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A TIME-CRITICAL TARGETING ROADMAP

by

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Preface

I wrote this paper to draw attention to the Time Critical Targeting (TCT) problem. Although headway is being made towards achieving TCT in single-digit minutes, there appears to be no definitive roadmap or vision for achieving this goal. Although the solution presented here may not be the best, it is hoped that the facts outlined in this paper will stimulate thought and discussion, ultimately leading to a capable solution.

I have drawn ideas for this paper from my vast experience as an Instructor Weapon Systems Officer in the F-4E, RF-4C, F-111E, F, and G models, and the F-15E. I graduated from Fighter Weapons School in 1995, and have over 2200 hours of fighter time, including 260 hours of combat time in Operations PROVIDE COMFORT, NORHTERN WATCH, JOINT GUARD, DILIBERATE FORCE, and ALLIED FORCE. My last assignment was at the 422 Test and Evaluation Squadron where I tested many of the weapons and concepts discussed in this paper.

I would like to thank the people at the AC2ISRC office at Langley AFB for their contributions to this paper. In particular, Major Jack Cheney went out of his way to offer his insights during the development of the ideas presented here. Also, I would like to thank my Research Advisor, Lt Col Joseph Cheney, who provided the technical expertise and guidance necessary for producing a quality product. Finally, I would like to thank my wife Linda, and daughters Amy, Amanda, and Ashley, for their patience and understanding during the writing of this paper.

Abstract

Recent operations in Iraq, Kosovo, and Afghanistan have highlighted the fact that the U.S. military possesses very limited capability to engage and destroy time-critical targets. Although the U.S. military has been fortunate enough to adjust for this shortfall in the past, there is reason to believe that the prosecution and destruction of fleeting targets involving weapons of mass destruction will become extremely important in the near future. This applied research paper identifies critical shortfalls in the Time-Critical Targeting (TCT) mission as it exists today, identifies alarming trends in the TCT mission, and offers solutions for both the mid and far-term.

A trend currently developing among commanders is the reliance on Global Positioning System (GPS) guided weapons to engage time-critical targets. Not only is this trend dangerous, but it undermines the efforts of many to bring true TCT capability to the battlefield. Emerging technologies, especially in the areas of Advanced Targeting Recognition (ATR) and the Global Information Grid (GIG), offer the greatest promise of prosecuting time-critical targets in under 15 minutes by the year 2008. A far-term goal is to reduce the TCT timeline to single-digit minutes by the year 2015. This can be achieved by improving upon near-term capabilities and fielding both hypersonic weapons and Unmanned Combat Air Vehicle (UCAV) technology. This research also shows that improvements in the TCT Command and Control (C2) process will also significantly reduce the TCT timeline for both the mid and far-term.

Chapter 1

Introduction

Background and Significance of the Problem

"The (SCUD) launchers turned out to be more elusive than we'd expected. We picked off a few, but just as often bombers would streak to a site where a missile had been launched only to find empty desert"

—General H. Norman Schwarzkoph[1]

The Problem

If the past is an indication of future trends, tomorrow's commanders will be challenged with new and innovative uses of existing weapons that will present situations on the battlefield never seen before. An example of this trend is an adversary's unpredictable use of weaponry in unique and innovative ways, often affecting not only the tactical level of war, but also the operational and strategic levels as well. In Desert Storm, the SCUD missile developed by the Soviets to deliver a nuclear warhead was employed by Iraq not as a tactical weapon, but as a psychological weapon. Iraq hoped that the fear associated with the SCUD would drag Israel into the fight and result in the fracture of an already fragile coalition, with obvious strategic implications. Because of these implications, the coalition spent an inordinate amount of effort in locating and destroying the SCUD missiles, with very little success. After Desert Storm little headway was made in towards locating and destroying mobile targets such as the SCUD missile. Eight years later, in Operation ALLIED FORCE, the same deficiencies in targeting fleeting mobile targets were encountered yet again.

Realization of the U.S. military's shortfalls in attacking fleeting mobile targets has resulted in increased emphasis by both military and civilian leadership. Mobile fleeting targets, often referred to as time-critical targets, will present the Joint Force Commander (JFC) with a significant challenge in future conflicts. Many of our current and future adversaries understand and respect the limitations of today's airpower to identify and engage mobile targets, and have therefore developed tactics that prevent application of airpower against those high-value targets. Our adversary's ability to survive destruction of mobile type targets has not only tactical and operational implications, but strategic ones as well.

Currently the U.S. military's ability to engage time-critical targets is mediocre at best. We use antiquated and cumbersome systems and technologies to transmit imagery and tasking to the shooter and utilize weapons that weren't designed for the Time Critical Targeting (TCT) mission. A recent Government Accounting Office report stated that the chief reason it takes too long to strike time-critical targets is because "the systems involved in the sensor-to-shooter process do not operate effectively," and that "there are over 100 Command, Control, Communications, Intelligence, Surveillance, and Reconnaissance (C2ISR) systems that are needed to identify and strike targets."[2]

To make matters worse, there is an emerging belief among leadership that all new technologies provide better solutions. A reliance on Global Positioning System (GPS) guided weapons as an end-all, be-all solution has created unanticipated problems, such as a lower Probability of Kill (P_k), and increased probability of collateral damage. In addition, a significant shift from decentralized execution to centralized execution is occurring among leadership that undermines the ability to engage TCT in a timely manner.

DESERT STORM proved that in order to effectively engage time-critical targets, the sensor-to-shooter process had to be accomplished in single-digit minutes. The Iraqi's were able to vacate a SCUD launch site within minutes of firing a missile, thus preventing coalition forces from destroying the SCUD launchers.[3] General Jumper, the U.S. Air Force Chief of Staff, has outlined an initiative to reduce the TCT timeline to single-digit minutes.[4] Because the U.S. military currently lacks this capability to attack time critical targets in single-digit minutes, a solid roadmap for the near, mid, and far-term must be developed to achieve that capability. This roadmap for the future must involve the adoption of emerging weapons and information technologies, and the development of more streamlined Command and Control (C2) processes.

Thesis Stated

Anticipated reliance on J-series weapons will not meet the USAFs TCT needs in the near future. Furthermore, adoption of newer technologies, like Autonomous Target Acquisition (ATA) and the Global Information Grid (GIG), are required to engage time-critical targets in under 15 minutes by the year 2008. In order to engage targets in single-digit minutes by the year 2015, a combination of hypersonic missiles and UCAVs, utilizing ATA and the GIG, will be necessary. These improvements must also be supported by a decentralized execution structure to fully realize their potential.

TCT Defined

Although there is disagreement among the joint forces over the definition of time-critical targets, the USAF has adopted its own definition in order to facilitate the JFCs targeting priorities. The USAF recognizes time-critical targets as a subset of time sensitive targets.[5] Although all targets are to some extent time sensitive, the AF maintains that there is a distinction between important targets and critical ones. Critical ones are mobile, fleeting, surface targets, as designated by the JFC. Therefore, the USAF has adopted the following definition of TCT: "TCTs are high-priority, fleeting opportunity targets designated by the JFC and executed by the service components as requiring immediate or rapid response."[6] It is important to note that this is a USAF definition and that Joint Doctrine does not define TCT. For the purposes of this research, the USAF definition of TCT will be used. To further refine this definition, TCT are those targets that have either strategic implications or will significantly affect the ability of the commander to pursue his campaign objectives. Examples include SCUD missiles, Weapons of Mass Destruction (WMD) and their associated delivery vehicles, double-digit Surface-to-Air Missiles (SAMs) like the SA-20, or adversary leadership. Although the U.S. will most likely act with other nations as part of a coalition effort in future conflicts, this paper does not address any forces other than the U.S. military for accomplishment of the TCT mission.

TCT in DESERT STORM

TCT during Operation DESERT STORM was almost exclusively against Iraq's mobile SCUD missile launchers, with some effort expended towards destroying the fixed launch sites as well. Because of the strategic significance of the SCUD missiles, considerable effort was expended towards destroying Iraq's SCUD missile capability, absorbing as much as 25 percent of F-15E and LANTIRN equipped F-16 sorties in the war.[7] The SCUD hunt is of historical interest as the first air campaign against a mobile ballistic missile force.

The mobility of the SCUD missiles and the varying launch times provided minimal engagement time for the F-15E aircraft. Although JSTARS and other Intelligence, Surveillance, and Reconnaissance (ISR) assets were available in the AOR, the Iraqi's were very adept at minimizing their signature to prevent detection. Therefore, F-15E aircrew had to rely on visual detection of a launch in order to engage the mobile missile launcher. Even after detection of a launch, aircrews found it difficult to deliver ordnance because they could not identify the launch site or were unable to cue their weapons systems to the target location to deliver ordnance.

SCUD hunting tactics in Operation DESERT STORM were ineffective if measured in terms of the number of SCUDs destroyed. Although cockpit video does show what appears to be SCUD launchers being hit, they were later determined to be fuel trucks or other SCUD support equipment. At the end of the war, there were no confirmed reports of any SCUD missile launchers being destroyed during the entire SCUD hunting campaign. However, the level of effort expended in the campaign did have an effect on SCUD operations. The SCUD hunt discouraged road movement by those units and may have also resulted in fewer launches, as indicated by 50 percent reduction in the number of SCUD launches after the campaign started.[8] The inability to accurately identify the location of SCUD launches and pass that information to the aircrew is no doubt the root cause of why TCT failed in DESERT STORM.

TCT in Operation ALLIED FORCE

During Operation ALLIED FORCE (OAF), USAF TCT capabilities were limited to the Rapid Precision Targeting System (RPTS, discussed in Chapter 2) system used by the F-15E and some Close Air Support sorties. The major emphasis was on SAMs, Serbian aircraft, and Early Warning raiders. Unfortunately, the sensor-to-shooter timeline was so long it prevented the successful engagement of time-critical targets the majority of the times. Aircrews typically received airborne targeting up to 45 minutes after sensors had acquired the target, resulting in many missed opportunities because the Serbs had ample time to move the target before it was engaged. Another limiting factor during OAF was the quality of imagery sent through the RPTS system. Because the signal used to send imagery is non-secure, the pictures were declassified by degrading the resolution. Unfortunately, this degradation sometimes limited the aircrew's ability to properly identify the target.

OAF did have its successes. The innovative use of the AGM-130 in TCT missions presented the commander options that otherwise wouldn't have been available. Although the AGM-130 wasn't developed for this type of mission it proved to work well on most occasions. The AGM-130 was extremely successful against Serbian aircraft that were discovered while being moved from one location to another, and against SAMs early on in the war. As the war progressed, the Serbs became smarter and began moving their high-value assets more frequently to avoid their destruction.

The End, The Means, and The Way

The End

The ultimate goal in TCT is to find, fix, assess, track, target, and engage (F2AT2E)[9] critical, fleeting, mobile targets before those targets move or are utilized against coalition forces. Success of TCT isn't necessarily measured by how long the process takes, but whether or not the target of interest was destroyed. Time is completely relative. If a target remains fixed and dormant for 24 hours, then U.S. forces have 24 hours to kill it. However, if the time-critical target fires or becomes mobile before it can be engaged, the process is too slow, regardless of how many minutes the F2AT2E process took. Although the capability may someday exist to accomplish the kill chain in mere seconds, it is a topic of science fiction and is outside the realm of this paper. However, there are realistic mid and far-term goals that can reduce the kill chain to single-digit minutes, thus providing what amounts to a TCT solution. Unfortunately, the total TCT solution lies at least 13 years in the future and will only be achieved if a well-defined roadmap is developed and followed. This paper defines that roadmap.

The TCT roadmap has two well-defined waypoints that not only define the route to a TCT solution, but also provides for interim capabilities that can be applied in any mid-term conflict. The first waypoint is only six years from now, in the year 2008, and represents the mid-term goal of consistently engaging time-critical targets in 15 minutes or less. Although 15 minutes may seem excessive, and it is, this time period represents at least a 50 percent reduction in the current F2AT2E process. The second waypoint, or far-term, is the reduction of the F2AT2E process to single-digit minutes. Although single-digit minute destruction of targets won't guarantee success in all situations, it will be a significant improvement over today's capabilities and will undoubtedly change the face of tomorrow's battlefield.

The Means

Successful achievement of these mid and far-term goals requires significant improvement in three areas. The first area is munitions. Although the USAF possesses incredibly capable and accurate weapons, they have significant shortfalls when it comes to their application in a TCT environment. Current J-series weapons,[10] although suitable for large, fixed targets, aren't suitable for engagement of small, pinpoint, mobile targets as defined previously. Therefore, the fielding of weapons utilizing advanced imaging seekers and Autonomous Target Acquisition (ATA) algorithms are a prerequisite to achieving the goals mentioned above. The second area for improvement lies in the movement and storage of information. The development of the Global Information Grid will allow near instantaneous transfer of information from ISR assets to the shooter, utilizing data link as the transfer medium. The third area for improvement is the command and control of the F2AT2E process. Adopting a more decentralized execution process will result in significant timesavings and will have the most impact towards reducing the F2AT2E timeline to single-digit minutes.

The Way

As mentioned previously, the roadmap towards achieving TCT in single-digit minutes is defined by two waypoints: the years 2008 and 2015. However, in order to correctly use any roadmap you must not only know where you're going, but you must also know where you are starting from. Therefore, this paper first assesses current USAF TCT capabilities and then takes a hard look at where the USAF is currently heading. TCT enhancements which can be accomplished within two years are referred to in this paper as near-term improvements. Next is a proposal to meet the mid-term goal (2008) of achieving TCT consistently under 15 minutes by fielding ATA technologies and the GIG. Finally, this roadmap outlines the requirements necessary to achieve the far-term (2015) goal of TCT in single-digit minutes, particularly in the area of hypersonic munitions and UCAVs.

Notes

[1] General H. Norman Schwarzkoph and Peter Petre. It Doesn't take a Hero (New York, N.Y., Bantam Books, 1992), 419.

[2] Wiggins, James F., Attacking Time-critical Targets, GAO Report no. GAO-02-204R, Washington D.C.: Government Accounting Office, November 2001.

[3] Eliot A. Cohen, *Gulf War Air Power Survey*, Volume II (Washington, D.C., 1993), 335

[4] Elaine M. Grossman, "Air force Chief Launches Major Effort to Improve Targeting Speed," Inside the Pentagon, 8 November 2001, pg 3, on-line, Internet, 9 Jan 2002, available from http://www.af.mil.

[5] JP-1-02 defines Time sensitive targets as those targets requiring immediate response because they pose (or will soon pose) a clear and present danger to friendly forces or are highly lucrative, fleeting targets of opportunity. Joint Publication (JP) 1-02. *Department of Defense Dictionary of Military and Associated Terms*, 12 April 2001, 435.

[6] HQ AC2ISRC/C2N, Combat Air Forces Concept of Operations for Time Critical Targeting (Draft), October 2000, 8.

[7] Eliot A. Cohen, *Gulf War Air Power Survey* (Washington, D.C., 1993), 275

[8] Ibid, 291-292

[9] Often referred to as the "kill-chain."

[10] J-series includes JDAM and JSOW weapons.

Chapter 2

Current TCT Capabilities and Procedures

> *"GWAPS went even further and stated that no evidence was available that proved that the entire counter-SCUD effort had killed even one mobile launcher. The Iraqi SCUD reaffirmed Clausewitz's maxim about war being an enterprise between two thinking and reacting opponents, for the Iraqis used mobility, concealment, and camouflage to continue SCUD operations throughout the war."*
>
> —William Head[1]

The following section details the current capabilities possessed by the U.S. military with regards to TCT. Although the Navy is capable of accomplishing the TCT mission, the vast majority of TCT research, as well as combat missions, are conducted by the USAF. Accordingly, this section emphasizes USAF aircraft and weapons. TCT procedures are discussed in detail to give the reader an appreciation of how complex the TCT mission can become in a combat environment. It also demonstrates that current TCT methods can be both very flexible and very effective. This chapter will examine current procedures and munitions, followed by a discussion on collateral damage and the targeting chain.

The TCT Mission

USAF aircraft currently capable of performing true TCT missions include the F-15E, configured with the AXQ-14 data link pod, and the Predator Unmanned Aerial Vehicle

(UAV), modified to employ the Hellfire missile. Emphasis in this section will focus on the F-15E and data link weapons since it represents the best capability the U.S. currently has in engage time-critical targets. Another emphasis of this section is data link weapons. Although other weapons exist that can perform the TCT mission, such as Laser Guided Bombs (LGBs), they do not provide significant standoff or near all-weather capability that data link weapons provide. However, if the threat is low and the weather good, there is no reason why LGBs could not be substituted for data link weapons when engaging time-critical targets.

Procedures

A typical mission profile involves a two-ship of F-15Es orbiting at a predefined location awaiting tasking. The Air operations Center (AOC) receives TCT information from intelligence assets and identifies aircraft in the Air Tasking Order that are capable of engaging the target; in this case two F-15Es. Next, the AOC delivers the targeting information to a Rapid Precision Targeting System (RPTS) system, usually mounted in a van-size vehicle. The RPTS system then transmits the tasking to the F-15Es over an unsecure UHF frequency. For the TCT mission, each F-15E is configured with two data link weapons, such as the EGBU-15 or AGM-130, and an AXQ-14 data link pod. Although the AXQ-14 pod was originally designed for guiding the GBU-15 and AGM-130 data link weapons, a modification in the mid 1990s allowed the aircrew to record and play back transmitted video in the cockpit. The AXQ-14 receives streaming video from the RPTS system, which is then recorded on an 8mm tape mounted inside the pod. This allows the aircrew to receive imagery of a time-critical target and study it prior to employing ordnance.

Munitions

The EGBU-15 is a 2000lb-class data link weapon that has either an Infrared (IR) or Electro-optical (EO) seeker attached to the front of the bomb body (See figure 1). It is also modified with a GPS/INS guidance kit capable of guiding the weapon to target impact with in the absence of a valid data link signal. Target coordinates are programmed into the weapon prior to release to allow for midcourse guidance and target acquisition. After weapon release, which can occur as far as 17nm from the target, the Weapon Systems Officer (WSO) searches for the target using the video feed provided by the weapon's seeker.[2] After target acquisition, the WSO steers the weapon to impact, usually achieving a Circular Error Probable (CEP)[3] of 10ft.[4] Because the weapon can carry either an IR or EO seeker it possesses both day and night capability. However, cloud or fog cover will create some target acquisition problems, in which case the weapon can guide to the target coordinates based strictly on GPS/INS inputs.

The AGM-130 is very similar to the EGBU-15 but has been modified with a rocket motor and radar altimeter, which gives it greater range than the EGBU-15 and a low-altitude terrain-following capability (See Figure 1). It is also a 2000lb-class weapon with the same seeker options and GPS/INS capabilities as the EGBU-15. Typical release ranges are in excess of 40nm, which is a function of release altitude, airspeed, and profile flown.[5] Prior to release the WSO loads target coordinates and selects the flight profile desired. Profiles include medium altitude cruise up to 15000 ft MSL, or a terrain following profile as low as 200 ft AGL. This gives the weapon the capability to be flown under the weather to aid in target acquisition and avoid enemy fire. After release the weapon flies the programmed profile while the WSO achieves target acquisition and steers the weapon to impact. The AGM has a CEP of less than 10 feet.[6]

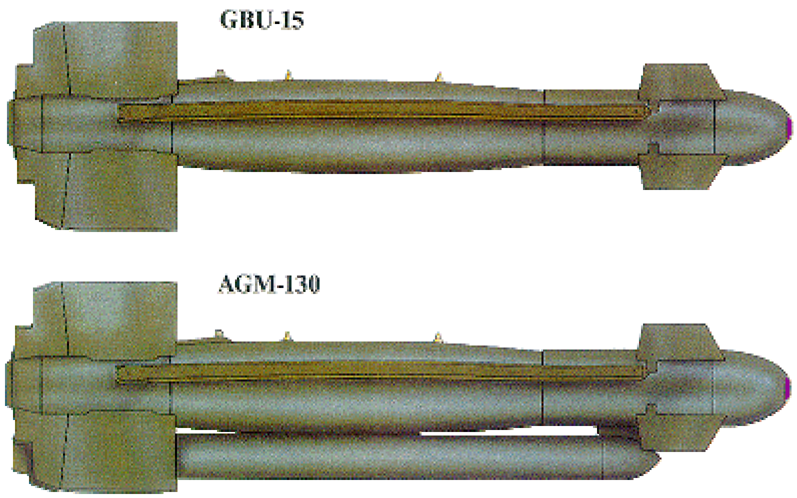

Figure 1. EGBU-15 and AGM-130[7]

Collateral Damage and Impact Point Selection

One of the primary concerns when engaging time-critical targets is collateral damage. Although steps are taken to minimize the risk, collateral damage does sometimes occur, often with strategic implications. Man-in-the-loop (MITL) weapons, such as the AGM-130 and EGBU-15, offer the unique capability to minimize the risk of collateral damage by maintaining the man-machine interface up until weapon impact. For this discussion on collateral damage two assumptions have been made: First, intelligence has positively identified the time-critical target and has completed a collateral damage assessment prior to engagement. The second assumption is that no weapon malfunction has occurred to cause the weapon to impact a point not intended by the operator.

When employing MITL weapons such as the AGM-130 and EGBU-15, the capability exists to constantly monitor weapon performance throughout the weapon time-of-fall (TOF). If for any reason the aircrew determines that the weapon may not hit the desired target, the capability exists to maneuver the weapon to an impact point that is more desirable. This capability becomes very useful should the aircrew determine that target identification is questionable, or that the situation has changed from initial target identification to weapon impact. For example, should the aircrew visually identify (through weapon video), that the target has relocated to a point where damage to civilian structures is likely to occur, they can select an alternate impact point, thus minimizing, or eliminating, collateral damage.

The MITL capability of the AGM-130 and the EGBU-15 has additional advantages. The ability exists to refine the impact point of the weapon should the target not be in the location initially programmed into the bomb. Although there are limitations, the aircrew can still destroy a target should that target become mobile, has moved its location a short distance, or if intelligence has provided coordinates that were less accurate than required. An added bonus of having video throughout the weapon TOF is that the aircrew can gather real-time intelligence around the target area prior to weapon impact. This has applications should the aircrew determine that additional attacks are warranted because more targets were identified during the first weapon attack. Also, the video data linked back to the aircraft provides real-time bomb impact assessment to assess the likelihood of engagement success. Although not considered bomb Damage Assessment (BDA), this information can be used to determine weapon impact point and likelihood of target destruction.

Newer GPS/INS guided weapons, often referred to as “J-series” weapons, (discussed in detail later), lack the ability to be controlled after release and make them a higher risk for collateral damage. The decision making process for these weapons ends at weapon release since bomb will impact its programmed target coordinates regardless of what exists at or around the target. Should the operator program the wrong coordinates, or if GPS is jammed, there is no guarantee that a J-series weapon will impact anywhere near the target. If this situation occurred with an AGM-130 or EGBU-15 the aircrew would immediately know and would apply corrections to account for the degraded weapon status. In addition, should Intelligence provide less accurate coordinates, or the target becomes mobile or moves slightly, the chances are less likely that the desired weapons effects will be achieved with a J-series weapon. Finally, J-series weapons also don't provide bomb impact assessment or intelligence gathering capabilities like the AGM-130 or EGBU-15 can.

Current Targeting Chain Shortfalls

Time-critical targeting is currently executed with a human-mental fusion of information derived from many disparate sources, usually existing in differing formats. In addition, TCT tasking relies heavily on voice communications between different agencies and the aircraft themselves. Coordination within the AOC is too slow and time consuming for rapid identification and classification of time-critical targets, and once identified, the time taken to task airborne assets usually results in many missed opportunities. In addition, there is currently no standardized C2 support hardware and software, and many lessons-learned from one conflict are not applied to the next because of personnel changes. The existing F2AT2E kill chain is a sequential process that is too slow to react to pop-up targets.[8]

As a result of lessons learned in Kosovo, an attempt is being made to identify where the shortfalls exist in the TCT process. To achieve the goal of engaging time-critical targets in single-digit minutes, four areas in the battle management process need significant improvement. These areas are: shared information environment, robust communications connectivity, data links, and automated decision tools. Although this paper addresses the first three areas only, it is worth mentioning that progress in automated decision tools is forthcoming. These decision tools are part of the Dynamic Battle Management (DBM) concept, which will fuse data from multiple sources and expedite the decision making process at the AOC level, thus shortening the sensor-to-shooter timeline in the near future.[9]

The DBM architecture envisioned requires both physical and process improvements to achieve dominant battlespace awareness. Physical improvements include sharing information over the GIG (discussed later), the sharing of a common operational picture through data link, and multi-sensor fusion for continuous tracking of objects. Automated decision support applications currently envisioned include TCT aids to display areas and targets of interest, ISR management tools to analyze the proper placement of ISR assets, Attack Operations Decision Aids to optimize weapons-target pairing, and the Multi-sensor Fusion Engine to assess the impact of potential NBC attacks on defended areas. Applied together, these improvements will aid the C2 decision making process and thus shorten the sensor-to-shooter timeline.[10]

Notes

[1] William Head and Earl T. Tilford Jr. The Eagle in the Desert (Westport, CT, Praeger Publishers, 1996), 121

[2] Source: Internet. Available from http://www.fas.org/man/dod-101/sys/smart/docs/man-sm-gbu15-000831.htm

[3] CEP is defined as 50 percent of the weapons landing inside the specified CEP distance and 50 percent landing outside the specified CEP distance.

[4] Ibid

Notes

[5] Source: Internet. Available from http://www.fas.org/man/dod-101/sys/smart/agm-130.htm

[6] Ibid

[7] Source: Internet. Available from: http://www.fas.org/man/dod-101/sys/smart/agm-130.htm

[8] *Time Critical Targeting (TCT) Functionality*. HQ AC2ISRC/C2N Operational Requirements Document. Langley, VA.: September, 2001.

[9] *Concept of Operations for Time Critical Targeting*. HQ AC2ISRC/C2N. Langley, VA.: October, 2000.

[10] Ibid

Chapter 3

Near-term TCT Improvements

> *"When the war came and the coalition was faced with a crisis in Israel, planners had to cobble together an anti-scud effort that did, in the event, experience great difficulty locating and attacking SCUDs."*
>
> —William Head[1]

The following section describes near-term TCT trends occurring in the U.S. military, particularly in the USAF. Near-term is defined as those weapons and capabilities that have just been fielded, or will be fielded in the next one to two years. These trends include data link, J-series weapons (JDAM and JSOW), and UAVs. Although data link will significantly enhance our TCT capability in the near and far-term, J-series weapons do not provide an enhanced capability, and more likely represent a step backward in capability. This following discusses how data link will positively impact TCT, followed by a review of J-series munitions capabilities why they are unsuitable for the TCT mission.

Data Link

Data link contributes to a coherent and comprehensive common operational picture of the battlespace by sharing current threat data, showing locations of ISR and warfighting assets, and provides cross cueing of sensors between ISR and weapons platforms.[2] Data link, or Fighter Data Link (FDL) in the case of the F-15E, will improve the synergistic effects of joint forces on the battlefield by allowing the fusion of sensor data from airborne and theater ISR assets. As a result, commanders will be able prosecute time-critical targets at a much faster rate than previously enjoyed. The most capable FDL platform is the F-15E, which is also the most capable TCT asset in the U.S. military. As a tribute to this capability, a squadron of F-15Es was modified with FDL capability prior to deployment to Operation ENDURING FREEDOM. Not only were the jets modified months ahead of schedule, they essentially cannibalized the entire F-15C fleet of their FDL equipment in order to bring that a TCT capability to the fight.

Description

Data link provides a secure, jam resistant, method of information transfer between fighter, surveillance, airborne C2, and ground stations. It provides the warfighter critical information such as air and surface target positions, position and status of friendly forces, and precise navigation. In addition, it facilitates the command and control of data link equipped aircraft from other airborne command aircraft or ground stations. Data link equipped aircraft enjoy greater situational awareness (SA), increased survivability, increased asset coordination, better target acquisition, and a decreased likelihood of committing fratricide. Data link information is displayed in the cockpit as determined by the aircrew and ISR assets, and requires no inter-flight verbal communication whatsoever. In addition, the ability to transmit imagery over the data link will be fielded within the next two years. This capability will significantly enhance the ability to engage time-critical targets in both the near and far-term.

Application

Data link capable fighter aircraft are capable of receiving theater surveillance and reconnaissance information from such platforms as Airborne Warning And Control System (AWACS), Rivet Joint, Unmanned Aerial Vehicles (UAVs), Joint STARS, TPS-75/59 ground radar variants, and data linked equipped ships. In addition, other airborne fighter aircraft are capable of contributing surveillance information as well as air-to-air and air-to-surface targeting information to other data link participants. This information is then used by fighters to engage targets of their choice, or as directed. The aircrew can cue sensors, such as a laser designator or Synthetic Aperture Radar (SAR) radar, to aid in target acquisition. Another option is to take the displayed target coordinates and load them into a GPS aided AGM-130, EGBU-15, or J-series weapon. The aircrew then flies their aircraft to a weapon release point and employs ordnance.

Advantages of Data Link

Data link allows the fusion of ISR information and literally puts it at the fingertips of the aircrew. In terms of TCT, data link significantly reduces the time required to send information to the shooter. These reduced transfer times are requisite to reducing the TCT timeline to meet both short and far-term goals as outlined previously. In addition, the increased situational awareness provided by data link significantly improves the survivability of both ISR platforms and the shooters. This increased SA allows the shooter to engage time-critical targets in higher threat areas where such engagement would have been too hazardous in the past. The forthcoming capability to pass imagery over the data link will also allow the aircrew to positively identify a TCT before employing ordnance, thus avoiding collateral damage or fratricide.

J-series Munitions

Trends in the munition-target pairing process indicate a heavy reliance on GPS/INS guided weapons for engaging both fixed and fleeting mobile targets. Although J-series weapons do provide an all-weather capability against many fixed targets, such as large buildings, troop concentrations, and some bridges, their relatively large CEPs preclude their use against small, pinpoint, or mobile targets. Most time-critical targets, as defined previously, are mobile and relatively small, thus requiring a small CEP to destroy it. J-series weapons, as defined here, include the JDAM and JSOW.

Types and Descriptions

The Joint Direct Attack Munition (JDAM) is a MK-82/83/84 (500/1000 and 2000lb respectively) bomb body modified with a GPS guidance kit. (See Figure 2). Target coordinates are passed from the host aircraft to the bomb prior to release, and after release the JDAM guides to the target using GPS and its embedded INS. If GPS jamming is affecting the weapon, the JDAM will guide using only its INS, resulting in a degraded CEP. The JDAM can achieved a CEP of 42ft in a jamming-free environment and under optimum GPS satellite coverage.[3] In a GPS jamming environment, where it relies solely on INS for guidance, the CEP increases to 98ft.[4] This error will most likely be significant when J-series weapons are employed against most time-critical targets.

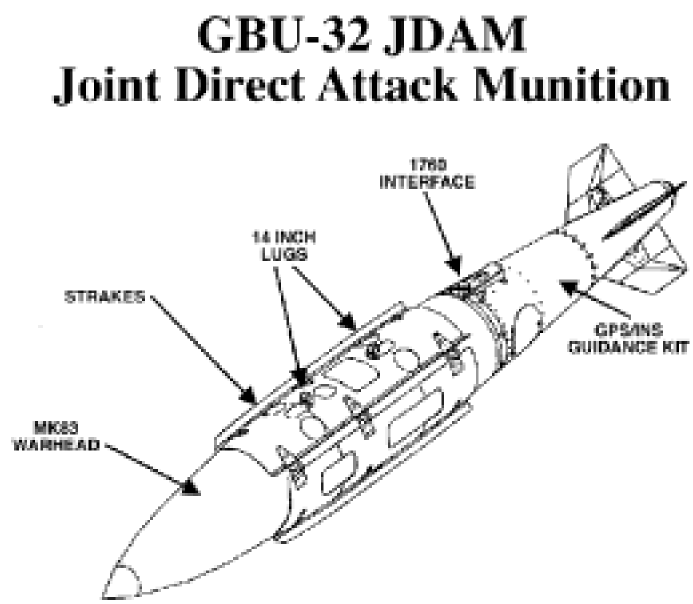

Figure 2: Joint Direct Attack Munition (JDAM)[5]

The Joint Stand Off Weapon (JSOW) is similar to JDAM but possesses unique capabilities that the JDAM does not (See Figure 3). First, the JSOW has deployable wings that allow for greater release ranges than the JDAM, as far as 40nm at medium altitude. This allows the releasing aircraft to remain outside the threat envelope when employing the weapon. Second, the JSOW is considered an area munition because of the 145 BLU-97 combined effects munitions or 6 BLU-108 Sensor Fused Weapon bomblets it can carry, as opposed to the unitary warhead in the JDAM.[6] The JSOW can be utilized against soft targets, like troops, or heavy armor, such as tanks and armored personnel carriers. Numerous kills can be achieved from one JSOW since the submunitions cover a large area. The currently fielded JSOW utilizes the same guidance as the JDAM, but a future modification includes an imaging IR seeker that may allow the JSOW to be employed against time-critical targets. This type of seeker will be discussed in the next chapter. Fielding of this improved version, called the AGM-154C, is expected this year.[7]

Figure 3. Joint Standoff Weapon[8]

TCT Application of J-series Weapons

Overall, J-series weapons currently lack the capabilities to be effectively employed in a TCT environment. Although they possess excellent capability against somewhat large fixed targets, they lack the capability to consistently destroy most time-critical targets. Several forthcoming enhancements to the J-series of weapons will help to rectify some of these shortfalls and will be addressed in Chapter 4. These enhancements include the Enhanced GPS and ATA technology.

Advantages of J-series Munitions in TCT

The only advantage of J-series weapons against time-critical targets is their all-weather capability, which may prove significant in some situations.

Disadvantages of J-series Munitions in TCT

The disadvantages of the J-series weapons in a TCT environment are three-fold. First, the increased CEP, as compared to MITL weapons, make destruction of pinpoint targets questionable at best. Many targets will be totally unaffected by a JDAM that hits within its CEP of 42ft, even though engineers would classify it as a hit. Second, J-series weapons currently have limited capability against mobile targets. After releasing the weapon, any real-time changes in the target location will result in a miss. For example, if the target starts moving after target coordinates were loaded, the weapon will impact the target coordinates, not the targets current location. Third, J-series weapons don't have the ability to be maneuvered after release. J-series weapons will impact a set of coordinates regardless of what is at those coordinates. MITL weapons possess the capability, through MITL architecture, to be maneuvered to a different impact point then was initially intended, should the situation warrant. This has serious implications when it comes to positively identifying targets prior to release. This situation occurred in Afghanistan when ground forces inadvertently relayed their own coordinates, instead of the target coordinates, to an airborne B-52, which resulted in the employment of a JDAM on the friendly position, killing three people.

Other factors contribute to the incompatibility of J-series weapons in the TCT role. First, the advertised CEP of J-series weapons are produced under ideal circumstances. GPS satellite coverage directly affects the accuracy of J-series weapons. Although the average accuracy of the GPS constellation is professed to be 23ft, satellite coverage is variable and can result in errors as much as 65ft, referred to as "spikes."[9] These spikes in accuracy can directly impact GPS weapon accuracy should they be employed during one of these spikes. The unfortunate aspect of TCT is that no one can accurately predict when TCTs will be engaged. In addition, a jamming environment would likely increase the CEP to where achieving target destruction would become extremely unlikely. This is becoming a very likely scenario given the availability of cheap, but effective, GPS jammers.

UAVs

UAVs are remotely piloted or self-piloted aircraft that can carry sensors, communications equipment, or other payloads, and have been used in the reconnaissance and intelligence gathering roles since the 1950s.[10]

Types and Descriptions

The most widely used tactical UAV is the RQ-1 Predator. It was designed to provide constant ISR coverage of a Joint Area of operations (JAO), and is considered a Joint Forces Air Component Commander (JFACC) owned theater asset. The Predator's sensor suite includes an EO/IR camera, a SAR radar, and a laser designator. This laser designator is used in conjunction with the Hellfire-C missile, which gives the Predator the capability to perform time-critical targeting. Video captured by the Predator is data linked to a Ground Control Station (GCS) where it is reviewed and disseminated through the Joint Broadcast System. The Predator has an unclassified endurance of 29 hours, and can communicate via line-of-sight date link or satellite. Its payload is limited to 700lbs.[11]

Figure 4. Predator Unmanned Aerial Vehicle (UAV)[12]

The RQ-4A Global Hawk UAV is a high altitude, high endurance UAV capable of reaching altitudes of 65,000 feet. Its 1200nm combat radius and 24-hour station time provide the JFACC an all-weather, near-real time, ISR platform. Its sensors include an EO/IR camera and a SAR with Ground Moving Target Indicator (GMTI) capability. Its total payload is limited to 2000lbs. The first production models are currently scheduled for FY03 and it is not postulated to have any air-to-ground capability as yet. ISR collection and dissemination is similar to the Predator except that the vehicle is essentially autonomous, using a preprogrammed flightpath with an in-flight reprogramming capability.[13]

Figure 5. Global Hawk UAV[14]

TCT Capabilities

Two applications exist with respect to UAVs and TCT. First, both the Predator and Global Hawk contribute valuable targeting information that can be utilized by other airborne assets to prosecute TCT. After acquiring targeting information utilizing its onboard sensors, the information is data linked back to the AOC for analysis. If the target in question turns out to be time-critical in nature it is passed on to the TCT Fusion or Unconventional Targeting Cell who would then task airborne aircraft to engage it.

The second application for UAVs in TCT exists with the Predator and its associated Hellfire-C missile. Although the collection and dissemination of targets is similar to that previously mentioned, the inherent capability to engage targets with its own weapons can significantly reduce the sensor-to-shooter timeline. Although the requirement still exists to obtain commander approval prior to engagement, once the decision to engage is made, the Predator is already in a position to employ ordnance immediately.

Advantages of UAVs in TCT

The obvious advantage of stand-alone UAVs for TCT is the shortened sensor-to-shooter timeline since no dissemination of information is required. In optimum conditions it is foreseeable that TCT could be achieved in single digit minutes utilizing UAVs. However, this would require that the Joint Forces Air Component Commander (JFACC) maintain a close relationship with the Unconventional Targeting Cell (UTC) in the AOC, or allow decentralized execution authority at the UTC level.

Disadvantages of UAVs in TCT

One significant disadvantage of the Predator UAV in the TCT mission is its limited weapons payload. Although the number of Hellfire missiles carried by the predator is classified, suffice to say the number is limited given the 700lb payload of the Predator.[15] Because of the long duration of Predator sorties, there will be situations when the number of time-critical targets exceeds the number of Hellfire's available.

Notes

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Chapter 4

Mid and Far-term TCT Solutions

> *"In sum, Iraq's operational approach and employment tactics meant that the probability of finding Iraq's mobile launchers and destroying them from the air before they were fired was very close to nil at the outset of the conflict."*
>
> —Eliot A. Cohen[1]

This section addresses the mid-term and far-term solutions for the TCT mission. Mid-term is defined as those capabilities that can be achieved by the year 2008, and consist of Autonomous Target Acquisition (ATA) seekers and the GIG technology. Far-term solutions are those capabilities that can be achieved by the year 2015 and include hypersonic munitions and Unmanned Combat Air Vehicles (UCAVs). This discussion includes a description of these capabilities, as well as the advantages and disadvantages of each. It is important to note that the near-term solutions play an important part in the ultimate realization of far-term solutions. Any delay realizing near-term capabilities will adversely affect the ultimate far-term solution.

Mid-term Solutions

Numerous recent technological advances show great promise for the TCT mission. Most notable is ATA technology, which is a hardware/software combination capable of seeking out and identifying targets based on preprogrammed information. It involves integration of an advanced seeker that compares the observed target to those stored in computer memory, and updates its impact point based on that information. Although this technology is currently undergoing development and testing, it is believed that a suitable solution can be achieved within the next five years given proper funding. Applying this technology to both existing and future weapons will further the goal of engaging time-critical targets in single-digit minutes.

Imaging Seekers

Imaging seekers are currently being developed to provide for all-weather engagement of time-critical targets. These new imaging seekers include EO (UV, visible light, and IR), radio frequency, SAR, millimeter wave, multi-spectral, and laser radar. Although no single method provides optimum capabilities in all situations and environments, the laser radar, or LADAR, and passive IR, show the most promise for future weapons integration.[2] Two weapons, designated as DOMASK and LOCAAS, are the most likely candidates for LADAR and passive IR respectively.

Weapons Descriptions

DAMASK

A modification kit for the JDAM munition called the Direct Attack Munition Affordable Seeker, or DAMASK, allows for greater accuracy over a GPS-only guided JDAM (See Figure 6). This new seeker, using an uncooled focal plane array, will be capable of achieving a CEP of under 10ft, a 300 percent improvement over a traditional JDAM, at a cost of $12,700 per seeker.[3] The weapon relies on GPS or INS for the midcourse portion of its flight profile much like the traditional JDAM. However, a few miles from the target the DAMASK seeker begins a search pattern trying to match the programmed target to what is being seen by the seeker. When the seeker achieves correlation it updates the JDAM guidance unit to refine the impact point.[4]

Prior to the mission a target template is created on a desktop computer and loaded into the DAMASK seeker. The template is created from infrared, visual, or SAR imagery obtained from any asset capable of producing these formats. In addition, a template can be downloaded from other airborne assets, or generated from an aircraft's on-board sensors, and loaded directly into the weapon for immediate employment. An excellent advantage DAMASK has over the traditional JDAM is in a GPS jamming environment. In such an environment the JDAM can utilize its INS for midcourse guidance to put it in a position for DAMASK to acquire the target, which would then provide terminal guidance.[5]

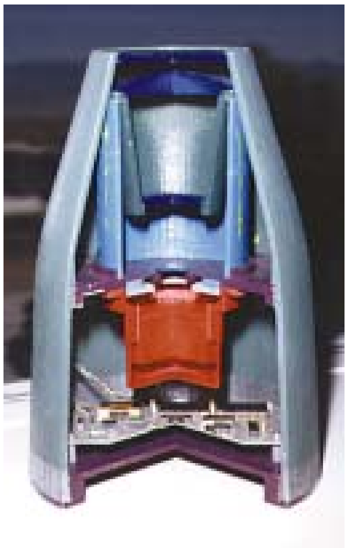

Figure 6. Cutaway of a DAMASK Seeker[6]

Another ongoing modification to the JDAM, called JDAM ER, is going to give the JDAM an extended range option. This is achieved by attaching a Diamondback wing assembly to the weapon. After release the wings deploy to give the weapon a gliding capability, significantly increasing its range.[7]

LOCAAS

LOCAAS, or Low Cost Autonomous Attack System, is a miniature, turbojet powered, endurance submunition outfitted with a Laser Detection and Ranging (LADAR) seeker (See Figure 7). The dispenser vehicle will be the SUU-64 canister, which is capable of carrying four LOCASS submunitions. LOCAAS has the capability to autonomously loiter while searching, identifying, classifying, tracking and engaging mobile and re-locatable targets. The turbojet allows the weapon to achieve standoff ranges in excess of 90nm. Once in the target area the LOCAAS can loiter for over 20 minutes while it attempts to acquire the target. It has a multimode warhead capable of armor penetration and fragmentation. The CEP of the weapon isn't available but it is projected to have a $30,000 per unit production cost.[8]

Like DAMASK, a target template, from on or off-board sensors, is loaded into the weapon prior to release. At release, the SUU-64 deploys the LOCASS submunitions which then utilizes GPS midcourse guidance as it proceeds to the target area. Using the LADAR, it correlates sensor data to that of the target template until it identifies the target and engages it.

Figure 7: Low Cost Autonomous Attack System (LOCAAS)[9]

Small Diameter Bomb

The Small Diameter Bomb (SDB) is a GPS guided penetrator weapon with a high length to diameter ratio, and will be the primary weapon of the F-22 and Joint Strike Fighter. It weighs 250lb, of which 50lbs is explosives, and can penetrate 6ft of 5000psi reinforced concrete.[10] The SDB will be fielded in two versions. Phase I weapons will have GPS guidance only and should be fielded prior to 2006. In order to achieve the desired 16-26ft CEP, the Phase I weapons will have receivers capable of tracking 12 GPS satellites, instead of the usual 5, and will be more resistant to GPS jammers. Phase II weapons will have a LADAR seeker modification giving it a CEP of less than 10ft, and should reach the field around 2009.[11] Another modification being considered is the attachment of a Diamondback Wingkit to increase the SDBs range to 25nm.[12]

JASSM

The JASSM, or Joint Air-to-Surface Standoff Missile, is a low-cost, stealthy, land attack powered cruise missile with a range in excess of 85nm (See Figure 8). It utilizes the same GPS/INS guidance system developed for the JDAM and JSOW, and has a penetrating warhead weighing 952lbs.[13] A major difference over the JDAM and JSOW is its infrared imaging seeker, similar to the one used on the Javelin missile. It utilizes ATA algorithms similar to LOCAAS and is capable of engaging mobile time-critical targets. Since the JASSM is still currently under development the CEP is unknown. Fielding of the JASSM should occur at the end of 2003.

Figure 8. Joint Air-to-Surface Standoff Missile[14]

Modifications to the JSOW

As mentioned previously, a proposed modification to the JSOW will give it ATA capability. Designated the AGM-154C, it utilizes an imaging infrared seeker that correlates the programmed target to the scene imaged by the seeker, similar to LOCAAS. The AGM-154C uses a unitary penetrator warhead and has a range of 35nm, but only the Navy is expected to purchase this version.

Author's Proposed Weapons Modifications

Although LOCASS, DAMASK, Small Smart Bomb, and JASSM all offer significant advantages over MITL and J-series weapons, their application in a TCT environment is still limited unless certain modifications are made. The first requirement is that there must be the capability to reprogram the target template while the munition is still on the host aircraft. Second, the munition must be fully adaptable. That is, the munition must be fully capable of engaging any target that is programmed into it by the host aircraft. Given the numerous forms that a time-critical target can assume, the weapon cannot be limited to certain target types as determined by the developers.

The third required modification to these ATA weapons is an adaptable fuse. Given the emphasis of reduced collateral damage on the battlefield, there must be a mechanism to select a warhead yield compatible with the selected target. This warhead yield should be cockpit selectable, and would be a function of target type, collateral damage concerns, and other factors.

The fourth modification requirement is to install an Identify Friend or Foe (IFF) interrogator aboard all ATA munitions. This will allow the weapon to further discriminate between friendly and enemy targets during the weapons acquisition and targeting phase of flight.

Advantages of ATA Technology in TCT

ATA munitions bring an all-weather TCT capability to the fight. Their precision is equal to that of MITL weapons, but are more capable of engaging mobile type targets. Their ability to loiter over the battlefield in large numbers offer the persistence required to engage tomorrow's time-critical targets. Modifications proposed by the author would further enhance their capabilities in the TCT role.

Global Information Grid

The concept of the Global Information Grid (GIG) was born out of concerns regarding interoperability and end-to-end integration of automated information systems and is the key requirement for obtaining information superiority as described in Joint Vision 2020. The GIG concept has been documented in several publications and it is widely accepted as a solution to a number of future information management and communications issues.[15] It is not yet certain if, or when, the entire GIG will be fully functional, but key portions important to the TCT mission should be available prior to 2008.

Description

The GIG is defined as a "globally interconnected, end-to-end set of information capabilities, associated processes, and personnel, for collecting, processing, storing, disseminating, and managing information on-demand to warfighters, policy makers, and support personnel." The concept of globally connected information and communications systems will allow near-instantaneous dissemination of time-critical targeting information through a single secure grid that links all Department of Defense (DoD) information systems. It can manage the collection, processing, storing, and dissemination of information for instant access to authorized warfighters worldwide, and will reduce the sensor-to-shooter timeline to under 15 minutes. Unfortunately, direct GIG access to airborne platforms will not occur until after 2010. However, an interim solution, called the Deployable Theater Information Grid, or DTIG, will give theater level users, such as airborne assets, indirect access to those portions of the GIG that are operational.

The DTIG is a module that acts as a gateway between the numerous information stovepipes and the data link. In concept, the DTIG would tie into the GIG and broadcast its information over data link so that airborne assets can access it. Since ISR assets would tie into the GIG, data link users would have near-instantaneous access to information provided by those ISR assets, thus providing a critical element for TCT. The DTIG module can be located in an AOC, or mounted in any large airborne platform such as AWACs or JSTARS. This will give users access to GIG information anywhere in the world regardless of any basing or access problems confronting the JFC.[16] The DTIG should be fielded around 2008.[17]

Capabilities

The GIG allows any participating member to contribute and extract information in order to accomplish mission objectives, while denying access to unauthorized users. This concept allows for the worldwide transmission of classified information to U.S. forces, and coalition forces if required. Also, a user can identify what information is important for mission accomplishment, and will be notified immediately when that information becomes available. An example would be the discovery of a time-critical target by an ISR asset.

CONOPS and Integration

Here is an example of how the GIG can be used for TCT, utilizing the Find, Fix, Assess, Track, Target, and Engage (F2AT2E) process. A ground station, located in the U.S., downloads imagery data from satellite that identifies (Find) a suspected mobile time-critical target located in Serbia. This ground station then loads that information into the GIG making it instantly accessible to an AOC located in Italy. The UTC in the AOC uses this information to correlate the time-critical target against other ISR assets, such as JSTARS, to pinpoint the target location (Fix). The UTC then does a collateral damage assessment of the target, accomplishes weapon pairing based on commander's guidance, and ensures ROE adherence, all prior to issuing engagement authorization. Meanwhile, the UTC tasks a nearby Predator UAV to proceed to the target location to positively identify (Assess), and follow (Track) the suspected time-critical target using its onboard sensors. The UTC also tasks two airborne F-15Es, via data link, to proceed to the time-critical target's location (Target) based on the Predator feed. Enroute, the F-15Es download imagery and other target information from the GIG (via a DTIG), which is then passed on as a target file to an externally loaded SDB. Clearance to engage is passed from the AOC to the F-15Es via data link. After achieving release parameters, the F-15Es releases their weapons (Engage) and egresses the target area. The weapons proceed to the target area while attempting to correlate the image produced from its onboard sensor to the one that was loaded into its memory by the F-15E. After achieving correlation the weapon updates its impact point and destroys the target. The same Predator that provided the assessment portion of the kill-chain can now provide the AOC real-time Battle Damage Assessment (BDA) of the time-critical target. If required, reengagement of the target can be accomplished using the same process.

Far-term Solutions

Hypersonic Munitions

After receiving TCT tasking, an aircraft has to fly to a weapon release point to employ ordnance, which can take several minutes depending on the aircraft's original location and the target. In addition, the Time-Of-Fall (TOF) of the weapon has to be considered in the TCT timeline, which is the time it takes a weapon to impact its target after being released from the host aircraft. A limiting factor regarding the use of MITL and J-series weapons for TCT is their excessive weapon TOF. The TOF can very anywhere from 30 seconds for a JDAM, to over 4 minutes for an AGM-130 when launched from maximum range, and does not include the time required for the aircraft to fly to the release point. Even under ideal circumstances, where targets are identified, processed, and engaged, in minimum time, the TOF of MITL and J-series weapons make it unlikely the target can be engaged in single-digit minutes.

The requirement exists to design and field weapons capable of extremely short TOFs. Such munitions would be powered, have a terminal seeker, a significantly longer release range, and a significantly shorter TOF than our existing munitions. These munitions, classified as hypersonic weapons, include the Fast Reaction Standoff Weapon, the Affordable Rapid Response Missile Demonstrator, and the High Speed Strike Missile. By definition, these weapons fly at speeds greater than mach six.

Description

The Fast Reaction Standoff Weapon (FRSW) is a solid rocket powered munition that was designed for rapid response to time-critical targets, achieving an average speed of Mach 8.1. It utilizes a boost phase, followed by a glide phase, that results in a standoff range that places the employing aircraft well outside most theater missile defenses. It is designed to be carried by most fighters and bombers. It utilizes INS/GPS for midcourse guidance and will carry two SDBs capable of destroying time-critical targets as well as high value buried hard targets. The SDB submunitions would be fitted with a LADAR seeker to allow for ATA during terminal guidance and will boast a CEP of less than 10ft.[18]

The High Speed Strike Missile is a Navy sponsored program to field a hypersonic missile in the 2005 to 2010 timeframe. Although specifics aren't yet available, this penetrating weapon will achieve speeds of Mach 8 and is capable of destroying both time-critical and underground targets, and can be launched from both surface and airborne platforms. Unlike the FRSW, the High speed Strike Missile won't have the ability to deploy ATA equipped submunitions.

The Affordable Rapid Response Missile Demonstrator (ARRMD) is an USAF program to build and demonstrate an affordable, Mach 6-8, scramjet powered missile for use against time-critical targets. It will have a max range of 600nm and should be operational by 2010. Specifics are not yet available.

UCAVs

The USAF and Navy are currently funding programs to develop Unmanned Combat Aerial Vehicles (UCAVs) for fielding in the post 2010 timeframe. The USAF UCAV, the X-45 Advanced Technology demonstrator (ATD), is being developed for the Suppression of Enemy Air Defenses (SEAD) mission. The Navy's version is called the UCAV-N, and is a dual-role reconnaissance UAV and attack UCAV aircraft. It is expected to be larger than the X-45 with a greater range and payload, and will be capable of carrier operations.[19] The current vision calls for the employment of UCAVs for missions that are “dull, dirty, or dangerous.” Dull being a long time on-station, dirty involving the sampling of hazardous materials, and dangerous involving extreme exposure to hostile action. The X-45 is being developed for the SEAD mission because that mission falls in the “dangerous” category. However, because TCT can involve long dwell times (dull), in a hostile environment (dangerous), the X-45 shows great potential for success in the TCT role.[20] Since both the Navy and Air Force programs are similar, the USAF X-45 will be used as the basis of this discussion.

The X-45 is a stealthy vehicle that weighs 8000lbs and can carry a 3000lb payload. It has a wingspan of 34 ft and has a 27ft long airframe (See Figure 9). X-45 employment would involve a cooperative formation of between three and six vehicles. Each X-45 would be preprogrammed on the ground and would conduct autonomous operations once airborne, but would possess the capability to be retasked.[21] Utilizing on-board as well as off-board sensors for cueing, each X-45 is capable of engaging multiple time-critical targets over on extended period of time. A huge advantage over existing TCT airframes is the ability to wait until a time-critical target moves, uncovers, or otherwise becomes identifiable. Because of the large number of UCAVs employed at any given time, the ability to successfully engage time-critical targets in a timely manner is significantly enhanced.[22]

Figure 9. X-45 Unmanned Combat Air Vehicle (UCAV)[23]

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Chapter 5

Recommendations

> *"With the target size of the (SCUD) mobile launcher, even the F-15E had little chance of identifying and acquiring the launcher if its precise position relative to more readily discernable returns was not known to the aircrew prior to takeoff."*
>
> —Eliot A. Cohen[1]

The following recommendations lay the groundwork for development of a TCT roadmap for the future. Although this list is not all-inclusive, these recommendations address near, mid, and far-term solutions to the TCT problem.

The Requirement for TCT

Recent operations have highlighted the U.S. military's relative inability to counter fleeting mobile targets represented by SCUD missiles, and mobile SAMs. Imagine the destruction and loss of human lives that would occur should our TCT shortfalls allow the enemy to employ WMD against friendly forces in some future war. It is therefore vitally important that the U.S. military perfect its TCT capability now so that it is never in a position where it wished it had allocated additional resources for this critical mission. The following recommendations address not only the shortfalls in today's TCT capabilities, but also present near, mid, and far-term solutions to the TCT problem.

Near-term Improvements

Data link provides a significant near-term improvement to the TCT mission. Continued fielding of this capability, especially in the F-15E community, will allow the JFC increased flexibility when confronted with time-critical targets. Also, the UAV has successfully demonstrated its ability to engage time-critical targets in combat. The USAF should pursue this capability further by acquiring more UAVs, as well as increasing their payload so that more Hellfire missiles can be carried. On the other hand, the current trend of using J-series munitions in the TCT role is not only unnecessary, it is dangerous. The relatively large CEP of J-series munitions, as well as the inability to engage mobile targets, calls into question their use in the TCT mission. Although J-series munitions do provide certain advantages to the JFC, such as an all-weather engagement capability, the added risk of fratricide and collateral damage far outweigh those advantages. A more logical, and safe, approach is to continue utilizing data link weapons, or even LGBs, until more advanced sensors, like LOCASS and DAMASK, are fielded.

Mid-term Solutions

ATA Technologies

The adoption of emerging sensor technologies will be the next major step towards solving the TCT problem. The development of LOCAAS and DAMASK will provide the warfighter with an all-weather, discriminate targeting capability, while at the same time reducing the risk to pilots and aircraft. These technologies can be fielded by 2008, at which point the dependence on current MITL weapons for TCT will fall by the wayside. However, there are important considerations that must be addressed while these technologies are still in the design and development phase. First, any munition employed in a TCT environment must be capable of being reprogrammed in the air by the host aircraft. This ability to download both target imagery and coordinates into an ATA weapon will allow for increased flexibility in a TCT mission. The second consideration that should be addressed is a comprehensive battlespace IFF capability that can be utilized by ATA weapons to prevent fratricide on the battlefield. This would require all coalition hardware be outfitted with a transponder capable of being interrogated by ATA weapons, thus reducing mistargeting and fratricide.

Global Information Grid

The GIG promises to significantly improve our capability to engage time-critical targets in both the mid and far-term. The concept of globally connected information and communications systems will allow the near-instantaneous dissemination of time-critical targeting information. This instant access will reduce the sensor-to-shooter timeline to where engagement of time-critical targets will occur in under 15 minutes. However, other far-term improvements will be necessary to achieve the TCT goal of single-digit minutes.

Shortening the Kill Chain

Current ongoing improvements and proposals for enhancing C2 capabilities at the AOC level will also shorten the sensor-to-shooter timeline. However, because the decision process still involves the human element, there will continue to be an inherent delay in engaging time-critical targets. The USAF relies on centralized control and decentralized execution to accomplish most of its missions. With the adoption of the

GIG, the decentralized control for TCT missions can occur in the AOC UTC as a minimum, possibly even by the aircrew themselves.

Obviously, success in TCT requires timely and accurate decisions by the warfighter. Any delay in the process will ultimately affect the outcome of any TCT endeavor. Since most AOCs have a UTC cell that is well versed on the commanders priorities and guidance, it only makes sense to put the decision for striking time critical targets at this level. Seeking authorization from senior leadership, such as the JFC, adds several precious minutes to an already long process. Even though some time-critical targets have strategic implications, the TCT engagement decision should rest at the UTC level, not the JFACC or higher level of command.

Although commanders may initially balk at putting the decision to engage TCT in the hands of the aircrew, future improvements in information fusion brought about by the GIG make this concept worth exploring. Although TCT is a demanding mission, requiring flexibility, discipline, and a thorough understanding of the nature of the mission, it differs very little from the counterair mission that has been practiced for decades. Any pilot engaging in the counterair mission must adhere to strict Rules Of Engagement (ROE) usually involving positive identification of the enemy before employing ordnance. To help the counterair pilot out the AOC publishes guidelines during the ATO process to ensure the commander’s intent is known and executed. Similar ROE for TCT mission could be produced that would allow the aircrew to make timely decisions regarding engaging time-critical targets. Once a time-critical target is disseminated on the GIG, TCT assets would be immediately notified of its existence. Information supplied by the GIG, such as target location, collateral damage assessments, threats, and the position of friendly forces, would allow the aircrew to render a quick decision on whether to engage or not. Utilizing decentralization execution in the TCT process would undoubtedly save several critical minutes in the targeting process.

Far-term Solutions

Hypersonic Weapons

To achieve the 2015 objective of engaging time-critical targets in single-digit minutes will require a significant improvement in weapon speed. By reducing the last element of the TCT process, engagement, to its absolute minimum time will require weapons that transcend traditional weapons in terms of weapon TOF. The fielding of hypersonic weapons, like the FRSW, will reduce the TCT timeline by several minutes. because of increased release ranges and reduced TOF. Hypersonic weapons, coupled with ATA seekers, will provide the ultimate solution for achieving TCT in single-digit minutes by 2015.

UCAVs

UCAVs, and the X-45 in particular, hold great promise for accomplishing the TCT mission in the year 2015. Their ability to provide continuous coverage of the battlespace affords them the luxury to persistently engage time-critical targets in a manner not readily achievable by today's aerospace forces. By merging the technologies of the GIG, the X-45, and the hypersonic missile, the U.S. military will realize its goal of TCT engagement in single-digit minutes. However, a TCT roadmap must be developed that envisions these two fledgling technologies as the far-term TCT solution.

Chapter 6

Challenges for the Future

> *"Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur."*
>
> —Giulio Douhet

The roadmap presented in this paper represents the best solution for achieving TCT in single-digit minutes by the year 2015. It identifies numerous shortcomings in the sensor-to-shooter timeline that need to be addressed. Whether or not these methods are chosen as a solution for the TCT problem, a clear vision, or roadmap, of the future must be formulated to ensure the most capability for the money invested. This section addresses the challenges associated with the roadmap presented in this paper. These challenges will require overcoming not only technological roadblocks, but also overcoming the J-series and C2 mindsets of today's commanders.

Technology Roadblocks

Most of the technologies mentioned in this paper have been successfully tested n a controlled environment. Exceptions to this are hypersonic missiles, and to some extent UCAVs. In addition, even though ATA technology has been demonstrated during testing, there is no guarantee that the technology will mature enough to warrant its application on the battlefield. Only time will tell. However, all technologies mentioned here are feasible, and given the right funding priorities should be available to meet the guidelines set forth in this paper.

J Series Mindset

Although it is sometimes difficult to get people to change the way they do things, it is sometimes equally difficult to convince them not to change. This dilemma is most evident among leadership in their adoption of J-series munitions as end-all, be-all weapons. While it is easy to understand their zeal for new technology and its application on the battlefield, a more restrained approach must be adopted when using new munitions for traditional roles. While J-series munitions do provide options to the JFC, such as all-weather capability, it must be understood that these weapons bring about their own unique problems as well, such as and increased CEPs and increased risk of collateral damage. It is only after understanding these pros and cons will the full potential of all weapons in our inventory be fully utilized.

Although the capability currently exists to accomplish the TCT mission, with somewhat mixed results, current trends indicate that we may actually be taking backward steps in what many perceive as forward progression. This is most evident by the adoption of J-series weapons by many commanders as the solution to their TCT problems. Nothing could be further from the truth. While J-series weapons do provide some additional capabilities, the increased risk and decreased success rate associated with these weapons don't warrant diverging from existing tactics, munitions, and procedures that are currently being employed by the USAF. That is, we should continue to using data link weapons until ATA technology is mature enough to take over as the premier guidance method for munitions.

Command and Control Hurdles

The proper integration of emerging technologies will greatly increase the speed and accuracy of the decision making process. If the U.S. military is to take advantage of this situation it must adapt its tactics and procedures to allow the warfighter a greater role in the prosecution of time-critical targets. Although it is understandable for commanders to want to retain the ultimate decision authority, the advent of the GIG will allow the warfighter access to the same information as the commander. Commander's guidance and intent, coupled with information obtained from the GIG, are all that is required to allow the aircrew to engage time-critical targets. Removing the commander from the sensor-to-shooter chain will eliminate several valuable minutes from the TCT timeline, and indeed may be the only way to achieve TCT in single-digit minutes. This delegation of authority will obviously increase risk to commanders, with possibly strategic implications, but it will nonetheless a prerequisite for future success in the TCT mission.

Notes

[1] Eliot A. Cohen. Gulf War Airpower Survey Volume II (Washington, D.C., Library of Congress, 1993), 335.

Chapter 7

Conclusion

> *"If our armed forces are to faster, more lethal, and more precise in 2020 than they are today, we must continue to invest and develop new military capabilities"*
>
> —America's Air Force Vision 2020

This investigation has demonstrated the need to improve the U.S. military's ability to prosecute time-critical targets. Several solutions were also presented which were broken down into near, mid, and far-term. The main focus has been the application of emerging technologies to achieve the ultimate goal of prosecuting time-critical targets in single-digit minutes. In addition, this paper lays the groundwork for developing a TCT roadmap to provide unity-of-effort in pursuit of that goal.

Thesis Restated

Anticipated reliance on J-series weapons will not meet the military's TCT needs in the near future. Furthermore, adoption of newer technologies, like ATA and the GIG, are required to engage time-critical targets in under 15 minutes by the year 2008. In order to engage targets in single-digit minutes by the year 2015, a combination of hypersonic missiles and UCAVs, utilizing ATA and the GIG, will be necessary. These improvements must also be supported by a decentralized execution structure to fully realize their potential.

Recommendation Review

The following recommendations are broken down into three categories. The first category recommends near-term improvements that are possible in the next one to two years. The second category addresses the next six years (up to 2008), and is referred to as the mid-term. The last category addresses the far-term requirements for accomplishing TCT in single-digit minutes by the year 2015. Since these far-term goals piggyback on the mid-term goals, all mid-term goals must be achieved in the time specified.

Near-term

1. Refrain from employing J-series weapons in the Time Critical Targeting mission. Continue to utilize current tactics, procedures, and weapons against time-critical targets, which will ensure target destruction while continuing to minimize fratricide.
2. Equip as many F-15E platforms as possible with full data link capability.
3. Expand use of armed UAVs in the TCT mission.

Mid-term

4. Field Autonomous Target Acquisition (ATA) technology as soon as possible. Ensure ATA weapons are a suitable replacement for Man-in-the-loop and laser guided munitions prior to adoption for the TCT role.
5. Continue development and fielding of the Global Information Grid. Adopt the Deployable Theater Information Grid as an interim solution.

6. Reduce the kill-chain timeline by moving the engagement decision from the JFACC to the aircrew.

Far-term

7. Develop and field hypersonic weapons utilizing ATA technology. Ensure compatibility with all existing fighters and bombers as well as future UCAVs.
8. Develop and field UCAVs capable of providing sustained coverage for the persistent engagement of time-critical targets. Ensure these UCAVs have the ability to carry future munitions such as Small Diameter Bombs and hypersonic munitions.

Recommended Future Research

Although most topics discussed in this paper warrant further research, two areas in particular stand out. First, the interoperability of the GIG and the existing data link architecture will likely be a major hurdle in allowing the near real-time dissemination of targeting information. This area is perhaps the most important in terms of achieving both near and far-term TCT goals, and should be researched further. Lastly, the feasibility of re-programmable ATA weapons should be examined since very little is written about this subject. This leads the author to believe that this option was never considered or was disposed of as too costly or technically infeasible.

The Importance of TCT

Past operations have shown the USAF to be very adept at most air-to-air and air-to-surface missions. However, these operations have also highlighted the fact that the

USAF lacks the ability to attack and destroy mobile, fleeting, targets that affect the commander's ability to prosecute the war or present a strategic threat. This shortfall has the potential to prove disastrous in the future as more and more rogue nations acquire WMD and the means to employ it. As a result of past conflicts, many of future adversaries are acutely aware of the tactics employed by the U.S. military, and have developed their own procedures for ensuring the survivability of their assets. Their ability to utilize hit-and-run tactics makes targeting these assets ever more difficult. Thus, the requirement to engage in TCT in the near, mid, and far-term will become increasingly more important.

Glossary

AGL	Above Ground Level
AGM	Air-to-Ground Missile
AOC	Air operation Center
ATA	Autonomous Target Acquisition
AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
C2	Command and Control
C2ISR	Command and Control, Intelligence, Surveillance, and Reconnaissance
CEP	Circular Error Probable
DAMASK	Direct Attack Munition Affordable Seeker,
DBM	Decision Battle Management
DMPI	Designated Mean Point of Impact
DOD	Department of Defense
DSP	Defense Support Program
DTIG	Deployable Theater Information Grid
EO	Electro-Optical
EGBU	Enhanced Guided Bomb Unit
F2AT2E	Find, Fix, Assess, Track, Target, and Engage
GBU	Guided Bomb Unit
GPS	Global Positioning System
GIG	Global Information Grid
GMTI	Ground Moving Target Indicator
IFF	Identify Friend or Foe
INS	Inertial Navigation System
IOC	Initial Operational Capability
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
JFC	Joint force Commander
JFACC	Joint Force Air Component Commander

JSTARS	Joint Surveillance Target Attack Radar System
MITL	Man-In-The-Loop
MSL	Mean Sea level
OAF	Operation ALLIED FORCE
PGM	Precision Guided Munition
P_K	Probability of Kill
JAO	Joint Area of Operations
JASSM	Joint Air-to-Surface Standoff Missile
JDAM	Joint Direct Attack Munition
JSOW	Joint Stand Off Weapon
LOCAAS	Low Cost Autonomous Attack System
ROE	Rules Of Engagement
RPTS	Rapid Precision Targeting System
SA	Situation Awareness
SAM	Surface-to-air Missile
SDB	Small Diameter Bomb
SEAD	Suppression of Enemy Air Defenses
TCT	Time Critical Targeting
TOF	Time-Of-Fall
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Air Vehicle
USAF	United States Air Force
WMD	Weapons of Mass Destruction
WSO	Weapon Systems Officer

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