aircraft are not readily available. ATACMS can be on alert for TST missions continuously, always able to hit their target within minutes of receiving the engagement order.

Many TST scenarios are not so clear-cut. In the case where Army missiles and fixed-wing aircraft can achieve similar weapons effects without accepting excessive risk, TST planners must assess the time and cost of deconflicting ATACMS fires and the time and second order effects of retasking attack and support aircraft. Although the attack guidance matrix addresses the necessary concerns, TST planners must use doctrine, historical data, their experience, and coordination with the Joint Air Operations Center and ASOC when assessing these scenario-specific issues.

Since the TST scenario itself has such a large role in determining the weapon-to-target matching process, a single weapon system cannot always be the best choice for every TST engagement. Fixed-wing aircraft possess exclusive capabilities that can be utilized in all six phases of the TST process and can engage a wider variety of targets, but are not always the most responsive and must consider the enemy's air-to-air and surface-to-air threat en route to and in the vicinity of the target. A joint TST team may not desire Army missiles to engage the majority of TSTs, but ATACMS and GMLRS provide a responsive and low-risk engagement option when needed. The bottom line is that the joint TST process requires both fixed-wing aircraft and Army missiles be made available for engaging TSTs.

Recommendations

A Joint TST team should plan for fixed-wing aircraft to be the most desirable weapon system for the majority of TST engagements, remembering that ATACMS do provide some niche capabilities necessary to complement a joint TST team's engagement options. The joint TST process should continue to view both Army missiles and fixed-wing aircraft as primary weapon systems for engaging TSTs.

When TST planners request ATACMS to attack a TST, they should also assign fixed-wing aircraft with appropriate sensors to the same target. The capability of fixed-wing aircraft to perform CAs and immediate reattacks cannot be overlooked even when ATACMS is initially the most responsive weapon system. Therefore, TST planners should assign fixed-wing assets to assist ATACMS engagements. Exceptions are when the weather in the target area or the threat prevents an aircraft from effectively using its sensors or weapons.

The JFC should ensure that both Army missiles and fixed-wing aircraft are tasked or apportioned to the TST process. One of ATACMS' greatest TST strengths is its responsiveness. Regardless of who owns the TST process in an operation, joint TST planners need a guarantee that a minimum number of ATACMS, at known locations, will always be available for TST tasking. The JFC's apportionment decision most likely is the source of this guarantee. In addition to TSTs, the JFC should also consider the benefits of apportioning Army missiles to JFACC dynamic targets that are time-sensitive but do not fit into the specific TST definition.

The Army should increase its ATACMS inventory and or provide guidance to limit their use in joint TST missions. Although fixed-wing aircraft have executed the majority of TST engagements in the past, future TST operations may request higher numbers of ATACMS fires. ATACMS are expensive, not reusable, and are available in fewer numbers compared to most other weapon systems with similar capabilities on the joint battlefield. If the Army is concerned about losing too many ATACMS to joint fires requests, then it should provide initial guidance for their use to the Joint Target Coordination Board and follow up with additional guidance as the operation progresses. This is especially true if the JFC apportions ATACMS to both joint TST and dynamic targets.

The Army should pursue further development of ATACMS in order to produce a hardened-target penetrating weapon and a variety of fusing options. One of ATACMS Block IVA's biggest limitations is its inability to achieve specific weapons effects due to its "one size fits all" unitary warhead and contact-only fuse.

If available, the JFACC should allocate appropriately configured fixed-wing aircraft to remain on airborne and or ground TST alert. The TST cell determines its expected target types and locations and provides the JFACC with their predicted requirements for weapons effects and sensor capabilities. The JFACC will, in turn, allocate aircraft to support the TST mission. Allocating fixed-wing aircraft to TST alert missions has the same effect as apportioning ATACMS to the TST process in that these assets are not immediately available to execute regular missions. Based on the nature of the operation and the number of emerging TST targets, it may be more effective to retask aircraft when a TST emerges rather than require aircraft to remain on alert. A potential compromise is to require aircraft to remain on ground TST alert when the air tasking order shows reduced numbers of airborne attack aircraft.

A joint time-sensitive targeting cell should build, use, and update a capabilities analysis and attack guidance matrix that is specific to its operation. TST planners should have each unit's aircraft capabilities and configuration options available for reference when matching weapon systems to targets. Different units flying the same aircraft may carry different sensors and weapons, may accept different risk levels, and may have different fuel requirements. TST planners must also keep up with changing ATACMS batteries changing positions and inventories.

Joint publications need to develop common definitions for the differing levels of accuracy and coordinate confidence. The Army and Air Force use "precision" and "accurate" quite differently, which can seriously affect the result of GPS-guided weapons employment. If these terms cannot be agreed upon for all JPs, then the Joint Target Coordination Board should provide joint definitions for a specific operation that reflect the opinions of the majority of users.

For Further Study

This thesis limits its discussion to 2005 fielded technology and only compares ATACMS, GMLRS Unitary, and the capabilities of fixed-wing aircraft found on the majority of attack fighters and bombers. Emerging technology, such as Precision Strike Suite-Special Operation Forces, also known as PSS-SOF, gives a soldier the capability of generating GPS-quality coordinates instead of requiring a Raindrop team. This technology can significantly change the nature of the TST targeting process.

All services are increasing their numbers of UAVs to include those that carry weapons. A significant increase in the number of weapon-wielding UAVs brings additional capabilities and a potential overload of sensor information to today’s TST cell.

Apportioning ATACMS and fixed-wing aircraft to the TST process needs doctrine to back it up and ensure its survival.

Finally, Army GMLRS can provide fires to the TST process in addition to ATACMS. A non-contiguous and non-linear battlefield may have MLRS batteries within range of TSTs while ATACMS may not be able to engage the target. Further, a TST can emerge on this type of battlefield well inside of the fire support coordination line which may result in an MLRS being much more responsive compared to a fixed-wing aircraft or combat UAV flying directly overhead.

APPENDIX A

SCENARIO 1

SOF on the ground discovers a WMD missile launcher prior to D-Day. Enemy has integrated and coordinated air defense system with surface-to-air missiles and defensive counter-air aircraft. Coalition forces do not have air superiority. TST is < 165nm to nearest ATACMS battery. SOF provides GPS-quality coordinates.

Matrix result: ATACMS should engage the TST. Both weapon systems are capable of achieving desired weapons effects against the target, but the risk to fixed-wing aircraft is too great unless using LO/stealth aircraft. Therefore, engage with survivable ATACMS and use SOF for CA.

ATTACK GUIDANCE MATRIX		
	Fixed-Wing	ATACMS/GMLRS
FEASIBILITY		
1. (Y/N) Does weapon system have the range to hit the target? - Consider MLRS if min-range for ATACMS. - Check if air-refueling assets are available.	Y	Y
2. (Y/N) Can weapon system physically hit the target? - Moving target? - Coordinate confidence - good enough for GPS? - Terrain obstacles	Y	Y
3. (Y/N) Do target area meteorological conditions allow desired weapon system employment? - clouds, wind, thermal crossover	Y	Y
4. (1-10) Can weapon system achieve desired weapons effects? - Delayed fusing, attack axis, specific impact conditions, penetration, area coverage/pattern density? - Collateral damage constraints (warhead size, fusing) - Fratricide possibility?	10	10
5. (Y/N) Can weapon system comply with ROE? - PID prior to release? - 3rd party verification exception for GPS-guided weapon?	Y	Y
6. (Y/N) Can weapon system engage during TST's vulnerability window?	Y	Y
RISK (ACCEPTABILITY)		
1. (Y/N) Can weapon system navigate to target area with acceptable risk? - Do weapons have standoff capability?	N	Y

- Does weapon system need SEAD/Escort support? - Is weapon vulnerable to any threat en route?		
2. (1-10) Can weapon system engage TST with acceptable risk to soldiers and/or assets? - Is SEAD/Escort support required? - Does weather require aircraft to descend into high-threat envelope in order to engage?	N	Y
3. (1-10) Is retasking asset worth the secondary effects? - What target(s) will not get hit by retasking assets?	N/A	N/A
4. (1-10) Will deconfliction measures have minimal impact on current operations (10 = least impact)? - How many assets must divert/delay in order to execute the mission?	10	10
RESPONSIVENESS (SUITABILITY)		
1. (Y/N) Is weapon system available? - Consider weapon and fusing requirements - Consider retasking, airborne alert, and ground alert	Y	Y
2. (1-10) How quickly can weapon system put effects on TST? - Airspace deconfliction (FSCM, ACM) - Expected time from execute order to effects - Consider assets on alert status - Initiate warning order to weapon system?	3	10
3. (Y/N or N/A) Are additional assets available (if required)? - Consider availability and Time On Station of SEAD, Escort, and tanker assets	Y	N/A
4. (Y/N) Does the weapon system have adequate on-station time? - Can it remain in the target area long enough for a reattack?	Y	Y
SYNERGY		
1. (1-10) Can a “sensor-as-the-shooter” increase responsiveness / decrease response time of entire F2T2EA? - Can weapon system derive GPS-quality coordinates? - Will meteorological conditions limit asset’s capability? - Can shooter help with coordinating attack or assist in CDE? - Is ISR asset (UAV, SOF) sufficient?	3	N/A
2. (Y/N) Can weapon system provide immediate BHA/BDA? - Can SOF in the area provide immediate BHA/BDA?	Y	N/A
3. (Y/N) Can weapon system execute immediate reattack? (target moved, bad coords, desired effect not achieved)	Y	N/A

APPENDIX B

SCENARIO 2

A UAV is tracking a leadership vehicle as it travels through a city. The vehicle makes frequent stops, but never for more than 10 minutes. Enemy aircraft pose no threat but there are mobile surface-to-air missile systems in the area. ROE requires PID prior to weapon release in an urban environment, but they allow for a 3rd party to PID the target for GPS-guided weapons if the coordinates have been mensurated at the Combined Air Operations Center or Battlefield Coordination Detachment. Weather is not a factor.

Matrix result: Fixed-wing aircraft with a targeting pod should engage this mobile target with 500lb laser-guided bombs and/or gun (accurate coordinates are not necessary). LGBs should have delayed fusing to limit CD in an urban environment. The TST team should retask SEAD assets to support the engagement due to the mobile surface-to-air missiles in the area. Fighter aircraft with a targeting pod can assist in the Fix and Track Phases and coordinate with the UAV. Pilots can also assist with CDEs and engage the target when collateral damage is lowest. Engaging aircraft can meet PID requirements. Engaging aircraft can provide immediate BDA/BHA and can immediately reattack if necessary. ATACMS cannot feasibly engage this mobile target. Additionally, ATACMS' contact fuse may result in excess collateral damage.

ATTACK GUIDANCE MATRIX		
	Fixed-Wing	ATACMS/GMLRS
FEASIBILITY		
1. (Y/N) Does weapon system have the range to hit the target? - Consider MLRS if min-range for ATACMS. - Check if air-refueling assets are available.	Y	Y
2. (Y/N) Can weapon system physically hit the target? - Moving target? - Coordinate confidence - good enough for GPS? - Terrain obstacles	Y	N Unless vehicle stops long enough
3. (Y/N) Do target area meteorological conditions allow desired weapon system employment? - clouds, wind, thermal crossover	Y	Y
4. (1-10) Can weapon system achieve desired weapons effects? - Delayed fusing, attack axis, specific impact conditions, penetration, area coverage/pattern density? - Collateral damage constraints (warhead size, fusing) - Fratricide possibility?	10	2
5. (Y/N) Can weapon system comply with ROE? - PID prior to release?	Y	Y 3rd party exception

- 3rd party verification exception for GPS-guided weapon?		
6. (Y/N) Can weapon system engage during TST's vulnerability window?	Y	N
RISK (ACCEPTABILITY)		
1. (Y/N) Can weapon system navigate to target area with acceptable risk? - Do weapons have standoff capability? - Does weapon system need SEAD/Escort support? - Is weapon vulnerable to any threat en route?	Y	Y
2. (1-10) Can weapon system engage TST with acceptable risk to soldiers and/or assets? - Is SEAD/Escort support required? - Does weather require aircraft to descend into high-threat envelope in order to engage?	Y	Y
3. (1-10) Is retasking asset worth the secondary effects? - What target(s) will not get hit by retasking assets?	8	N/A
4. (1-10) Will deconfliction measures have minimal impact on current operations (10 = least impact)? - How many assets must divert/delay in order to execute the mission?	10	7
RESPONSIVENESS (SUITABILITY)		
1. (Y/N) Is weapon system available? - Consider weapon and fusing requirements - Consider retasking, airborne alert, and ground alert	Y	Y
2. (1-10) How quickly can weapon system put effects on TST? - Airspace deconfliction (FSCM, ACM) - Expected time from execute order to effects - Consider assets on alert status - Initiate warning order to weapon system?	7	7
3. (Y/N or N/A) Are additional assets available (if required)? - Consider availability and Time On Station of SEAD, Escort, and tanker assets	Y	N/A
4. (Y/N) Does the weapon system have adequate on-station time? - Can it remain in the target area long enough for a reattack?	Y	Y
SYNERGY		
1. (1-10) Can a "sensor-as-the-shooter" increase responsiveness / decrease response time of entire F2T2EA? - Can weapon system derive GPS-quality coordinates? - Will meteorological conditions limit asset's capability?	8	N/A

- Can shooter help with coordinating attack or assist in CDE? - Is ISR asset (UAV, SOF) sufficient?		
2. (Y/N) Can weapon system provide immediate BHA/BDA? - Can SOF in the area provide immediate BHA/BDA?	Y	N/A
3. (Y/N) Can weapon system execute immediate reattack? (target moved, bad coords, desired effect not achieved)	Y	N/A

APPENDIX C

SCENARIO 3

Terrorists are meeting in a 1-story building on the edge of a thinly populated urban area. There are no significant threats in the area. A UAV is the primary ISR sensor. ATACMS is in range and coalition aircraft are operating in a nearby kill box. ATACMS fires must deconflict with aircraft holding for a CAS mission. There are scattered cumulus clouds moving through the target area.

Matrix result: Fixed-wing aircraft is the preferred weapon system, but both weapon systems can engage this target. The TST team can likely deconflict airspace while waiting for mensurated coordinates. However, fixed-wing aircraft can coordinate with the UAV and potentially attack the target with LGBs before mensurated coordinates are available. Fixed-wing aircraft can employ a delayed fused bomb to maximize effects inside the building and limit collateral damage compared to ATACMS' contact fuse. Fixed-wing aircraft can also provide immediate BDA/BHA and reattack if required.

ATTACK GUIDANCE MATRIX		
	Fixed-Wing	ATACMS/GMLRS
FEASIBILITY		
1. (Y/N) Does weapon system have the range to hit the target? - Consider MLRS if min-range for ATACMS. - Check if air-refueling assets are available.	Y	Y
2. (Y/N) Can weapon system physically hit the target? - Moving target? - Coordinate confidence - good enough for GPS? - Terrain obstacles	Y	Y
3. (Y/N) Do target area meteorological conditions allow desired weapon system employment? - clouds, wind, thermal crossover	Y - GPS Maybe - LGB	Y
4. (1-10) Can weapon system achieve desired weapons effects? - Delayed fusing, attack axis, specific impact conditions, penetration, area coverage/pattern density? - Collateral damage constraints (warhead size, fusing) - Fratricide possibility?	10	8
5. (Y/N) Can weapon system comply with ROE? - PID prior to release? - 3rd party verification exception for GPS-guided weapon?	Y	Y
6. (Y/N) Can weapon system engage during TST's vulnerability window?	Y	Y

RISK (ACCEPTABILITY)		
1. (Y/N) Can weapon system navigate to target area with acceptable risk? - Do weapons have standoff capability? - Does weapon system need SEAD/Escort support? - Is weapon vulnerable to any threat en route?	Y	Y
2. (1-10) Can weapon system engage TST with acceptable risk to soldiers and/or assets? - Is SEAD/Escort support required? - Does weather require aircraft to descend into high-threat envelope in order to engage?	Y	Y
3. (1-10) Is retasking asset worth the secondary effects? - What target(s) will not get hit by retasking assets?	10	N/A
4. (1-10) Will deconfliction measures have minimal impact on current operations (10 = least impact)? - How many assets must divert/delay in order to execute the mission?	10	7
RESPONSIVENESS (SUITABILITY)		
1. (Y/N) Is weapon system available? - Consider weapon and fusing requirements - Consider retasking, airborne alert, and ground alert	Y	Y
2. (1-10) How quickly can weapon system put effects on TST? - Airspace deconfliction (FSCM, ACM) - Expected time from execute order to effects - Consider assets on alert status - Initiate warning order to weapon system?	10	8
3. (Y/N or N/A) Are additional assets available (if required)? - Consider availability and Time On Station of SEAD, Escort, and tanker assets	N	N/A
4. (Y/N) Does the weapon system have adequate on-station time? - Can it remain in the target area long enough for a reattack?	Y	Y
SYNERGY		
1. (1-10) Can a “sensor-as-the-shooter” increase responsiveness / decrease response time of entire F2T2EA? - Can weapon system derive GPS-quality coordinates? - Will meteorological conditions limit asset’s capability? - Can shooter help with coordinating attack or assist in CDE? - Is ISR asset (UAV, SOF) sufficient?	8	N/A
2. (Y/N) Can weapon system provide immediate BHA/BDA?	Y	N/A

- Can SOF in the area provide immediate BHA/BDA?		
3. (Y/N) Can weapon system execute immediate reattack? (target moved, bad coords, desired effect not achieved)	Y	N/A

APPENDIX D

SCENARIO 4

A UAV discovers a missile launcher capable of employing WMDs. The TST is in isolated area. Air and surface threats are minimal. There are no CD issues or restrictive ROE considerations. The nearest strike aircraft available to engage a TST are on 30 minute ground alert at an airbase 100nm away. Target area weather is clear. ATACMS do not need to deconflict with any aircraft.

Matrix result: ATACMS is the preferred weapon system. Both weapon systems are capable of engaging the target, but ATACMS is more responsive. ATACMS can engage with the unitary warhead or the Block IA missile since collateral damage is not an issue. Recommend tasking the fixed-wing aircraft until the UAV confirms successful engagement. This allows high demand/low density UAV to be retasked before performing CA of ATACMS attack. If ATACMS fire missed, fixed-wing aircraft can reattack.

ATTACK GUIDANCE MATRIX		
	Fixed-Wing	ATACMS/GMLRS
FEASIBILITY		
1. (Y/N) Does weapon system have the range to hit the target? - Consider MLRS if min-range for ATACMS. - Check if air-refueling assets are available.	Y	Y
2. (Y/N) Can weapon system physically hit the target? - Moving target? - Coordinate confidence - good enough for GPS? - Terrain obstacles	Y	Y
3. (Y/N) Do target area meteorological conditions allow desired weapon system employment? - clouds, wind, thermal crossover	Y	Y
4. (1-10) Can weapon system achieve desired weapons effects? - Delayed fusing, attack axis, specific impact conditions, penetration, area coverage/pattern density? - Collateral damage constraints (warhead size, fusing) - Fratricide possibility?	10	10
5. (Y/N) Can weapon system comply with ROE? - PID prior to release? - 3rd party verification exception for GPS-guided weapon?	Y	Y
6. (Y/N) Can weapon system engage during TST's vulnerability window?	Y	Y

RISK (ACCEPTABILITY)		
1. (Y/N) Can weapon system navigate to target area with acceptable risk? - Do weapons have standoff capability? - Does weapon system need SEAD/Escort support? - Is weapon vulnerable to any threat en route?	Y	Y
2. (1-10) Can weapon system engage TST with acceptable risk to soldiers and/or assets? - Is SEAD/Escort support required? - Does weather require aircraft to descend into high-threat envelope in order to engage?	Y	Y
3. (1-10) Is retasking asset worth the secondary effects? - What target(s) will not get hit by retasking assets?	N/A (dedicated)	N/A
4. (1-10) Will deconfliction measures have minimal impact on current operations (10 = least impact)? - How many assets must divert/delay in order to execute the mission?	10	10
RESPONSIVENESS (SUITABILITY)		
1. (Y/N) Is weapon system available? - Consider weapon and fusing requirements - Consider retasking, airborne alert, and ground alert	Y	Y
2. (1-10) How quickly can weapon system put effects on TST? - Airspace deconfliction (FSCM, ACM) - Expected time from execute order to effects - Consider assets on alert status - Initiate warning order to weapon system?	4	10
3. (Y/N or N/A) Are additional assets available (if required)? - Consider availability and Time On Station of SEAD, Escort, and tanker assets	N	N/A
4. (Y/N) Does the weapon system have adequate on-station time? - Can it remain in the target area long enough for a reattack?	Y	Y
SYNERGY		
1. (1-10) Can a “sensor-as-the-shooter” increase responsiveness / decrease response time of entire F2T2EA? - Can weapon system derive GPS-quality coordinates? - Will meteorological conditions limit asset’s capability? - Can shooter help with coordinating attack or assist in CDE? - Is ISR asset (UAV, SOF) sufficient?	1	N/A
2. (Y/N) Can weapon system provide immediate BHA/BDA?	N	N/A

- Can SOF in the area provide immediate BHA/BDA?		
3. (Y/N) Can weapon system execute immediate reattack? (target moved, bad coords, desired effect not achieved)	Y	N/A

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