Network-enabled Precision Guided Munitions

by

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CHAPTER 3
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I. Introduction

Network-centric warfare (NCW) is changing the way the U.S. military fights and wins wars. Recent U.S. combat operations in Afghanistan and Iraq have benefited from new Department of Defense (DOD) strategies and technologies such as improvements in precision guided munitions (PGMs) and network-centric operations. Networked technology and new operational concepts enable networked units and individual platforms to operate in ways not possible a few years ago. The goal is to link weapon systems, sensors, and people into a single network in which the whole is greater than the sum of its parts. To accomplish this goal, DOD is moving toward highly integrated force networks that combine information superiority with advances in technologies for surveillance, communications, and precision weapons.[1]

Collectively, the integration of these systems offers the possibility of creating a well-populated global information grid (GIG).[2] The GIG is a "system of systems" consisting of an accessible knowledge base where users may disseminate or retrieve information real-time. Users may connect to the GIG by accessing nodes on the network to collaborate with other warfighters, see a real-time map of the battlespace, or even coordinate fire support. These nodes consist of sensors [to yield intelligence, surveillance, and reconnaissance (ISR)], networks [to support command, control, communications, and computers (C^4)] and even PGMs.[3] PGMs are an easily overlooked node on the network and, if properly integrated, can add flexibility, speed, and real-time situational awareness to the battlespace. As munitions link directly to the GIG, they become contributors providing in-flight position updates, time-to-impact, and bomb impact assessment prior to warhead detonation. Most importantly, network-enabled PGMs provide a means to fill a documented capability gap against mobile targets.

In 2003, the Integrated Armament Planning Panel (IAP) of the Air Armament Summit highlighted network-enabled weapons as the single most cost-effective means available for enhancing overall armament capability against the most challenging targets—time sensitive and mobile targets.[4] At the conclusion of the summit, the IAP recommended the fielding of a net-enabled weapon at the earliest opportunity to greatly enhance overall flexibility, lethality, and command and control awareness. Currently, DOD and industry are pursuing technologies that will enable weapons to produce and consume information within the GIG construct. Threshold air-to-ground weapon candidates are Small Diameter Bomb Increment II (SDB Inc. II), the Joint Air-to-Surface Standoff Missile (JASSM), and the Wind Corrected Munition Dispenser-Extended Range (WCMD-ER).[5]

Much research exists concerning NCW and its potential for a Revolution in Military Affairs (RMA), but very little information is available regarding network-enabled weapons. The purpose of this research paper is to discuss how the next generation of air-to-ground weapons may impact network-centric operations. To begin, the paper will briefly discuss how NCW improves battlespace awareness and then examine current PGM capabilities and limitations to use as a framework for further analyzing the benefits of network-enabled weapons. The paper will conclude by offering recommendations to streamline this capability to the warfighter.

II. Network-centric Warfare

> *The art of commanding aerospace power lies in integrating systems to produce the exact effects the nation needs.*[6]
>
> Air Force Vision 2020

The information revolution is creating a "systems of systems" that will give coalition forces superior battlespace awareness and fundamentally change the way U.S. forces fight.[7] NCW is transforming the battlespace into an integrated array of sensors, weapon systems, and users that share information real-time. Studies have shown that networking enables forces to undertake a different range of missions than non-networked forces by improving both efficiency and effectiveness of operations.[8] A quicker flow of information improves the situational awareness of networked users and allows more rapid and effective decisions at all levels of military operations. Commanders at all levels share a continually updated understanding of objectives and operations of both friendly and enemy forces. Overall, NCW increases operations tempo and enables U.S. forces to find, fix, track, target, engage, and assess (ie. the kill chain) the enemy at an accelerated rate. Figure 3.1 is a high-level operational concept that illustrates the complexity and integration of networked military users. Note that information flows almost instantly to commanders at all levels of warfare through networking and global connectivity.

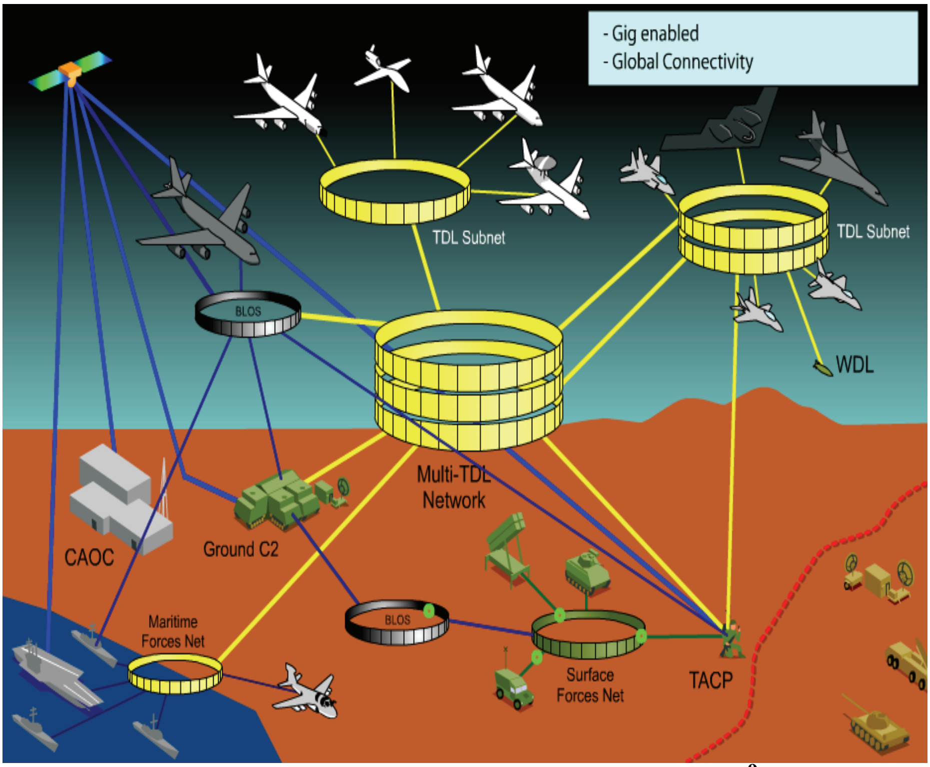

Figure 3.1 Network-centric Operations[9]

Conceptually, NCW provides battlespace entities with "shared battlespace awareness" through interconnectivity and networking techniques.[10] Warfighters can use a common operational picture (COP) to self-synchronize and increase their situational awareness to reduce the fog and friction of war. The air-to-air mission area is the most thoroughly documented and convincing example of the power of NCW.[11] When fighter aircraft are networked, digital information on friendly and hostile forces is shared instantaneously, thereby enabling participants to employ with enhanced awareness. For example, fighter pilots only need to look at their joint tactical information distribution system (JTIDS) display to get an entire assessment of the air battle including who is supporting missiles and who needs assistance. In contrast, non-networked fighters must share information via voice communications with other fighters and controllers. Building a mental picture through voice communication takes much more experience and leads to informational gaps. Communicating the minimum essential information takes time, and the resulting situational awareness often differs significantly from reality.[12]

Digitizing air-to-ground mission tasks offers similar benefits to warfighter execution as in the air-to-air mission areas. Digitization and networking of friendly and known hostile forces engaging on the battlespace can provide a COP that reduces the fog of war. Engaging forces require exact positions of both friendly and hostile forces before conducting precision strikes and operational fires because battlespace uncertainty decreases combat effectiveness and increases the risk of fratricide. NCW offers a more responsive and less burdensome approach than voice communications by fusing, routing, and displaying information in a user-friendly format. Netted commanders can pass digital information real-time allowing them to task units, assign targets, and coordinate fires.[13] Additionally, the elimination of fratricide may be realized by situation displays that alert the warfighter if inadvertently engaging friendly forces. Network-centric systems enhance the air-to-ground mission areas by reducing the kill-chain timeline while contributing to improved responsiveness and flexibility of network-centric operations. To achieve maximum efficiencies and effectiveness, PGMs need "machine to machine" interfaces that link air-to-ground weapons to the GIG. Currently, PGMs do not connect digitally to the GIG and provide no information outside of their respective launch or designating platforms. Just as Blue Force tracking aids situational awareness on the battlespace and prevents fratricide, net-enabled precision munitions promise incredible leaps in warfighter capabilities. Before proceeding, a brief discussion on current PGM capabilities and limitations is in order to use as a framework for analyzing the potential benefits of network-enabled weapons.

III. Precision Guided Munitions

> *The United States is] converging very rapidly…to see all high value targets on the battlefield at any time…make a direct hit on any target we can see, ... destroy any target we can hit... make the battlefield untenable for most modern forces.*[14]
>
> -- Under Secretary of Defense William J. Perry (1978)

Current Capabilities

The development of PGMs has provided military commanders with increased flexibility and accuracy in bombing operations making them increasingly lethal on the battlespace. PGMs are defined as weapons that can be controlled after release, so as to give them a higher probability of hitting the target.[15] Prior to PGMs, air-to-ground weapons were extremely inaccurate, so planners compensated for bombing errors by attacking enemy targets with large force packages carrying heavy bomb loads. During World War II the Air War Plans Division allocated 6,860 bombers to destroy only 154 targets.[16] Today, technology allows the U.S. military to destroy a single target with only one weapon. To achieve the desired effect with a single weapon, munitions must be controllable after release. Current air-to-ground weapon guidance control is through man-in-the-loop or autonomous control systems. Both types guide the weapon to the intended target by adjusting bomb trajectory while still in-flight but differ in the method and amount of human input after release. The ability to adjust bomb trajectory in-flight not only destroys targets with pinpoint accuracy but also reduces risk of collateral damage and fratricide. Overall, PGMs offer warfighters unprecedented increases in efficiency (require fewer weapons and platforms) and effectiveness (kill discriminately) for conducting warfare.

As depicted in Figure 3.2, the transition to guided weapons has accelerated rapidly since Desert Storm, when unguided weapons were the norm. During the last decade, many studies and reports conclude that precision weapons are key contributors to the success of an air campaign. The development of technologies such as laser guided bombs (LGBs) and Global Positioning System (GPS) guided weapons expands the effectiveness of each strike aircraft by reducing the limitations caused by bombing inaccuracies and poor weather employment restrictions.[17] Advances in precision weapons technology were apparent during recent U.S. combat operations in Afghanistan and Iraq. Both operations are regarded as an unprecedented demonstration of combat power. According to a DOD report to Congress, the destruction of fixed targets increased by 12 percentage points from Kosovo to Afghanistan while the attacks resulting in the damage or destruction of mobile targets increased by 21 percentage points.[18] The report did not have data to incorporate Operation Iraqi Freedom (OIF) but concluded that advances in precision weapons have improved the accuracy of bombing operations. Today's inventory of precision weapons provides the warfighter with an accurate and lethal weapon to engage enemy targets.

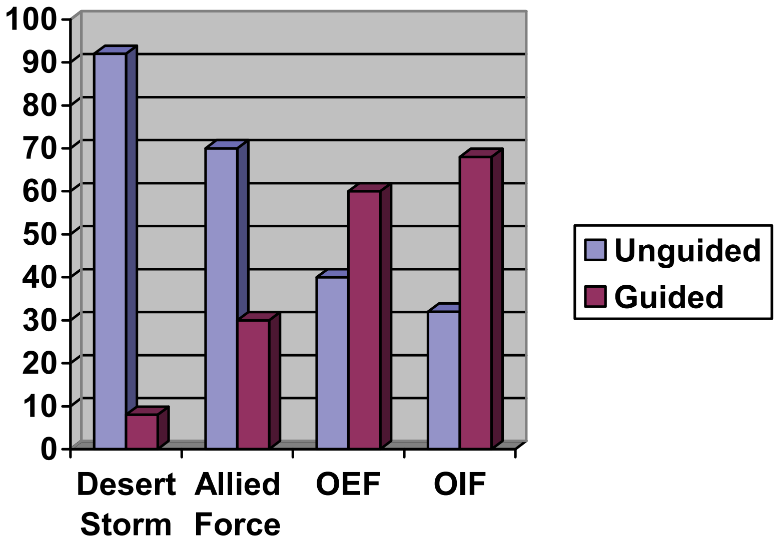

Figure 3.2 Percentage of Guided and Unguided Munitions Used in Recent Operations[19]

As discussed, PGMs are accurate and lethal. However, many military and civilian officials incorrectly group all precision weapons together. Actually, the U.S. military weapons inventory possesses many different types of PGMs, and each offers unique attributes based on its accuracy requirement and guidance method. For example, the two accuracy classifications for PGMs are "precision" and "near-precision." To be classified as "precision," the munition must have a circular error of probability (CEP) equal to or less than 9.9 feet from the aim point. If the munition hits outside that circle but inside 66 feet, it is called "near-precision."[20] However, most warfighters categorize PGMs by guidance into two types: laser bombs or satellite guided bombs.

LGBs are simply general-purpose bombs with an added guidance kit that transforms a "dumb" bomb into a "smart" munition. Employment is simple and flexible with either an air or a ground designator lasing a target aim point while the munition centers the laser spot on its seeker's field of view and guides itself to the laser spot. This family of PGMs allows tactical fighter aircraft to release, guide, and destroy a target with MITL control throughout the time of flight (TOF) of the weapon. Both fixed and moving targets are vulnerable to LGBs' lethality, but dependent on the laser designator's ability to find, track, and illuminate the target. Operation Desert Storm highlighted the awesome capabilities that LGBs provide to the warfighter. LGB employment largely swung the outcome of the 1991 Gulf War by shutting down Iraq's integrated air defense system, keeping its air force out of the fray, and destroying its fielded forces.[21] However, employment constraints led to development of the next family of precision weapons.

GPS-guided munitions were developed in the 1990s to fill a capability gap against fixed target employment when weather conditions obscured the target area and restricted attacks. The satellite constellation is the fundamental underpinning for satellite-guided munitions in use or development today. These munitions have the benefit of precision guidance by using GPS for navigation, but their weapon effectiveness and accuracy requires precise, timely target coordinates.[22] Employment is simple, with aircrew downloading target coordinates to the weapon via a data transfer device or hand loaded real-time through system avionics. After release, the munition autonomously acquires the satellite constellation and navigates itself to a target coordinate that was inputted pre-release, freeing the release platform to prosecute another target attack or threat react if necessary. Recent operations in Afghanistan and Iraq highlighted U.S. military PGM capabilities but also uncovered capability gaps with existing munitions.

Current Limitations

Current operational limitations vary based on individual weapon type and guidance control; however, broad comparisons serve to illustrate overall employment constraints. If accuracy is most important, LGBs deliver increased accuracy compared to GPS-guided weapons but require a clear line of sight from the laser designator to the target. Any obscuration that prevents target laser illumination, like weather, will result in miss distance and a less effective weapon. Miss distance is measured in meters or feet from the target aim point to the actual weapon impact point. Depending on warhead size, excessive miss distance will result in minimal to no target damage. In poor weather, LGBs usually are not released due to miss distance concern and the inability to positively identify the target with on-board infrared sensors.

GPS-guided bombs autonomously guide to the aim point regardless of target area obscurants but have limitations as well. Satellite-guided weapons require precise target coordinates, which take time to mensurate, thus delaying prosecution of time sensitive targets (TSTs). Additionally, GPS-guided munitions have no capability against moving targets because the weapon navigates only to the coordinate inputted pre-release. Currently, there is no method to redirect a GPS-guided weapon after release and, consequently, it has no capability against mobile targets. Overall, a well-documented capability gap exists with current PGMs in their lack of ability to engage moving targets in poor weather conditions or targets that maneuver during the kill chain. Joint fighter/bomber aircraft employ a number of weapons to attack fixed targets but have few options to attack time sensitive or mobile targets.[23]

The inability to find, fix, track, engage, and assess the enemy during all weather conditions affords the enemy sanctuary if they relocate. According to senior Air Force officials, the goal is to strike mobile and emerging targets in less than 10 minutes so such targets will have no sanctuary from U.S. airpower.[24] To accomplish this goal, each stage of the kill chain must be compressed and new ways sought to improve efficiencies. Currently, the kill chain requires inefficient human interfaces at every level in the process. For example, common to all munitions is a deficiency in assessing battle damage, which results in the inefficient use of weapons by repeatedly striking targets to ensure their elimination.[25] To improve the process, machine-to-machine interfaces must replace human linkages where possible.

To summarize, skilled human operators employing PGMs enable precision strike, but the root cause of most operational limitations is a lack of real-time information. Information is required not only for warfighters to find and kill their targets but also to save lives by building a COP of friendly and enemy forces. Fratricide or unplanned collateral damage is a symptom of poor situational awareness and a lack of real-time relevant information. Aircrews must know the precise geo-location of the target and of friendly forces to adequately deconflict and prevent fratricide. Machine-to-machine connectivity to the GIG will improve the kill chain process and reduce fog and friction by increasing efficiency. Future smart weapons must possess the capability to re-direct trajectory in-flight in order to attack time sensitive and mobile targets and must contain safeguards to minimize fratricide. Given current PGM capabilities and limitations, the paper will next examine the potential benefits of linking precision weapons to the GIG.

IV. Capabilities from Networking Weapons

The electron is the ultimate precision guided weapon.[26]

--John M. Deutch, Director of Central Intelligence (1996)

Precision strike capabilities allow the USAF to discriminately apply force where required. In order to apply force, the kill chain must find, fix, and track the target; identify as hostile and assign a shooter for engagement; and analyze bomb impact results against the desired effect. Technology has not yet evolved to allow the kill chain to transition through each phase seamlessly, but networking weapons has the potential to dramatically improve efficiency and effectiveness within each kill chain element, especially "engage" and "assess." Network-enabled weapons provide a means to fill an existing capability gap, with the potential payoff in capability being enormous and limited more by imagination than innovation. These weapons provide the capability to exchange information between weapons and nodes attached to the GIG construct. The nodes include delivery platforms, command and control (C2) centers, and ISR systems.[27] The delivered capability is a weapon that collaboratively interfaces with the network and can adjust its trajectory in-flight to enhance accuracy and achieve real-time effects. Other potential benefits include an in-flight status update of the weapon and real-time bomb impact assessment.

Network-enabled weapons will provide the warfighter with the capability to prosecute time sensitive and mobile targets by supplying real-time accurate target information to the weapon from release through impact. In essence, network-centric systems establish communication nodes linking weapons with the most accurate information available on the GIG. Information will be provided to the weapon by the most timely and accurate source available and not be limited to the delivery platform. In-flight, the weapon receives target location updates and incorporates real-time data into guidance systems for aim point adjustments. This will provide a means to redirect a GPS-guided weapon after release and hold the mobile target set at risk regardless of weather conditions. If the weapon is equipped with a seeker, the seeker may be preprogrammed to take over and gain greater accuracy for discriminate targets.[28] Overall, network-enabled weapons that can transmit and receive information from the GIG will impact every element within the kill chain. The sections below further describe the attributes of network-enabled weapons and assume they are equipped with a seeker.

Find/Fix/Track

Air-to-ground weapons are designed to destroy enemy targets but may provide utility for the first three kill chain elements. Current and near-term PGM imaging suites include electro-optical [ultra- violet, visible, and infrared (IR)], radio frequency, synthetic aperture radar, millimeter wave, laser radar, and multi-spectral seeker technologies.[29] Many of these imaging technologies enhance seeker capabilities by providing automatic target recognition (ATR) features. ATR is the ability to automatically recognize sensed visual, IR, radar, or electronic signatures.[30] Automatic recognition of known signatures offers a significant operational benefit by the detection and identification of enemy targets. Theoretically, future weapons programmed with ATR features may autonomously locate, prosecute, and destroy an enemy target.

Looking farther into the future, networked-enabled munitions that possess ATR features may benefit the find, fix, and track kill chain elements by gathering real-time intelligence. At any given time during an air campaign, ubiquitous weapons with sophisticated sensor suites may "swarm" the battlespace, giving commanders and analysts an avenue for gathering intelligence. Weapons with ATR algorithms may pulse the GIG and alert commanders of potential targets while waiting for further guidance if not preprogrammed to engage. In addition, intelligence analysts may use a weapon's sensor to provide a quick look into a specific area to find, fix, or track emerging targets. In essence, these weapons will become sensors themselves, able to promulgate the network with information, and thereby increasing battlespace awareness. True, this sounds far-reaching, but is actually within the realm of the doable, as the sensor is already embedded in the weapon and required to engage the target.

Engage

Extending connectivity to weapons ensures the timeliest and highest quality information is available for their use while engaging fixed, stationary, or moving targets. Networking weapons via a common weapons data link (WDL) provides an ability to attack time sensitive or mobile targets by using the most accurate information available throughout the weapons TOF.[31] Following the weapon's release, the network will redirect/adjust the weapon's aim points up to impact or until the weapon's seeker can acquire and autonomously guide to the enemy target. In a true network-centric environment, the limiting engagement factor is the time for a delivery platform to obtain proper release conditions plus the TOF of the weapon. Machine-to-machine connectivity reduces kill chain workload by digitally passing release clearance and target coordinates to the desired delivery platform. Once the aircrew accepts tasking, avionics are automatically programmed for the corresponding target engagement and loaded with essential information (target coordinates, initial point coordinates, weapon choice, fuze setting, release altitude) to prosecute the target attack. Overall, the concept of operation (CONOPS) is the same regardless of air-to-ground mission area assignment. However, differences may exist with weapon release ranges and who assumes control of the weapon while in flight.

The underlying basis for this entire concept is a common weapons data link architecture that links weapons to the GIG. Access to the GIG occurs after weapon release and at the first indication of need. This paper will assume proper configuration and access requirements are available for weapons to adaptively enter and exit the network. In addition, just as aircraft have a unique net identification, networked weapons will possess an identification that ensures controlling elements pass information to the correct node (weapon) to enhance battlespace awareness, ensure positive weapon control, and allow users to tag weapons for in-flight status updates. Potential weapon in-flight status information may consist of current weapon location, health, target assignment, time to impact, and fuze status. The following two scenarios illustrate the CONOPS from tasking through BIA. The first scenario may have a weapon release well within 20 miles to the target while the second assumes a standoff PGM like SDB is employed.

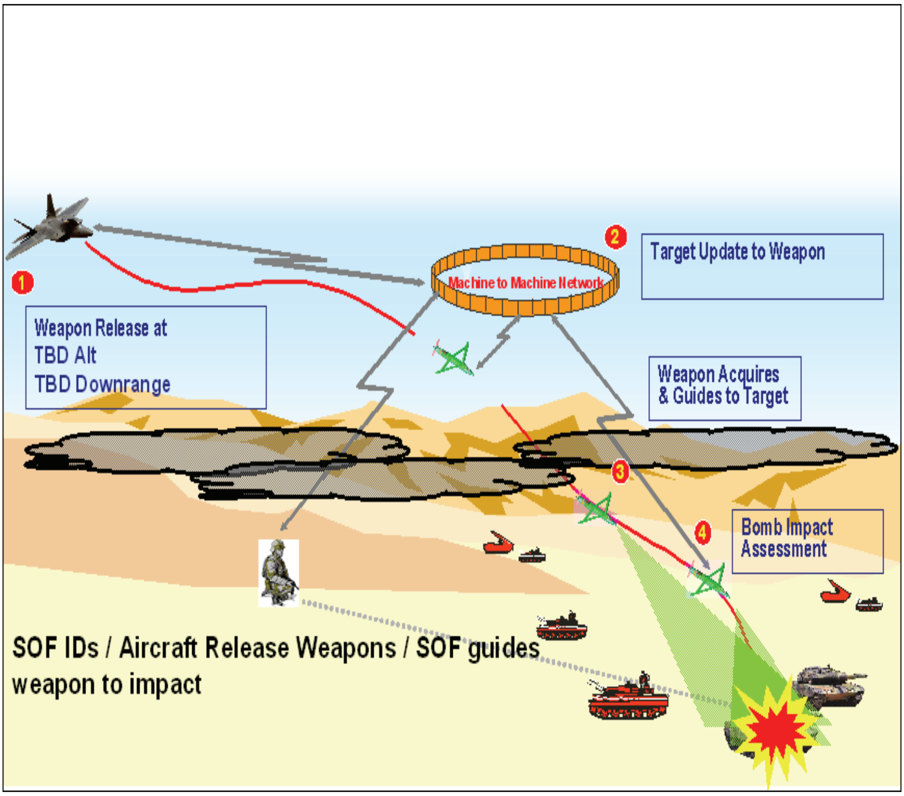

Figure 3.3 Net-enabled Munitions Capabilities in a CAS Scenario.[32]

Close Air Support Scenario

As depicted in Figure 3.3, a joint terminal attack controller (JTAC) finds, fixes, tracks, and targets an enemy tank moving toward friendly forces and digitally tasks an on-call F/A-22 equipped with network-enabled PGMs. The F/A-22 accepts the tasking and downloads the target coordinates and the location of known friendly forces into the weapon's guidance computer. Weapon algorithms will automatically avoid emitting Blue Force trackers and no strike targets. After release, the Raptor "bugs out" while the weapon enters the network and transmits current location with target assignment. Due to the close proximity of friendly forces, the JTAC takes weapon is still in flight. Updates are important until the weapon can autonomously acquire and engage the target. High quality new data reduces target location uncertainty and provides the seeker with the most accurate cue for target acquisition. The weapon will accept midcourse cue updates until the seeker autonomously transitions to endgame terminal guidance. During the engagement, the JTAC confirms the weapon has autonomously transitioned to the enemy tank by viewing his situation display and begins prosecuting another attack. However, if the weapon never autonomously transitions to the tank, then the JTAC will provide updates until weapon impact (similar to lasing a target except the weapon receives coordinates instead of guiding to reflected laser energy). Prior to impact, the weapon transmits BIA over the network.

Time Sensitive Targeting Scenario

The second scenario, shown in Figure 3.4, is a time sensitive mission of an enemy surface-to-air missile (SAM) threat. ISR assets alert commanders of a real-time tactical SAM threat against coalition air forces. A C2 node digitally re-tasks an F/A-22 to engage the pop-up threat. The F/A-22 accepts the tasking, downloads the new target coordinates into the weapon's guidance computer, and releases the weapon with more than 40 miles standoff. In this scenario, standoff range is important to minimize threat exposure. Shortly after release, the weapon enters the network and accepts midcourse guidance updates until the seeker autonomously guides to the enemy target. Prior to impact, the weapon transmits BIA to the GIG and alerts the C2 node of task completion. ISR assets or the F/A-22 could supply the weapon with in-flight target updates, but updates are not required unless the target maneuvers during the kill chain.

Assess

The last element in the kill chain is assessing the level of damage to the target against desired effect. Battle damage assessments (BDA) are an increasingly important component of combat operations. Reports from DOD and others have identified repeated difficulties in conducting BDA in operations dating back at least to Desert Storm.[33] Technology does not exist for sensors within weapons to accomplish BDA since the outcome of an attack occurs after weapon detonation.[34] However, networking weapons allows a capability to provide a burst of information to the network just before weapon impact making it accessible to C2, ISR, and delivery platforms. As a minimum, BIA information may include impact coordinates and fuze-arming status, but the potential exists to send a digital photo just prior to weapon impact. This digitized imagery data may provide intelligence analyst's with real-time data to evaluate results of bombing operations and assess the need for re-attack. If targets are undamaged, the air operations center (AOC) can re-task airborne missions to strike joint force commander (JFC) higher priority targets or reintroduce them into the air tasking order (ATO). Truly, BIA has the potential to conduct operational assessment with greater accuracy and relevance than ever before.

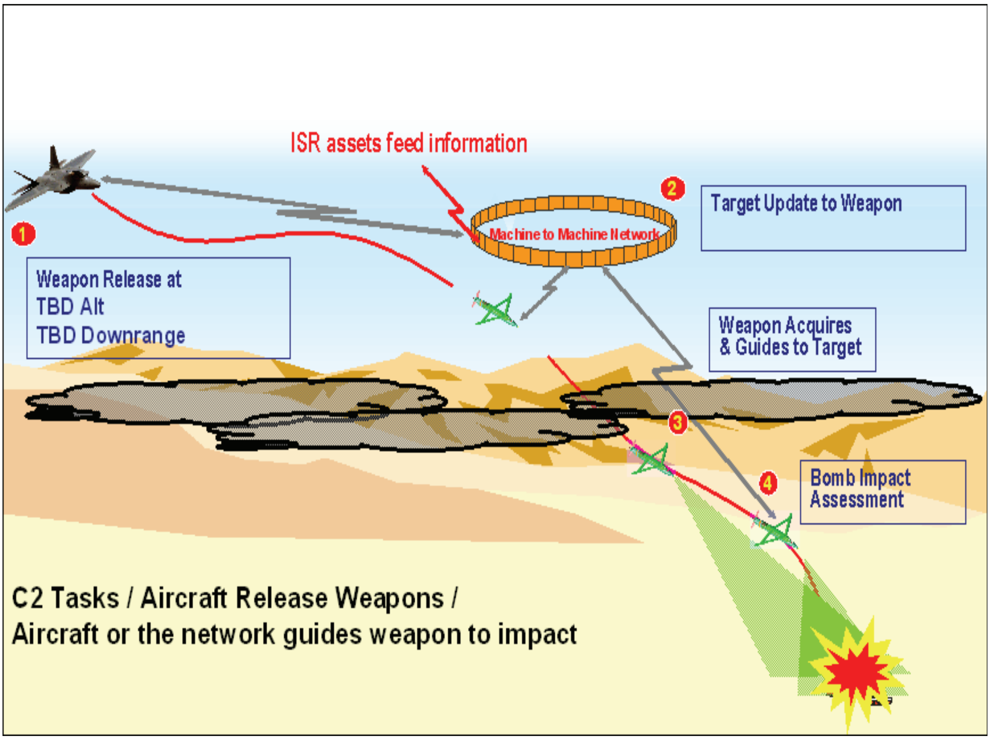

Figure 3.4 Network-enabled Munitions Capabilities in a TST Scenario.[35]

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V. Recommendations and Conclusion

> *Our legacy aircraft systems were built with specialized roles and they were very good. But we have limited networking, limited all-weather delivery and limited stand off, and our sensors are only partially integrated…We will network these systems in ways that enable us to find, fix, track, target, engage, and assess in timelines unimaginable just a few years ago.*[36]
>
> --Dr. James Roche, Secretary of the Air Force (2003)

Overall, the full impact of network-enabled weapons is still unclear, but the benefits clearly touch every element within the kill chain. Networking weapons provides a technological solution that fills a documented capability gap and has the potential to spawn an RMA. This paper only introduces the capabilities that these new weapons may deliver to the warfighter by briefly describing potential weapon attributes and offering two sample CONOPS. More research must be accomplished to properly integrate weapons onto the GIG without creating stovepipe solutions that meet only near-term needs. To prevent stovepipe solutions and achieve full network weapon integration, an overarching joint acquisition strategy is required to streamline this capability to the warfighter.

Joint Acquisition Strategy

The acquisition strategy needs to define the evolutionary approach to integrate weapons into network-centric warfare systems and achieve interoperability. When a program uses an evolutionary acquisition strategy, each increment has a specific set of requirements appropriate to the increment. This approach allows more time for technology to mature while fielding partial capability to the warfighter. The DOD preference is evolutionary acquisition,[37] and this approach fits the unique aspects of these weapons. Unlike other weapon programs, network-enabled weapons will affect numerous systems outside their scope, including delivery platforms, JTAC equipment, communications equipment, and AOC systems just to name a few. Many systems will require hardware and software modifications to communicate with these new weapons. Without an overarching acquisition strategy, the development of the first net-enabled weapon programs may self-impose limitations by setting precedents that is cost prohibitive to change. For example, initial waveform selection is crucial because the waveform will determine the data throughput capability and the total number of weapons that the network may support simultaneously. A poor waveform choice may limit not only imagery data but prevent the warfighter from delivering weapons when needed most.

A well-developed strategy results from extensive planning and preparation, thereby minimizing the time and costs required to satisfy approved capability needs. Both the Air Force and Navy have ongoing initiatives that support a weapon data link concept. The Air Force Research Laboratory is conducting a joint study to develop and demonstrate a common weapon-data-link architecture suitable for use in network weapon applications. The goals of the program are to develop technology that allows weapons to integrate into existing network-centric warfare systems, maximize interoperability, and ensure long-term viability and low life-cycle cost using re-programmability.[38] In addition, a study goal was to determine how best to integrate a weapon data link terminal into a set of weapons consisting of JASSMs, SDBs, and JSOWs (joint standoff weapons). The study concluded that to reduce the costs of integration and operation, one weapon data link terminal should be designed that would meet the mechanical and electrical requirements of as many weapons as possible.[39] However, no single weapon program will design a data link terminal suitable for all programs unless directed by an overarching acquisition strategy that identifies the specific requirements, delivery schedule, and funding path. Typically, individual weapon programs will develop hardware and software for their respective programs only. An overarching joint acquisition strategy could address these unique issues and identify paths to save costs for all programs, meet schedule, and streamline the delivery of this capability.

For clarity, the approved overarching acquisition strategy should only cover broad issues relevant to all network-enabled weapon programs and serve as a guide to facilitate the development of individual programs. Individual weapon programs are still responsible for their own development and schedule, but an overarching strategy will focus efforts and ensure programs work towards a common end-state. The strategy will assist programs technically by establishing guidelines and approving standard message sets that are applicable to all programs. The development of the strategy is important and requires collaboration between all joint stakeholders to produce a useful product. To assist in the development and coordination of the acquisition strategy, the acquisition community should organize and spearhead a joint integrated product team

(IPT) responsible for identifying the end-state and managing overarching issues. Without the guidance of an overarching IPT, weapon programs might duplicate effort, or worse, develop initiatives that lead to different network paths and reduce interoperability.

Joint Requirements

Another key team to focus this effort is an overarching high performance team (HPT) organized and spearheaded by the warfighter to refine the CONOPS and develop joint requirements that will be applicable to all network-enabled weapon programs. This team should be composed of warfighters, acquisition experts, and the test community to ensure all stakeholders understand what needs to be developed and why. Initially, their main effort should be to scrub the CONOPS and achieve consensus among stakeholders. Currently, many documents exist that propose a variety of CONOPS for these new weapons, but none provide a joint unified position. In today's environment, interoperability and connectivity are crucial as DOD fields new weapon systems. Normally, the CONOPS overview within the weapons capability definition document is sufficient to detail joint employment. However, network-enabled weapons are a new family (if procured) of munitions that will touch many systems and will require more detail than a single weapon program can provide. Air Combat Command's Directorate of Requirements Weapons Division has taken the initiative and developed a weapons data link CONOPS, but no single document exists that provides a unified joint position.

An overarching joint CONOPS will provide the acquisition community with an understanding of how their program fits into the operational level of war and what is important to the warfighter. This CONOPS must address many overarching program issues. For example, what is the maximum number of weapons that may be simultaneously in flight? Outside of release platforms, who will guide the weapons? What is the maximum distance required between the weapon and guider (LOS and/or beyond LOS capability)? Does the weapon need to both receive and transmit information (BIA requires transmit)? Many more issues must be addressed, but a high fidelity CONOPS will provide a framework for developers to understand their system requirements. During the weapon development phase, program managers may suggest trades that enhance system performance, streamline schedule, and reduce costs. This CONOPS will focus efforts and provide a coherent understanding of the warfighter trade space.

In essence, the key to success in developing a network-enabled weapons capability is collaboration among the key stakeholders and interoperability. In preparing requirements documents, the Services must articulate their unique needs to ensure weapons will be interoperable with existing and developing systems. Interoperability will ensure any weapon controller can guide any type of net-enabled weapon. Otherwise, many stovepipe weapon systems will exist and require a cumbersome CONOPS for execution. With rising acquisition costs, it is unlikely more money will be available for research and development initiatives. Thus, the warfighter needs to look beyond a single weapon solution and towards a system of systems approach that supports existing NCW transformation efforts. This approach combines sensor, communication, processing, guidance and precision weapon technologies to create an affordable highly networked weapon system solution.[40] Combined, these systems will provide the warfighter with an unmatched warfighting capability. However, as the warfighter moves forward and develops these weapons, a proper balance between technology and creating effects on the battlespace must be maintained to prevent an over-reliance on technology. Otherwise, the network itself will become the U.S. military's Achilles' heel.

Conclusion

NCW is changing the way the U.S. military fights wars by transforming the battlespace into an integrated array of sensors, weapon systems, and users that collaborate and share information in real-time. Linking PGMs directly to the global information grid will improve kill chain efficiencies while reducing the fog and friction of war. Technology has not yet evolved that allows the kill chain to transition through each phase seamlessly, but network-enabled PGMs will improve the warfighter's efficiency and effectiveness in waging war. Most importantly, these weapons will possess a means to re-direct weapon trajectory in-flight, thereby filling a documented capability gap against mobile targets.

The full impact of network-enabled weapons is still unclear, but its benefits clearly touch every element within the kill chain. More research must be accomplished to properly integrate weapons onto the GIG without creating stovepipe solutions. In the interim, the creation of two teams could maximize warfighter initiatives and minimize costs by focusing weapon integration efforts for the joint community. An IPT, spearheaded by the acquisition community, could manage and develop an overarching joint acquisition strategy that addresses broad issues relevant to all network-enabled weapon programs. In tandem, a warfighter-led HPT could develop a unified joint CONOPS that provides all stakeholders with a coherent understanding of the required weapon attributes and trade space. In summary, if the U.S. military is to maintain its competitive edge in the 21st century, DOD must continue to move ahead in this vital area of NCW transformation.

Notes

[1] Comptroller General of the United States, *Report to the Congress: Recent Campaigns Benefited from Improved Communications and Technology, but Barriers to Continued Progress Remain,* GAO Report 04-547, (Washington D.C.: General Accounting Office, 2004), 1.

[2] Martin C. Libicki, *Illuminating Tomorrow's War,* McNair Paper 61 (Washington D.C.: INSS, 1999) 1.

[3] Ibid., vii.

[4] Ron Taylor, "Net-enabled Weapons," *Intercom,* (December 2004), 11.

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