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An analysis of the common missile and TOW 2B on the Stryker anti-tank guided missile platform, using the Janus simulation

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THESIS

AN ANALYSIS OF THE COMMON MISSILE AND TOW 2B ON THE STRYKER ANTI-TANK GUIDED MISSILE PLATFORM, USING THE JANUS SIMULATION

by

Samuel L. Peterson

December 2002

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The U.S. Army is beginning to field the first of six Stryker Brigade Combat Teams (SBCTs) and equip the organic Anti-Tank (AT) Company of the Brigade with the LAV III Anti-Tank Guided Missile (ATGM) Platform and the Tube-Launched, Optically-Tracked, Wire-Guided 2B (TOW 2B) missile system. A developmental effort is currently underway to replace the aging TOW 2B and Hellfire missile systems with a common missile that meets both ground and air requirements. With increased range, lethality, and target acquisition capability, the Common Missile (CM) is being designed as the primary weapon system for the Army’s Comanche helicopter and is a candidate for the lethality system of the Future Combat System (FCS) within the Army’s Objective Force. Additionally, the CM is designed to be “backwards compatible” with existing TOW 2B and Hellfire launch platforms. The objective of this research effort is to determine the increase in operational effectiveness through the employment of the CM in the AT company of the SBCT in three different scenarios, using the high-resolution Janus Combat Model. Operational effectiveness will be assessed and statistically analyzed using lethality, survivability, and engagement range for three measures of effectiveness (MOEs).

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AN ANALYSIS OF THE COMMON MISSILE AND TOW 2B ON THE STRYKER ANTI-TANK GUIDED MISSILE PLATFORM, USING THE JANUS SIMULATION

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The U.S. Army is beginning to field the first of six Stryker Brigade Combat Teams (SBCTs) and equip the organic Anti-Tank (AT) Company of the Brigade with the LAV III Anti-Tank Guided Missile (ATGM) Platform and the Tube-Launched, Optically-Tracked, Wire-Guided 2B (TOW 2B) missile system. A developmental effort is currently underway to replace the aging TOW 2B and Hellfire missile systems with a common missile that meets both ground and air requirements. With increased range, lethality, and target acquisition capability, the Common Missile (CM) is being designed as the primary weapon system for the Army's Comanche helicopter and is a candidate for the lethality system of the Future Combat System (FCS) within the Army's Objective Force. Additionally, the CM is designed to be "backwards compatible" with existing TOW 2B and Hellfire launch platforms. The objective of this research effort is to determine the increase in operational effectiveness through the employment of the CM in the AT company of the SBCT in three different scenarios, using the high-resolution Janus Combat Model. Operational effectiveness will be assessed and statistically analyzed using lethality, survivability, and engagement range for three measures of effectiveness (MOEs).

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I. INTRODUCTION

The United States (U.S.) Army is undergoing a significant transformation from its traditional Cold War organization and equipment to a lighter, more strategically responsive force. Over the next five to ten years, the Army plans to form brigade combat teams that combine the capabilities of both light and heavy forces, while also maintaining and modernizing legacy heavy forces. During the interim phase of the Army's Transformation, six Stryker Brigade Combat Teams (SBCTs), formerly referred to as Interim Brigade Combat Teams (IBCTS), will be formed and equipped with a family of medium-weight armored vehicles. During the first two phases, the Army will continue to both modernize and re-capitalize current equipment and simultaneously invest in the new technologies required to create the objective force. Concurrently, the Army plans to design and establish a new Objective Force to replace both the legacy forces and interim brigades. The Objective Force will operate under newly defined warfighting doctrine and will be equipped with the Future Combat System (FCS) that maximizes available state-of-the-art technology. The transformation will have far-reaching implications upon force structure, systems acquisition, training, logistics, information technology, and the way the Army fights in the 21st Century. (Both of the terms "IBCT" and "SBCT" will be used interchangeably throughout this document, as a function of the chronological development of the brigade.) [Ref. 4]

Each SBCT possesses an organic anti-tank (AT) company, which will be equipped with the Light Armored Vehicle III (LAV III) platform and armed with the Tube-Launched, Optically-Tracked, Wire-Guided 2B (TOW 2B) missile system. The primary mission of this company is to provide accurate, long-range anti-armor fire support for the brigade in offensive, defensive, and small-scale contingency (SSC) operations. With its standoff capability and high strategic and tactical mobility, this platform operates as either an organic company with three platoons, or task-organizes by platoon to support the three infantry battalions within the SBCT.

In order to address the dramatically declining availability of TOW 2B and Hellfire missiles due to their expiring shelf-lives, the Army is investing in the development and procurement of a common missile system that meets both ground and air requirements. A missile system that is common between air and ground forces will result in benefits in the areas of logistics, common launcher interface, common storage and maintainability requirements, and overall reduction in life cycle costs in contrast to procuring both air and ground capabilities separately. It is being designed as the primary weapon system for the Army's Comanche helicopter and a candidate for the lethality system for the FCS within the Objective Force. Additionally, the Common Missile (CM) is designed to be "backwards compatible" with existing TOW 2B and Hellfire launch platforms.

Throughout the past two decades, the two primary means of defeating enemy armor has been either with direct fire tank ammunition or anti-tank missiles. The M1 Abrams tank fires primarily kinetic energy (KE) ammunition to defeat enemy armor. KE rounds are characterized by a long sub-caliber depleted uranium penetrator that is fin-stabilized. Once the round is fired it travels at supersonic speed, and upon hitting the target, the penetrator rod concentrates an extremely high amount of kinetic energy over a small surface area of the target. This high energy enables the KE round to penetrate even the most formidable armor. [Ref. 13]

In anti-tank missiles such as the TOW 2B, a shaped charge is used in the warhead to defeat enemy armor. This type of warhead is basically a cone-shaped hollow liner made up of a metal material such as aluminum or copper. The back, or hollow side, of the liner consists of the explosive material. Once the warhead strikes a target, a fuze detonates the explosive, causing the metal liner to become partially molten, with the rest of the cone forming a metal slug that penetrates the target. Advances in armor protection such as explosive reactive armor (ERA) have a demonstrated capability of defeating both KE and shaped charged warheads by firing an explosive charge outward from the target platform, defeating the incoming projectile. Advanced missile warheads can now defeat ERA through the use of a precursor or tandem warhead, which serves to pre-detonate the reactive armor, allowing the main warhead to penetrate the target. The CM is proposed to be an advanced chemical energy missile with a shaped charge, multi-mode warhead, capable of defeating a wide array of threats. [Ref. 12]

This study will employ the Janus Combat model to determine if a significant increase in operational effectiveness is gained through the employment of the CM within the AT company of the SBCT. This comparative analysis will use the LAV III ATGM platform and TOW 2B missile system as the base case, with the LAV III and CM system as the alternate case. (The term “LAV III ATGM platform” and “Stryker ATGM platform” will be used interchangeably throughout this document due to the Army naming of the platform as “Stryker” in February 2002.)

A. THESIS PURPOSE/OBJECTIVE

The purpose of this research is to evaluate the differences in the operational effectiveness between the CM and the TOW 2B missile system when employed by the Stryker ATGM platform within the SBCT. Currently, the Stryker ATGM platform is being produced and fielded to the SBCT on the LAV III platform with a TOW 2B and an Improved Target Acquisition Sight (ITAS) capability. The CM program is currently being developed as a multi-purpose, combined arms missile. Envisioned as an Objective Force system, the CM is also viewed to be a potential risk mitigator to the aging stockpile of TOW and Hellfire missile systems; this is especially applicable to the IAV ATGM system within the SBCTs. Within this research effort, the primary focus will concentrate on the modeling and simulation of the tactics and techniques of the SBCT AT Company, establishing and inputting realistic parameters of both systems within Janus, developing three operational scenarios reflective of the Operational and Organizational (O&O) employment of the unit, executing the simulations, and conducting statistical analysis of the results.

B. RESEARCH QUESTIONS

1. Primary Research Question

Within the context of the Stryker ATGM platform in a Janus simulation, which missile system provides the most operational effectiveness?

2. Subsidiary Research Questions

- How did the variation of terrain between scenarios affect the performance of the missile systems?
- What are the specific advantages of employing the CM system rather than the TOW 2B within the SBCT AT company?

C. RESEARCH SCOPE

The scope of this research will include a review of the Operational and Organizational (O&O) plan for the SBCT, an in-depth review of the operational requirements for the Stryker ATGM platform, a review of the doctrine, tactics, techniques, and procedures for the SBCT AT Company, a study on the capabilities and tutorial of the Janus Combat Model, and the development of three tactical scenarios for the simulation runs. The TOW 2B simulations will be designated the base case, while the CM simulations designated the alternate case. Each scenario for each case will be run in Janus twenty-five times, so that a total of 150 runs will be conducted. The thesis will conclude with a comparative analysis of the statistical findings per the Janus Post Processor Reports.

D. METHODOLOGY

The research methodology for this thesis followed five steps: literature review, Janus tutorial, Janus scenario and model development, simulation execution, and data collection, synthesis, and analysis.

The literature review and background research began with reviewing all current documentation on Army Transformation and the continuing development of the SBCTs. Coordination with combat developers from the U.S. Army Training and Doctrine Command (TRADOC) was conducted to review the most current documentation on the stand-up of the SBCTs and the fielding of the Stryker ATGM platform. Concurrently, both the CM Project Office and the Close Combat Missile Systems (CCMS) office of PEO Tactical Missiles provided information on the respective capabilities of the CM and TOW 2B missile systems. Lastly, a thorough review of the O&O concept and emerging doctrine for the SBCT and AT company was conducted to provide the basis for tactical scenario development.

The Janus tutorial and subsequent scenario development and execution was performed at the TRADOC Analysis Center (TRAC) – Monterey, located at the Naval Postgraduate School (NPS). The Janus User Guide and tutorial documentation were reviewed to provide a baseline understanding of the Janus model, and to learn how to input the necessary data to develop the three scenarios.

Designing the scenario encompassed inputting and reviewing the attributes for the applicable weapon systems, developing the tactical scenarios in accordance with the doctrine of the SBCT and AT company, and incorporating the force structure and scenarios on the different terrain locations. A run matrix was developed and used to record the results of each simulation run.

The next step, simulation execution, encompassed running all of the iterations per the run matrix. Each scenario for each weapon system was run twenty-five times to provide the fundamental data for the statistical analysis.

Lastly, the data collection, synthesis, and analysis step consisted of collecting the data from each run, developing graphical spreadsheets, and reviewing the results from the subsequent statistical analysis. These results were synthesized into conclusions that answered the primary and subsidiary research question, provided insights into the operational effectiveness of each missile system, and led to recommendations for further research.

E. THESIS ORGANIZATION

The thesis is comprised of six chapters. Chapter I, Introduction, provides the framework for the study and the methodologies employed to develop the simulation and conduct the analysis.

Chapter II, Background, provides an overview of Army Transformation, the SBCT, the AT Company, the Stryker ATGM platform, the TOW 2B, and the CM. The purpose of this chapter is to present the capabilities of each organization and weapon system to establish the underpinnings for the scenario development.

Chapter III, Janus Overview, describes the model and scenario development process, execution of the simulation, an overview of each of the three scenarios, and a definition of the Measures of Effectiveness (MOEs).

Chapter IV, Data Presentation and Methodology; and Chapter V, Data Analysis; present the data and the statistical analysis techniques used to compare the results for each system from each scenario. The data is graphically depicted in spreadsheets for each MOE, while the analysis comparatively examines the statistical differences.

Chapter VI, Conclusions and Recommendations, draws and summarizes the conclusions from the statistical analysis, thus answering the research questions. Potential areas for further research are also listed, and include a short description for each.

F. POTENTIAL BENEFITS FROM THIS THESIS

This study is intended to provide the CM Project Office and Program Manager (PM), Brigade Combat Team (BCT), with insights into the potential for increased operational effectiveness of the SBCT if it were to be equipped with the CM. It will also provide lessons learned for the employment of the SBCT AT Company based upon emerging doctrine. Lastly, the results will provide both the Program Executive Office (PEO) for Tactical Missiles and the Department of the Army (DA) with additional justification for the requirement and procurement of a common missile.

II. BACKGROUND

A. ARMY TRANSFORMATION OVERVIEW

The demise of the Soviet Union in the late 1980s initiated unprecedented changes for the United States Army. Instead of the traditional monolithic threat to prepare for, the Army was called upon to conduct a series of deployments in response to several regional or contingency threats. With the exception of Desert Storm, the deployments to Panama, Somalia, Haiti, and Bosnia, from the late-1980s to the mid-1990s, can be characterized as Small Scale Contingencies (SSCs). This type of operation requires some scale of combat forces to stabilize or contain a regional crisis, until the situation can be downgraded to a stability and support operation (SASO). The next level of conflict is termed a major regional crisis (MRC), and is represented by potential challenges from adversaries such as Iraq, Iran, or China. [Ref. 25: p. 2] The final stage of conflict is referred to as a major theater of war (MTW), and is characterized as the "most serious conventional military scenario the United States would have to face." [Ref 25: p. 2] The National Military Strategy (NMS) of 1997 states that the U.S. must be capable of responding to all types of potential environments ranging from "…humanitarian assistance to fighting and winning major theater wars, and conducting concurrent smaller-scale contingencies…" [Ref. 25: Ch. II, p. 1] To meet the requirements of the NMS, the two concepts of strategic agility and power projection are required. With the downsizing of the military, the U.S. must have the capability to rapidly deploy forces from the continental United States (CONUS) in order to respond effectively to SSCs. Based on the legacy forces of the M1 series Abrams tank, the M2/M3 Bradley Infantry/Cavalry Fighting Vehicle (BFV/CFV), and the M109A6 Paladin artillery system, it became clear that the heavy forces of the Army are incapable of rapid power projection from CONUS, thus requiring a new way of thinking and a new type of force to resolve this deficiency.

In October 1999, General (GEN) Eric K. Shinseki, the Chief of Staff for the Army (CSA), unveiled his vision for Army Transformation at the annual convention of the Association of the United States Army (AUSA) in Washington, D.C. In that speech, GEN Shinseki described his Vision for the Army, which encompasses transformation, readiness, and people. Within this Army Vision, GEN Shinseki's intent for Army Transformation was described as follows:

> Heavy forces must be more strategically deployable and more agile with a smaller logistical footprint, and light forces must be more lethal, survivable and tactically mobile. Achieving this paradigm will require innovative thinking about structure, modernization efforts and spending. [Ref. 40: p. 2]

With the theme of "Soldiers on point for the nation – persuasive in peace, invincible in war," the goal of the Army Vision is to achieve "strategic dominance across the entire spectrum of operations." [Ref. 32] The Vision stresses the need for land forces in joint, combined, and multi-national operational structures and environments. Additionally, the Army must possess the necessary responsiveness, and strategic and tactical dominance to train for and execute operations in missions ranging from humanitarian operations, to SASO operations, to SSCs, to MTWs. To meet the requirement for full spectrum dominance, the CSA outlined seven key characteristics in the Army Vision that the Army must possess:

- **Responsiveness** – Strategic responsiveness through forward deployed forces, forward positioned capabilities, and force projection capabilities.
- **Deployability** – Capability to deploy a combat force anywhere in the world within 96 hours.
- **Agility** – Capability to transition rapidly from SASO to MTW and back, as necessary.
- **Versatility** – Capability for organizational forces to seamlessly task organize to maximize force effectiveness for the mission at hand.
- **Lethality** – Includes the traditional elements of fires, maneuver, leadership, and protection. Army Transformation will focus on retaining the lethality of heavy forces while improving deployability, as well as retaining the deployability of light forces while improving lethality.
- **Survivability** – Must leverage technology to provide maximum protection to soldiers, both mounted and dismounted.
- **Sustainability** – Must aggressively reduce the logistics footprint of our forces. [Ref. 32]

During the initial phase of Army Transformation, which is currently ongoing and will continue through 2003, two SBCTs are being organized, equipped, trained, and tested. In the interim phase, an additional four SBCTs will be formed and equipped with a family of medium-weight IAVs, now called the "Stryker." [Ref. 39] During these first two phases, the Army will continue to modernize and re-capitalize current equipment and concurrently invest in the new technologies required to develop and eventually field the Objective Force. The final phase of Army Transformation will be the transition to the Objective Force. In this phase, the entire Army will be organized into new organizations and equipped with new technologies, which the Army intends to come to fruition within the next 10 to 15 years.

The initial phase of the transformation is currently underway at Fort Lewis, Washington, where the Army is organizing, equipping, and training the first two SBCTs. The core forces for these two brigades are a heavy mechanized brigade of the Army's 2nd Infantry Division and a light infantry brigade of the Army's 25th Infantry Division. Extensive cross-leveling of personnel and equipment, conversions of military occupational specialties, and training at all levels have taken place to facilitate the initial stand-up of the brigades. In July 2001, the Army announced in the following statement the identity of the next brigades to transform:

> The next brigades to transform, in order, are the 172nd Infantry Brigade (Separate), Forts Wainwright and Richardson, Alaska; the 2nd Armored Cavalry Regiment (Light), Fort Polk, La.; the 2nd Brigade, 25th Infantry Division (Light), Schofield Barracks, Hawaii; and the 56th Brigade of the 28th Infantry Division (Mechanized), Pennsylvania Army National Guard. [Ref. 41]

The Army evaluated candidate vehicle prototypes, referred to as bid samples, throughout the month of June 2000. A six-year, $4 billion contract was awarded to General Motors/General Dynamics Land Systems Limited Liability Corporation (GM/GDLS LLC) on 17 November 2000 for

2,131 LAV IIIs. [Ref. 30] The two initial SBCTs are serving as the operational and organizational models for the follow-on SBCTs, using medium-weight vehicles on loan from Canada and other countries.

Throughout the initial phase of Army Transformation, the Army will continue to revise key concepts, doctrine, and strategic plans for the SBCTs and continue to refine the organizational and operational design for a new divisional structure. The Army will also address interoperability issues between the Services and other nations, as well as the transformation efforts of the Army Reserve Component and the Army's institutional force. A key milestone for this phase is Fiscal Year (FY) 2003, at which time the first SBCT is scheduled to reach its Initial Operational Capability (IOC). Prior to this milestone, the initial brigade will undergo operational testing and evaluation to validate its operational and organizational concept, ending in a final certification exercise at the Joint Readiness Training Center. [Ref. 7: p. 47]

In the interim phase, the Army will apply lessons learned from the initial phase and form one additional follow-on brigade per year over the next seven years. One Army National Guard brigade, the 28th Infantry Division (Mechanized) of the Pennsylvania Army National Guard, will be converted to the new SBCT design during the interim phase. These SBCTs will be equipped with the same family of vehicles as the initial SBCTs, until the Army is ready to begin transition to the Objective Force with the fielding of the FCS.

The final phase consists of the total transformation to the Objective Force. The Objective Force, to be completely fielded in about 10 to 20 years, will be designed and equipped as standardized, vehicle-based, medium-weight brigades. It will be completed only after research and development of science and technology advances make possible the procurement of the FCS necessary to realize the capabilities required by the Objective Force. Three separate research consortia are currently conducting experimentation and trials using modeling and simulation in support of Objective Force development. The Army will pursue a conditions-based strategy to ensure that appropriate conditions are met before moving from the initial phase to the interim and objective phases of the transformation effort. [Ref. 7: p. 31]

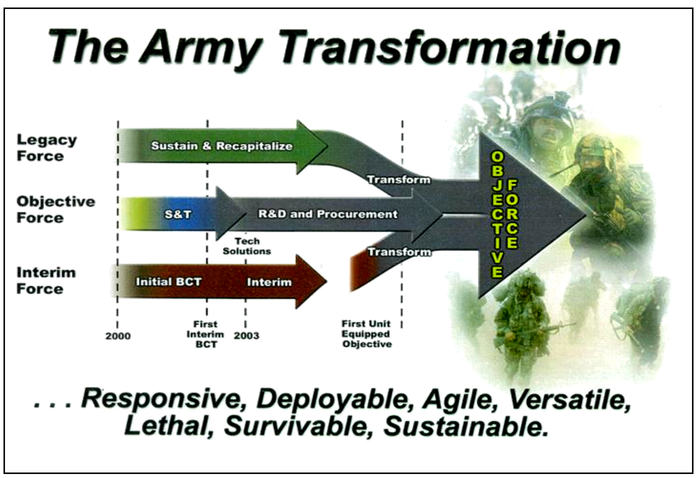

Figure 1. Army Transformation [Ref. 7]

The Army Vision will be executed in accordance with the Transformation Campaign Plan as depicted in Figure 1. While concurrently maintaining focus on the seven key characteristics of the Army Vision, the Army will conduct its transformation following a three-axis strategy. The top axis of Figure 1 represents the focus of the Army senior leadership to ensure the capability of near-term warfighting readiness through an aggressive strategy of recapitalization of our legacy equipment. The bottom axis represents the strategy to address the immediate deficiency of power projection through the fielding of the six SBCTs.

Finally, the middle axis depicts the Army's commitment to funding significant research and development efforts in order to identify, maximize, and implement revolutionary science and technology solutions in order to develop and produce the FCS of the Objective Force. Based on an accelerated schedule, a Technology Readiness Decision will be made in FY 2004 in order to select the most advanced technologies that will support the desired capabilities of the Objective Force.

B. STRYKER BRIGADE COMBAT TEAM

Based on the vision, guidance, and intent of the CSA, each of the proponent schools within TRADOC began to explore the organizational and operational characteristics of a medium-weight based force throughout the summer and fall of 1999. Leading up to GEN Shinseki's announcement at the AUSA convention in October 1999, the Combat Development (CD) directorates at Fort Knox and Fort Benning, in conjunction with TRAC-Leavenworth, conducted extensive modeling and simulation experiments that resulted in the organizational configuration depicted below in Figure 2. The main goal throughout the development of the brigade was to optimize it for employment in SSCs and, with augmentation, employment in MTWs. To do this, the CD community realized the need to design the brigade with a focus on maximizing the force effectiveness qualities of projection dominance and battlespace dominance. Projection dominance is comprised of the characteristics of air deployability, sustainability, and Manpower and Personnel Integration (MANPRINT), while battlespace dominance consists of lethality, survivability, and battlefield mobility characteristics. [Ref. 40]

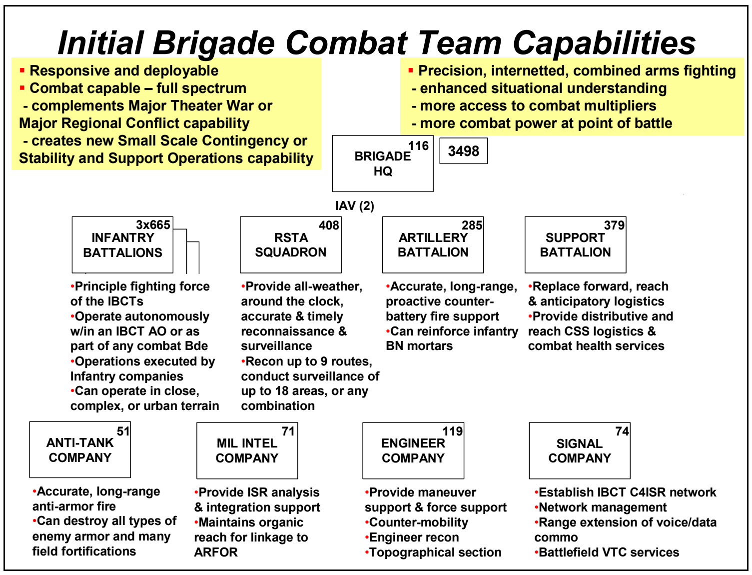

Figure 2. IBCT Capabilities [Ref. 21]

The mission of the brigade is as follows:

> The brigade deploys very rapidly, executes early entry, and conducts effective combat operations immediately on arrival to prevent, contain, stabilize, or resolve a conflict through shaping and decisive operations. The brigade participates in Major Theater War (MTW), with augmentation, as a subordinate maneuver component within a division or corps, in a variety of possible roles. The brigade also participates with appropriate augmentation in Stability and Support Operations (SASO) as an initial entry

> force and/or as a guarantor to provide security for stability forces by means of its extensive combat capabilities. [Ref. 40]

As the mission statement indicates, the SBCT, as a divisional brigade, is designed to be employed as a full spectrum force. With a core quality of high mobility, it possesses increased strategic, operational, and tactical mobility through its rapid deployability; the goal is for this brigade to be deployable anywhere in the world within 96 hours as an early-entry divisional force. Each Stryker platform is designed to be transportable by a C-130 aircraft within a theater of operations, and the speed of the Stryker during execution of land operations will meet or exceed 40 miles per hour (mph). [Ref. 23]

With three motorized infantry battalions, the SBCT is infantry-centric. It is primarily designed to get the infantry to the fight rapidly, augmented by a robust Reconnaissance, Surveillance, and Target Acquisition (RSTA) squadron whose primary purpose is to provide unprecedented situational awareness. This capability provides the maneuver commanders at each echelon the ability to employ their forces at the time and place of their choosing. In addition to the infantry battalions and RSTA squadron, other major sub-elements include the anti-tank company, an artillery battalion, an engineer company, a brigade support battalion, a military intelligence company, a signal company, and a brigade headquarters company. Their primary missions are described within Figure 2.

C. ANTI-TANK COMPANY

The AT company of the SBCT is the primary long-range anti-armor element of the brigade. It is capable of conducting full spectrum operations in its anti-tank role, ranging from SASO to SSC missions. Within an MTW, the AT company can effectively support a larger force. The mission of the AT company is as follows:

> The anti-tank company provides accurate, long-range anti-armor fire support to enhance the infantry's lethality and survivability. [Ref. 40]

The AT company is organized per Figure 3. With a total of 51 personnel, it consists of a company headquarters element and three AT platoons. The company headquarters is comprised of the command group, the company fire support section, and a medic section. Each of the three AT platoons is led by a lieutenant responsible for five NCOs and seven soldiers.

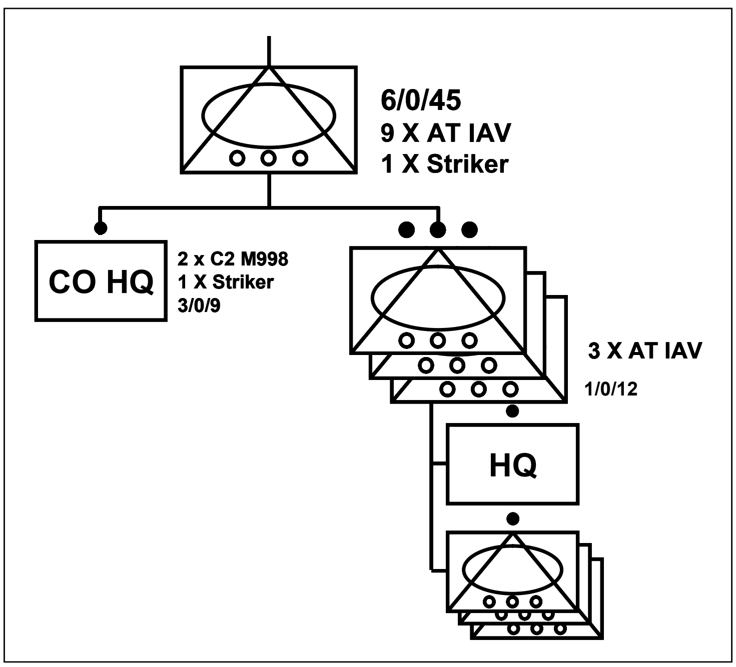

Figure 3. AT Company Organization [Ref. 40]

The AT company supports the missions of the SBCT through its ability to achieve and maintain standoff engagement ranges with the enemy. As the primary anti-tank force within the brigade, the AT company can operate either as a unified company, or it can task organize by AT platoons and conduct missions with the maneuver battalions. The latter capability is an essential component of the SBCT and required to conduct combined arms operations. The company will occupy battle positions for the AT platoons to occupy and provide overwatch from throughout the area of operations. As necessary, the company will refine and develop these positions in order to develop engagement areas that optimize the stand-off capabilities of the TOW 2B system. From these positions, the AT platoons retain the capability to close with and destroy the enemy, or to support reconnaissance and surveillance operations of the RSTA squadron. [Ref. 25: Ch.6]

In the conduct of offensive operations, the AT company will serve in an overwatch or support-by-fire role in support of the maneuver battalion's operations, protecting the flanks of the SBCT from ambushes or counter-attacks. If assigned to the subordinate maneuver battalion, the AT platoons will conduct similar type missions when operating in a pure company organization. The primary purpose of offensive operations is to "seek to seize, retain, and exploit the initiative to decisively defeat the enemy." [Ref. 19: p. 4-1] Offensive operations also attempt to:

- Disrupt enemy coherence.
- Secure or seize terrain.
- Deny the enemy use of resources.

• Fix the enemy.

• Gain information.

• Deceive the enemy. [Ref. 19: p. 4-1]

The two main types of offensive operations the AT company may conduct are the attack, both hasty and deliberate; and the movement to contact. Offensive operations are usually “force-oriented attacks against a stationary enemy force, force-oriented attacks against a moving enemy force, or terrain-oriented attacks.” [Ref. 19: p. 4-11] Figure 4 depicts the different types of situations in which the unit will conduct an attack. The time available will determine the different types of attacks available to accomplish the mission in order to meet the intent of the SBCT commander.

Attack Situations / Planning Time	Force-Oriented Moving Enemy	Force-Oriented Stationary Enemy	Terrain-Oriented
	Attack Options		
Less Time Available	• Hasty attack to [destroy, disrupt, or block] • Counterattack • Spoiling attack • Ambush	• Hasty attack to [destroy, disrupt, block] • Counterattack • Feint • Demonstration	• Hasty attack to [seize, clear, or secure] • Counterattack
More Time Available	• Deliberate attack to [destroy, disrupt, or block] • Counterattack • Spoiling attack • Ambush • Feint • Demonstration	• Deliberate attack to destroy • Raid • Counterattack • Feint • Demonstration	• Deliberate attack to [seize, clear, or secure] • Counterattack

Figure 4. Continuum of Attacks [Ref. 19: p. 13]

A hasty attack is often used by the AT company based upon either planning time available or tactical opportunities. It may be used to sustain the momentum of an offensive operation, to regain the initiative, or to prevent the enemy from reorganizing and preparing for future operations. This type of attack is limited by the resources that are immediately available. Because of the potential for frequent hasty attacks to gain and sustain momentum, the unit relies upon established standard operating procedures and battle drills due to the lack of planning time. After determining that favorable conditions exist for a hasty attack, the AT company will establish a base of fire to suppress the enemy force while concurrently employing a bounding force to close with and destroy the enemy. The platoon leader or commander will simultaneously employ both their organic long-range fires and available indirect fires to suppress and/or neutralize the enemy. Once the bounding force has reached a position where it holds the tactical advantage, it will conduct an assault to destroy any remaining forces. [Ref. 19]

In deliberate attack operations, the AT company or platoons will normally be employed as part of a larger force, as this type of attack is conducted against a well-prepared enemy defense. The planning time involved for a deliberate attack allows the enemy to continue to strengthen its defenses. Due to the complexity and synchronization involved, a deliberate attack will employ all resources available at both the AT company and SBCT levels. The AT company will normally be used to establish long-range suppressive fires as part of the overall attack, in coordination with indirect fires, maneuver forces, and mobility/counter-mobility forces. The critical mission for the AT company is its support of actions on the objective, where its long-range fire’s standoff capability provides a distinct advantage to the SBCT.

Another type of offensive operation the AT company or platoons will conduct is the movement to contact. The AT company or platoon will normally conduct this type of operation as part of a larger force. The purpose of this operation is to gain and maintain contact with the enemy when the enemy situation is unclear and other resources are unavailable. Certain fundamentals the commander must observe when conducting this operation include:

- Makes enemy contact with the smallest element possible.
- Rapidly deploys combat power upon enemy contact.
- Provides all-around security for the unit.
- Supports the higher commander’s concept and intent. [Ref. 19: p. 4-19]

Two techniques to execute the movement to contact are the search-and-attack technique and the approach-march technique. The search-and-attack technique “uses multiple, coordinated, small-unit (squad, section, or platoon) actions to find, fix, and finish the enemy.” [Ref. 19: p. 4-19] The approach-march technique is employed when the AT company or platoons conduct a movement to contact as part of a larger force. The AT unit will be deployed as an advance, flank, or rear guard for the higher unit, with the mission of preventing surprise attacks, facilitating the tactical movement of the larger force, destroying enemy forces within its capability, and developing the situation upon enemy contact.

The main purpose of defensive operations is to allow an organization sufficient time to regroup and reorganize in order to prepare for and conduct offensive operations.

Additional reasons for the conduct of the defense by the AT company or platoons may be to:

- Gain time.
- Retain key terrain.
- Support other operations.
- Preoccupy the enemy in one area while friendly forces attack him in another.
- Erode enemy forces at a rapid rate while reinforcing friendly operations. [Ref. 19: p.5-1]

In a defensive operation, the AT company will either operate as a pure company, in order to maximize the effects of its long-range fires capability, or task organize by platoons attached to the maneuver battalions. Either organization contributes to the SBCT's ability to counter armor threats while in a defensive scenario. The unit must recognize and incorporate the characteristics of the defense in order to successfully plan for and execute defensive operations. These characteristics are:

- Preparation – The unit must establish the defense on the terrain upon which the operation will be conducted with enough time to prepare positions, allocate resources, and rehearse the plan.
- Security – When used in a security role, the missions for the AT company or platoons include counter-reconnaissance, providing the SBCT early warning, or harassment of the enemy main body.
- Disruption – The main intent for disruption is to influence and disturb the enemy's decision cycle and synchronization in order to prevent him from massing against perceived weaknesses in the defense.
- Mass and Concentration – One of the most critical characteristics of the defense, "the defender must concentrate combat power at the decisive time and place if he is to succeed." [Ref. 19:

p. 5-2] This may be accomplished through planning for the element of surprise, incorporating a counter-attack plan, and maintaining a reserve force.

- Flexibility – The AT company or platoons must retain enough flexibility in the defensive plan in order to react to the enemy's offensive thrust, and to counter-attack effectively. Planning for primary and supplementary defensive positions, thorough terrain analysis, and extensive wargaming of potential enemy courses of action, will facilitate building flexibility into the defensive plan. [Ref. 19]

The AT company or platoons will use one of these three defensive techniques: defense in sector, defense from a battle position (BP), or defense on a reverse slope. [Ref. 19: p. 5-12] A defense in sector is basically a non-linear defense where the AT company will array its platoons in depth in their own sectors or in mutually supporting BPs, per Figure 5. This type of defense provides great flexibility for the AT company and platoons to orient on the enemy's disposition as retention of key terrain is not a primary goal. The AT company and platoons can mass their fires into one or several engagement areas, or maximize the stand-off capability and engage the enemy at long-ranges, attempting to attrite his advance. It is critical for the AT company and platoons to optimize the use of primary and supplementary positions so any one element can avoid being fixed or bypassed by the enemy. Each AT platoon will plan and rehearse displacement to successive BPs in the event of being bypassed or fixed. Finally, each AT platoon can maximize the use of indirect fires, obstacles, and other available combat multipliers to assist the AT company in shaping the battlefield. [Ref. 19: p. 5-13]

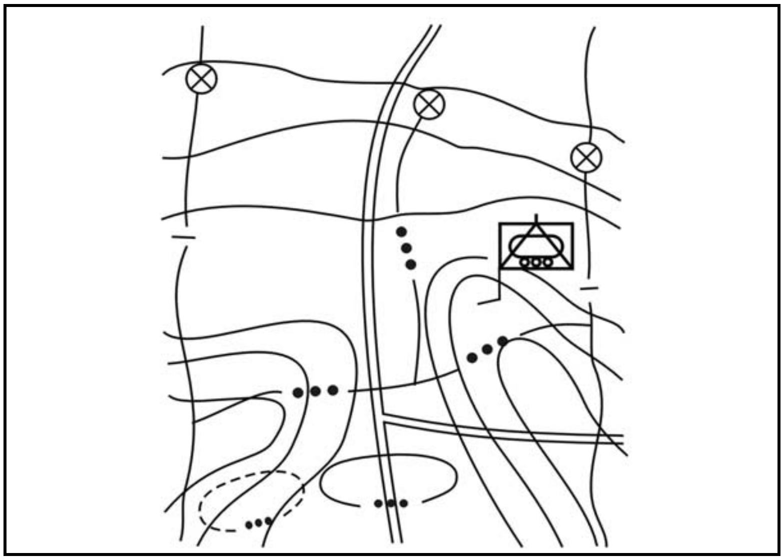

Figure 5. SBCT Antiarmor Company Defense in Sector, with a Platoon in a Battle Position. [Ref. 19: p. 5-14]

A defense from a battle position is used when a unit may or may not be mutually supported by adjacent units. For that reason, the AT platoon or company will generally be located within the BP, with security observation posts (OPs) deployed to the front, rear, and flanks of the BP. The AT company commander or platoon leader will assign primary sectors of fire from primary positions that are overlapping completely around the BP. Alternate, supplementary, and subsequent positions are also assigned. (See Figure 6) One key tenet of a BP defense is for the AT company or platoons to retain the element of surprise in order to maneuver effectively within the BP to maximize the effects of its fires. Aggressive counter-reconnaissance will ensure the element of surprise by limiting the enemy’s ability to determine the exact location and orientation of the BPs. If fighting as a pure company with platoons in BPs in depth, the AT commander can maximize either the stand-off range of his weapon systems or mass effects in one or several engagement areas. As with a defense in sector, the AT company or platoons must plan and rehearse for withdrawal to successive positions if the enemy should fix or bypass the BP. [Ref. 19: p. 5-15, 16]

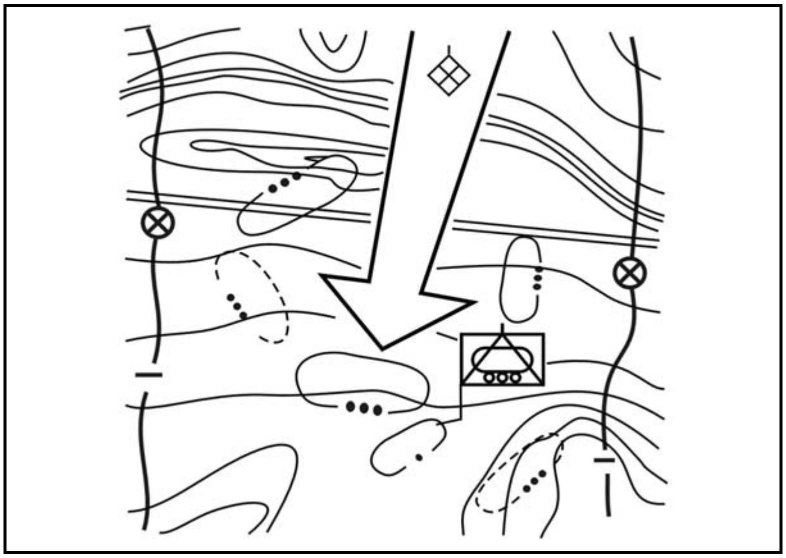

Figure 6. SBCT Antiarmor Company Defense From Mutually Supporting Battle Positions [Ref. 19: p. 5-18]

A defense on a reverse slope is defined when, “the antiarmor company (or platoon) is deployed on terrain that is masked by the crest of a hill from enemy direct fire and ground observation. [Ref. 19: p. 5-16] Using the crest of a hill to protect itself from long-range enemy fires or observation, this type of defense allows the AT company or platoons the time to improve positions, consolidate, re-organize, and re-supply its forces; and limit the enemy’s use of combat multipliers such as aviation, indirect fires, or target acquisition systems. It is critical that OPs are deployed forward of the reverse slope position to provide early warning of enemy activity. Deployment of fire support personnel within the OPs provides the opportunity to maximize the use of indirect fires before the unit engages with its organic systems. Planning for counter-reconnaissance efforts, obstacle emplacement, and unit displacement are also key concerns for this type of defense. [Ref. 19: p. 5-17, 18]

Within the SBCT range of operations that are designed for employment in complex or urban terrain, the AT company or platoons supports the brigade through the employment of its long-range fires capability on major routes throughout a sector or area of responsibility. In urban area operations, the AT company or platoons will support the maneuver of the infantry and reconnaissance elements with its ability to destroy deployed enemy armor in cities, maximizing the stand-off capability of its weapon systems. The AT company or platoons will typically establish blocking positions or attack-by-fire positions to counter the enemy armor threat in these types of operations.

D. REQUIREMENTS GENERATION FOR THE IAV

When GEN Shinseki assumed the position of Chief of Staff of the Army in 1999, he subsequently charged TRADOC as the lead agent for the Army Transformation effort. [Ref. 38: p. 6] The TRADOC Commander’s responsibilities included developing the O&O concepts, related doctrine, and necessary materiel requirements if a materiel solution were deemed necessary. Each of the proponents and branches within TRADOC were tasked to develop separate, yet mutually supporting, products all coordinated by various directorates within TRADOC Headquarters (HQ). The requirements generation process for the IAV followed a different path than most legacy programs that had followed the traditional process.

The development of the IBCT O&O was the joint responsibility of the Deputy Chief of Staff for Doctrine (DCSD) and the Deputy Chief of Staff for Combat Developments (DCSCD) of the TRADOC staff. Subsequently, all of the proponents/branches within the TRADOC community were tasked in September of 1999 to support the effort. The mission statement for all of TRADOC in this process was as follows:

> Develop a medium weight capability using available systems and technical insertions to provide an interim solution which allows the Army to better deal with small scale contingencies without risk to its primary role to fight and win major theater wars. [Ref. 20: p. 14]

To accomplish this mission, the United States Army Armor Center (USAARMC) at Fort Knox, Kentucky; and the United States Army Infantry Center (USAIC) at Fort Benning, Georgia; were primarily tasked to conduct force design experiments supported by modeling and simulation, and to develop the optimal medium-weight force to bridge the gap between the Army's heavy and light forces. The modeling and simulation effort provided the foundation for the force design and utilized Serbia as the base case, due to its weak infrastructure, complex and urban terrain, asymmetric threat, technology base, and historical lessons learned. Hundreds of simulation exercises were conducted at USAARMC, USAIC, and the Combined Arms Center (CAC) at Fort Leavenworth, Kansas. [Ref. 40: p. 12] The results of those simulations, coupled with the expertise of combat developers throughout TRADOC, became the underpinnings for the IBCT. In order to maximize the force effectiveness of this brigade, projection dominance and battlespace dominance were identified as two required core competencies. Key contributors to force effectiveness within the competency of projection dominance are air deployability, sustainability, and MANPRINT. Battlespace dominance possesses the key contributors of lethality, survivability, and battlefield mobility. These core competencies and six key contributors would later serve as the foundation for the IAV ORD requirements. [Ref. 40: p. 14]

The development of the IAV requirements documents was initiated in late October of 1999, subsequent to the initiation of the O&O development. Originally referred to as the Family of Medium Armored Vehicles (MAV), the Combined Arms Directorate (CAD) of DCSCD at TRADOC was charged with the responsibility for developing the necessary requirements documents. Working closely with the O&O writers that were supervising the coordinating effort at TRADOC, the staff of CAD produced several initial versions of a MAV Mission Needs Statement (MNS) and Operational Requirements Document (ORD) for each of the proponents to review and recommend changes. Initial versions envisioned seven variants to support the emerging tenets of the O&O. These included a troop carrier (for infantry, engineers, and general cargo), an assault vehicle, a fire support vehicle, a reconnaissance vehicle, a medical evacuation/medical treatment vehicle, a command & control vehicle, and an antitank guided missile vehicle. [Ref. 24: p. 1] As the process evolved and further revisions were made to support the continuously evolving O&O, TRADOC eventually assigned various proponent schools the responsibility for developing the requirements for certain platforms within the ORD, retaining responsibility for the MNS, but soliciting proponent input throughout the process. In doing so, TRADOC not only retained overall responsibility for the requirements process and documents, but also retained responsibility for the base MAV vehicle requirements. Based upon traditional proponent responsibility, USAARMC eventually became responsible for developing the requirements for the Mobile Gun System (MGS) (formerly referred to as the assault vehicle), the Reconnaissance Vehicle (RV), and the Commander's Vehicle (CV). USAIC became responsible for developing the requirements for the Infantry Carrier Vehicle (ICV) (formerly referred to as the troop carrier), the Anti-Tank Guided Missile platform (ATGM), and the newly-created Mortar Carrier platform (MC). Other platforms delegated to the various proponent branches were: the Fire Support Vehicle (FSV) to the Artillery Center at Fort Sill, Oklahoma; the Engineer Squad Vehicle (ESV) and the Nuclear, Biological and Chemical (NBC) Reconnaissance Vehicle to the Maneuver Support Center (MANSCEN) at Fort Leonard, Missouri; and the Medical Evacuation Vehicle (MEV) to Fort Sam Houston, Texas. Since the TRADOC Mission Statement mandated developing "…a medium weight capability using available systems and technical insertions to provide an interim solution…", the task to each of the proponents was to conduct market research and determine what was commercially-available, off-the-shelf, to support their respective functions and emerging mission areas as defined by the evolving O&O.

Additionally, each proponent was responsible for researching and identifying potential pre-planned product improvements for their respective platforms that could feasibly be integrated into the off-the-shelf technology of the base platform at a later date. Logistics requirements for the various platforms were conducted by each proponent school in coordination with the Combined Arms Support Command (CASCOM) for input into Paragraph 5 of the ORD, Program Support. By December 1999, the platform was re-named the “Interim Armored Vehicle” (IAV) to dispel any pre-conceived notions about weight, the track vs. wheels dilemma, and to support the name of the newly designated “Interim Brigade Combat Teams” (IBCTs) at Fort Lewis, Washington. In late December 1999, each proponent was tasked to conduct a crosswalk of the O&O tenets to their emerging requirements, ensuring their requirements were feasible and supported by the appropriate operational requirements. This analysis was also supported by the results of the Platform Performance Demonstration (PPD), which will be discussed later. The result of this evolutionary process was an IAV family that consisted of two variants: the ICV and the MGS. The ICV variant became the key platform for a total of nine configurations, including the ATGM.

With each of these requirements allocated between the proponents and the TRADOC staff, the following table illustrates the final areas of responsibility for the ORD:

ORD Section	Agency	ORD Platform
IAV Base ORD	TRADOC	Common base vehicle requirements
Annex A	USAIC	Infantry Carrier Vehicle
Annex A, App. 1	USAIC	Mortar Carrier
Annex A, App. 2	USAIC	ATGM Vehicle
Annex A, App. 3	USAARMC	Reconnaissance Vehicle
Annex A, App. 4	Ft. Sill	Fire Support Vehicle
Annex A, App. 5	MANSCEN	Engineer Squad Vehicle
Annex A, App. 6	USAARMC	Commander’s Vehicle
Annex A, App. 7	Ft. Sam Houston	Medical Evacuation Vehicle
Annex A, App. 8	MANSCEN	NBC Reconnaissance Vehicle
Annex B	USAARMC	Mobile Gun System
Annex D	TRADOC	Common Preplanned Product Improvements (P3I)
Annex D, App. 3	USAIC	ATGM P3I Requirements
Annex D, App. 4	USAARMC	Reconnaissance Vehicle P3I Requirements
Annex D, App. 5	Ft. Sill	Fire Support Vehicle P3I Requirements
Annex D, App. 8	Ft. Sam Houston	Medical Evacuation Vehicle P3I Requirements
Annex D, App. 9	MANSCEN	NBC Reconnaissance Vehicle P3I Requirements
Annex D, App. 10	USAARMC	MGS P3I Requirements

Table 1. IAV ORD Responsible Agencies

Several concurrent activities took place throughout the fall of 1999 that centered on the early involvement of the acquisition community. The Program Management Office for IBCT supported the development and review of requirements at the TRADOC level. Additionally, the PM hosted an Advanced Planning Briefing for Industry (APBI) in Detroit, Michigan on 1 December 1999. By 31 January 2000, the IAV MNS and ORD was completed and approved at the TRADOC level, and by 6 March 2000, the Joint Requirements Oversight Council (JROC) reviewed and approved the IAV MNS and ORD and validated the Key Performance Parameters (KPPs). [Ref. 31]

The PPD was conducted at Fort Knox from 05 December 1999 through 20 January 2000. The purpose of this demonstration was to educate the Army leadership on the current capabilities of off-the-shelf medium-weight platforms, and to demonstrate those capabilities so that lessons learned could be incorporated into the IAV ORD development process. One other critical component of the PPD was the examination of each vehicle for potential technology insertions, in accordance with the mission statement for TRADOC, and to assist in developing the pre-planned product improvements (P^3I) requirements for each platform of the IAV family. Seven total countries participated voluntarily in the PPD, contributing 35 vehicles that represented 11 different defense contractors. The PPD was divided into the following five phases:

- Phase I – (Planning phase) Army crews consisting of master gunners and drivers were trained at contractor locations on their respective vehicles.
- Phase II – (Reception, Staging, and Integration Phase) Contractors and their platforms arrived at Fort Knox. Additional crew training and risk assessments were conducted. Evaluations for MANPRINT and technology insertions were conducted.
- Phase III – (Deployability Phase) Each of the platforms were measured, weighed, and loaded aboard C-130 aircraft, rail cars, and Heavy Equipment Transport Systems (HETs).
- Phase IV – (Demonstration Phase) Each platform conducted rigorous on/off road driving courses, day/night live firing, a tactical situational

exercise, and a platform swim exercise (if so capable).

- Phase V – (Information Phase) – Written reports of observations were completed and provided to the Army leadership and the respective platform contractors. [Ref. 2: p. 1-2]

The PPD was not intended to serve as the sole basis for procurement decisions; instead it both displayed to the Army what types of technologies and platforms were currently available off-the-shelf, and assisted in the further refinement of the IAV requirements process. This market survey greatly facilitated that effort, and concluded as a safe, informative event.

The base vehicle requirements are characterized by strategic, operational, and tactical capabilities. With a KPP of transportability by C-130 aircraft, the IAV satisfies the gap between heavy and light forces in terms of power projection. The other KPP for the entire platform is its planned interoperability with all planned and existing Army command, control, communications, computers, intelligence surveillance, and reconnaissance (C4ISR) systems. This capability will enable the SBCT to maximize the use of the Army's emerging digital communications architectures and systems within the Army Battle Command System (ABCS). Other important requirements for the entire family include a hard surface speed of 40 MPH, all-around protection from 7.62mm ammunition, and the capability to add on scaleable armor for protection from 14.5mm rocket-propelled grenades (RPGs) should the enemy situation and capabilities dictate. All of the base vehicle requirements for the IAV family are summarized in Appendix A, part A.

The ATGM platform is a unique configuration of the ICV variant. Key requirements for the ICV include a KPP to carry an infantry squad of nine personnel, the requirement for armament to defeat enemy troops and light armored vehicles out to 1500m, and the capability to integrate mission equipment packages for specific configurations. The ATGM's requirements are based upon the ICV, with the requirement to integrate the TOW 2B missile system with an IBAS/ITAS capability. It must also be able to carry a minimum of two missiles that are ready to fire at all times, store a total of eight missiles on the platform, minimize crew exposure during missile re-load periods, and manned by a crew of four personnel. Both the ICV and ATGM requirements are completely summarized in Appendix A, parts B and C.

On 17 November 2001, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA (ALT)), the Honorable Mr. Paul Hoeper, and the Military Deputy to the ASA (ALT), LTG Paul J. Kern; announced the award of the IAV contract to General Motors/General Dynamics Land Systems Limited Liability Corporation (GM/GDLS, LLC) for 2,131 LAV III platforms. Stating that this platform was, "…the best off-the-shelf equipment available in the world in this class," Mr. Hoeper asserted that this platform would allow soldiers to, "…get to the fight quickly, win decisively, and come back alive." [Ref. 29: p. 1] LTG Kern reviewed several key characteristics for the LAV III that included 14.5mm armor piercing all around protection, C-130 transportability, 60 MPH sustained speeds, low sustainment costs, remote weapon station capability, and maintainability. (See Figure 7) LTG Kern also discussed each platform within the IAV family, and acknowledged that the ATGM, NBC Reconnaissance Vehicle, and the MGS would require developmental work that would take approximately two years. He also stated that the 2,131 platforms would be bought incrementally over six years through a requirements-type contract, not a multi-year contract, with the first contract awarded for 360 platforms at a cost of $580 million. [Ref. 29]

Figure 7. LAV III Characteristics [Ref. 29]

In February 2002, the Army named the LAV III platform the “Stryker” to honor two posthumously-awarded Army Congressional Medal of Honor recipients. PFC Stuart Stryker was awarded the Medal of Honor while serving with the 513th Parachute Infantry Regiment near Wesel, Germany, in WWII. He is credited with leading an attack that resulted in 200 enemy soldiers being captured, as well as the rescue of three American pilots. While serving with the 1st Infantry Division near Loc Ninh, Vietnam, SPC Robert F. Stryker received the Medal of Honor for saving the lives of his fellow soldiers. According to Sergeant Major of the Army Jack Tilley, "...both made the ultimate sacrifice for their country and their fellow soldiers." [Ref. 39] On 12 April 2002, the Army accepted its first Stryker Interim Armored Vehicle in a rollout ceremony at Anniston Army Depot, Alabama. [Ref. 3]

E. TOW 2B

Introduced to the U.S. Army in 1970, the M220 TOW missile system is designed to "attack and defeat tanks and other armored vehicles." [Ref. 33: p. 1] As a line-of-sight, wire-guided heavy antitank system, it can be used in a dismounted capability by infantry soldiers, fired from the Army's High Mobility Multi-purpose Wheeled Vehicle (HMMWV), the Bradley Infantry/Cavalry Fighting Vehicle (BFV/CFV) and is also fired from attack helicopters. It is capable of penetrating up to 30 inches of armor at ranges up to 3,750 meters. [Ref. 33] The TOW weapon system consists of a reusable launcher, a missile guidance set, and a day/night sight system. Managed by the Program Executive Office – Tactical Missiles (PEO-TM) in Huntsville, Alabama; the TOW program is currently in the sustainment phase. There are five versions of the TOW missile with the following characteristics:

CHARACTERISTICS	BASIC TOW	I-TOW	TOW 2	TOW 2A	TOW 2B
Missile weight (lb)	41.5	42	47.3	49.9	49.8
Weight in container (lb)	56.3	56.5	61.8	64	64
Prelaunch length (in)	45.8	45.8	45.9	45.9	46
Standoff probe (in)	NA	14.6	17.4	17.4	NA
Max velocity (fps/mps)	981/299	970/296	1079/329	1079/ 329	1010/309
Warhead diameter (in)	5	5	6	5	5(2x)
Explosive filler (lb)	5.4	4.6	6.9	6.9	-
Max range (m)	3000	3750	3750	3750	3750

Table 2. Characteristics of the TOW Missile Family [Ref. 33]

Primarily developed by Hughes Aircraft Company, the TOW system is combat-tested, having served in Vietnam and the Middle East. Over 500,000 TOWs have been built and it is believed to be the most "widely distributed anti-tank guided missile in the world…" [Ref. 33: p. 1] The TOW 2 launcher is the most current version and is compatible with all TOW missiles. The Improved Target Acquisition System (ITAS) is a 2d generation forward-looking infrared system (FLIR) with digital components and an eye-safe laser rangefinder. It was designed to significantly improve the target acquisition capability of the TOW system, and increase the engagement ranges of all TOW missile configurations.

Developed by Raytheon Missile Systems, the TOW 2B missile is capable of being fired from the BFV/CFV, the HMMWV, and dismounted, and is optimized for primary use against tanks. As the fifth generation, and most modern and capable missile of the TOW family, it "flies over the target and uses a laser profilometer magnetic sensor to detect and fire two downward-directed, explosively formed penetrator warheads into the target." [Ref. 15: p. 46] (See Figure 8) It actually follows a missile flight path that is slightly offset to the gunner's aim point. It was first fielded to both light and heavy Army units in 1991, and reached an Initial Operating Capability (IOC) in 1993. The last TOW 2B missile produced for U.S. forces was in July 1997. [Ref. 15: p. 46] The TOW 2B missile system is designed to be integrated with the Stryker ATGM platform and to serve as the SBCT's primary long-range anti-tank fires capability. (See Appendix A, Part C)

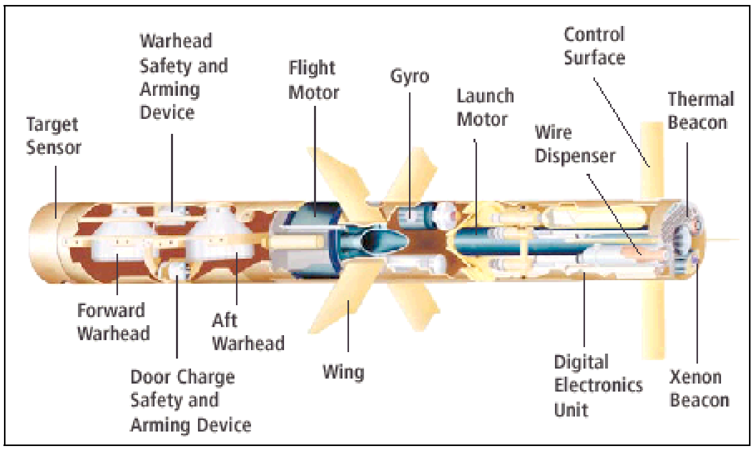

Figure 8. TOW 2B Diagram [Ref. 37]

F. COMMON MISSILE

One of the emerging technologies to improve the lethality of the Objective Force is the Common Missile (CM). This program is designed to develop a single missile system that is employable on both existing and future rotary and fixed wing aircraft. It will be the primary weapon system on the Comanche helicopter, and is a lethality candidate for Objective Force ground platforms. It also has the capability to mitigate the risk of declining missile stockpiles for our legacy ground platforms. The United States Navy, United States Marine Corps, and the United Kingdom are currently participating in the program.

The requirement for a Common Missile stems from the results of a Strategic Planning Review completed in 1998 by the Program Executive Office (PEO) for Tactical Missiles. The PEO chartered a panel of "Greybeards" to focus on six issues concerning current and future Army missile development. In Charter Issue 6, "Identify technologies required to bridge PEO Tactical Missiles into the AAN [Army After Next] and those technologies that would form new systems in the AAN" [Ref. 36, Introduction], their findings were, "the panel recommends the development of a common missile to replace HELLFIRE, [HELLFIRE] Longbow, and FOTT [Follow-On to TOW], placing first priority on meeting lethality, survivability, mobility and sustainment requirements and second priority on designing the systems to meet legacy platform constraints." [Ref. 36: p. 40] This Strategic Planning Review highlighted the growing concern over the shelf life and projected inventories of the TOW 2A, TOW 2B and Hellfire missiles. By FY 2010, it is projected that only 22% of the TOW inventory will exist, to be followed by 12% in FY 2011. Additionally, 100% of the TOW 2A/B and Hellfire will be beyond their designated 15-year shelf lives by FY 2010. (See Figure 9)

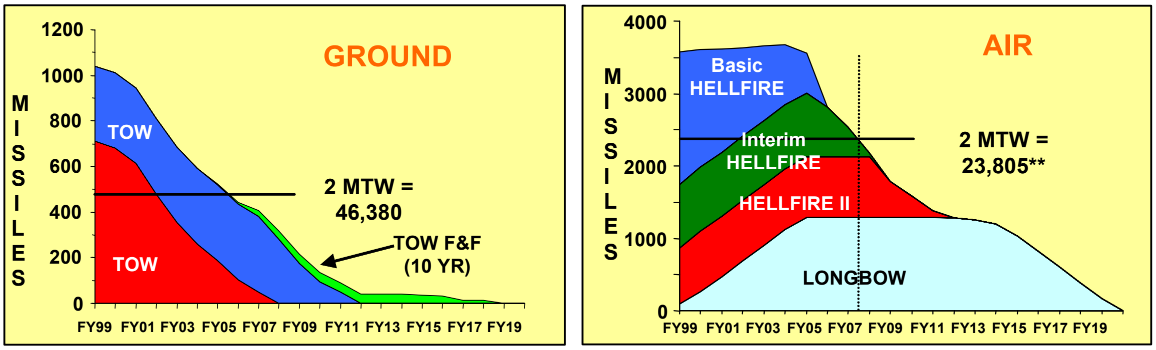

Figure 9. Decreasing Missile Stockpiles [Ref. 6: p. 2]

In 2000, and in the face of budget reductions and reduced world-wide threats, the House Armed Services Committee (HASC) expressed concern over the number of anti-tank programs, saying:

> The Committee questions the need to procure so many tank killing systems in a period in which our potential adversaries possess significantly smaller tank forces…The Committee believes the Office of the Secretary of Defense and the Joint Staff must do a better job in reviewing these programs to preserve resources for other priorities. [Ref. 35, p. 4]

The following year, while reviewing the Common Missile program, the Senate Armed Services Committee (SASC) expressed support for the program saying:

> The Committee understands that the Army is considering moving toward a "common" chemical energy missile in the future and that Modernized Hellfire is intended to be the baseline program to achieve this worthy goal. The Army is encouraged to provide a "Common Missiles" program funding line in the next budget submission. [Ref. 35]

Lastly, the Authorization Committee synthesized Congressional support in 2001 with the following statement:

> The conferees fully support the Army’s goal to reduce the different types of anti-tank missile systems in its future tactical inventory… Furthermore, the conferees expect the Army to begin funding this effort in the fiscal year 2002 budget submission. [Ref. 35]

The overall goal of the Common Missile program is to develop a missile capability that meets the aviation community requirements. The Common Missile will also support Army Transformation to the Objective Force through:

- Operational Flexibility
- Multi-Platform Capability
- Reduced Logistics Footprint
- Increased Missile Inventory
- Maintain Overmatch Lethality
- Increased Range
- Enhanced Countermeasures Capability [Ref. 6: p.9]

To support both existing and future air and ground platforms and systems, the CM will leverage heavily from existing technological capabilities, as well as take full advantage of Horizontal Technology Insertion (HTI) throughout the production process by following an evolutionary acquisition strategy. HTI is the application of common technology across multiple systems, resulting in an increase in overall force effectiveness and potential reduction of total ownership cost. The evolutionary acquisition strategy will allow the initial capability to provide an immediate improvement over existing missile systems, while incorporating and maintaining program flexibility focused on time-phased requirements. While still in development, the main unclassified operational requirements include the following [Ref. 6: p. 10]:

- Defeat latest armored threat, engage critical high value targets
- Tri-mode seeker (Imaging infrared (I^2R), semi-active laser (SAL), and millimeter wave (MMW))
- Counter active protective system
- Day/night adverse weather
- Fire & Forget and alternate mode precision hit
- Overmatch lethality
- Increased standoff range
- Resistant to Electronic Counter Measures (ECM)

As an advanced chemical energy missile, the CM is designed to defeat a wide range of targets on today's battlefield. It will be able to continuously engage targets through a "fire-and-forget" capability, and a lock-on-after-launch capability at an envisioned 10-12 KM range. The multi-mode warhead will be an advanced chemical energy shaped charge with precursor(s) in order to defeat modern reactive armor. The missile will possess a six-inch diameter, be no longer than 50 feet in length, and weigh less than 70 pounds. [Ref. 15]

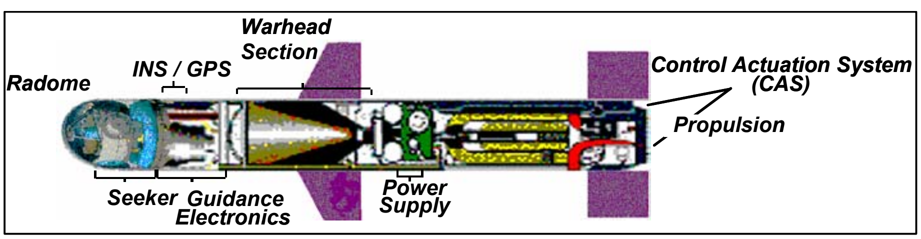

Figure 10. CM Concept Drawing [Ref. 6]

To meet the requirements of Army Transformation and to address the pending shortfalls in the current inventory of missiles, PEO Tactical Missiles has proposed an evolutionary acquisition strategy that maximizes competition and minimizes cost. The goal is to procure 73,000 missiles with production beginning in FY 2007 and continuing through FY 2023. First Unit Equipped (FUE) is scheduled for FY 2008. The proposed strategy per phase is outlined below and in Figure 11:

- System Definition and Risk Reduction Program, FY 2001-FY 2003 – The primary purpose of this phase is to complete and refine the operational requirements, facilitate the design and development of proposed missile concepts, assess and mitigate risk, and evaluate a Proof-of-Principle missile system.
- System Development and Demonstration, FY 2004-FY 2006 – The current strategy is to down-select to one contractor for this phase. The contractor will be responsible to establish a 2d source for the multi-mode seeker.
- Production and Deployment, FY 2007-FY 2023 – A determination will be made on establishing a leader-follower for full rate production. Technology insertion will be used to meet future block requirements. [Ref. 6]

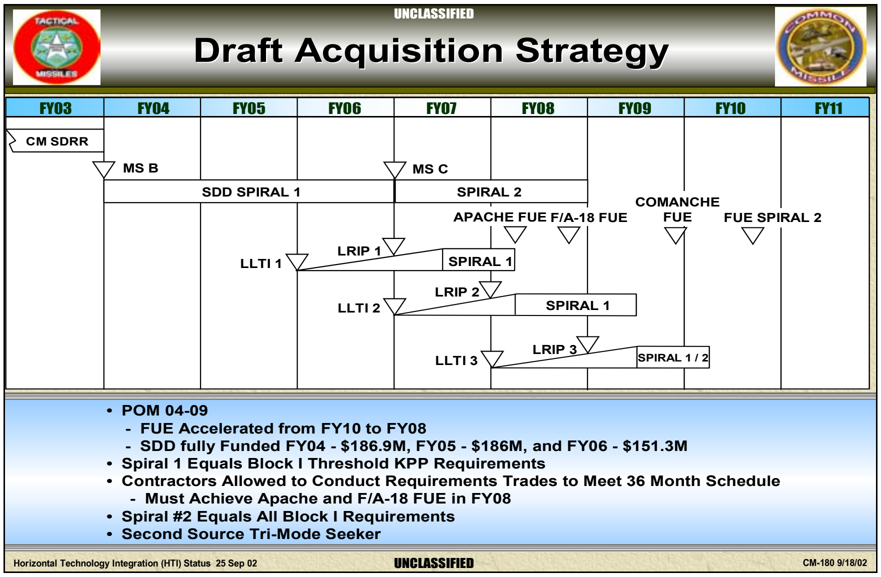

Figure 11. CM Draft Acquisition Strategy [Ref. 5]

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III. JANUS OVERVIEW

A. JANUS BACKGROUND AND OVERVIEW

The simulation used for this research was the Janus interactive wargaming simulation. The specific version resident at TRAC-Monterey is Janus v7.06D. The “D” refers to the Distribute Interactive Simulation interface that enables Janus to interact with other simulations. Janus was named after the Roman god known as the guardian of the gates of Rome who is two-faced and looks in opposite directions. He is the patron of the world’s past and future due to his ability to look in two directions at the same time. [Ref. 9: p. 1-1] The basic characteristics of the Janus model are as follows:

- Interactive – Refers to the real-time interaction of the personnel commanding the operation within the simulation, the tactical decisions they make, and the units/equipment within their command.
- Six-sided – Refers to the ability of the simulation to represent up to six friendly and/or enemy forces. Within this simulation, two opposing sides are represented.
- Closed – This characteristic describes the lack of complete, or perfect, information the opposing forces have on each other.
- Stochastic – This is the methodology the model uses to determine battlefield outcomes according to the laws of probability. These outcomes cannot be pre-determined.
- Ground combat – Refers to the primary focus of the Janus simulation on the tactical employment of ground combat units and systems in relation to potential battlefield effects. These effects, any of which may be incorporated into the simulation, are combat support and combat service support systems, terrain, weather, battlefield

obscuration, day or night operations, and NBC environments. [Ref. 9: p. 2-1]

Janus will model ground combat simulations through the brigade level, controlled by respective players on opposing sides. The high-resolution color graphics displays representations that include terrain features, contour lines, roads, rivers, buildings, and railroad tracks, all of which may impact the maneuver of systems and deployment of units. [Ref. 9: p. 2-1]

Ground combat forces may engage in direct fire engagements when they are within a specified range of each other. Based upon previously established database inputs, Janus will assess these and other factors such as range, firer motion/direction, and target motion/direction to determine the outcome. The database inputs include parameters such as probability of hit and probability of a kill, given a hit. Physical constraints such as available ammunition, out of range, or target suppression may prevent an engagement. Other tactical factors such as a weapons clearance status, rule of engagement, and other available priority targets may also affect whether or not an engagement occurs. [Ref. 9: p. 2-2]

Vehicles may use prepared fighting positions (referred to as PREPOS by Janus) to provide protection from opposing ground combat systems. Three protective postures that may be employed are fully exposed, partial defilade in which the hull of the vehicle is protected, or full defilade where the both the hull and turret of a vehicle are protected. The user may manually select these postures during scenario execution. If a vehicle is in full defilade, enemy ground forces will not be able to detect it until they are within 50 meters. Vehicles conducting tactical movement are displayed as fully exposed, but may go into partial defilade at specified periods as defined by the user. [Ref. 9: p. 2-4]

The user can establish engagement areas to designate a specific area in which forces may engage each other. These designated areas may prevent fratricide between different forces of the same side. This allows the user to establish a defensive position apart from the designated engagement area, maximizing the features of available terrain to establish PREPOS and coordinating fire control measures to maximize the effects of direct and indirect fire systems.

The terrain used in the Janus simulation is “digitized terrain elevation data developed by the National Imagery and Mapping Agency (NIMA).” [Ref. 9: p. 2-5] Using the Terrain Editor feature in Janus, terrain features including contour lines, urban areas, rivers, and roads may be digitized from a 1:50,000 map, and highlighted with different colors.

Target acquisition is a critical dimension in simulating combat scenarios. Janus uses two factors to assess line-of-sight (LOS). One is the ability for the firer to actually observe the target based upon terrain or man-made structures. The second is the capabilities of the sensor on the observing platform, and how it may be impacted at that point in time by battlefield conditions such as smoke, dust, or atmospheric conditions. Janus computes a cumulative probability for LOS (PLOS) along each terrain grid cell between the target and the firer. If there are no impediments, the probability for that cell will be 1.0. After it checks each terrain grid cell and multiplies the cumulative probabilities, Janus will determine if LOS exists; i.e. the PLOS must be greater than .01. Through data provided by the Night Vision and Electro Optics Directorate (NVEOD), of the U.S. Army Communications-Electronics Command (CECOM) in Fort A.P. Hill, Virginia; Janus also assesses other optical and thermal characteristics such as field of view, spectral band, and thermal temperature. [Ref. 9: p. 2-7]

Units in Janus may maneuver based upon system capabilities, terrain factors, and battlefield effects. During scenario development and execution, movement routes may be established to control movement and synchronize operations. Pre-determined halts may also be established along these routes based upon location or scenario time. This capability is especially critical for synchronizing offensive movement and operations. [Ref. 9: p. 2-7]

B. SCENARIO DEVELOPMENT PROCESS

Scenario development or creation within Janus is defined as:

> …selecting specific systems and weapons, terrain, force structures, and battlefield conditions to be represented in the scenario; designating the initial location of those systems and weapons on the battlefield terrain; and the creation and placement of command and control overlays. [Ref. 9: p. 2-15]

Once a scenario has been created or developed, it can be saved so that the file may be used again. Additionally, the scenario can also be run, or executed, after the development process is complete. The development process typically follows a nine-step procedure as summarized below:

- Use the Terrain Editor (TED) to create or modify the terrain file used in the scenario.
- Use the Symbols Editor (SYMBOLS) to create or modify the friendly force (Blue) and enemy force (Red) symbols to be used in the scenario.
- Use the Combat Systems Data Editor (CSDATA) to input and review the performance characteristics of the weapon systems used in the scenario.
- Use the Scenario Forces Editor (FORCE) to create the military force organization used in the scenario. This organization is maintained in the Force File.
- Use the Command and Control Overlay Editor (COED) to draw tactical control measures on the terrain either prior to or during scenario execution.
- To create new scenarios or modify old ones, scenarios may be merged.
- Verify the accuracy and completeness of the weapons and systems performance data by using the two Janus verification programs, the Tabular Verification program (VFYSCEN), and the Graphic Verification program (GRAFVFY).
- Execute the scenario.
- Review and analyze the results of the scenario execution using the following programs: Post Processing Reports (POSTP), Janus Analyst Workstation (JAAWS), or Janus Plan View Display (JANPVD). [Ref. 9: p. 2-14, 15]

Once completely developed and verified, the scenario is ready for execution. Scenarios may be executed with either player intervention or non-intervention. If intervention is desired, players may completely interact with systems and forces throughout the execution of the scenario by changing unit movement routes, deployment, and reaction to enemy contact. Non-intervention is traditionally used when the scenarios are executed repeatedly to produce a suitable amount of data for statistical analysis. The results for each run are stored in sequential files for further analysis.

1. Janus Model Inputs

In order to conduct the simulations required for this research project, several components of data were required to be inputted into the Janus model. Due to prior research conducted by TRAC-Monterey and other NPS thesis students, many of the system's data have already been created within the Janus database, specifically the TOW 2B and the CM. Coordination with the CM Project Office and PEO-TM resulted in adapting the two weapon systems to the LAV III platform, as well as the development of the three scenarios used for this study. Additionally, TRAC-White Sands Missile Range (WSMR) provided the necessary icons to represent the Stryker ATGM platform, and two of the three terrain files used in two scenarios. The Combat Systems Database of the Janus model includes components for system level data, weapons systems, chemical, engineer, and weather. For the purposes of this project, data was either copied from existing files or inputted at the system, weapons, and sensor level components of the database. Appendix B lists the specific data for each of the "blue" (friendly) and "red" (enemy) systems.

2. LAV III ATGM Platform Inputs

The LAV III ATGM platform was required to be created within the Combat Systems Database of the Janus model. Using data provided by PEO-TM and the IAV ORD, this platform was created to serve as the base vehicle in each of the scenarios. Within the systems characteristics of the database, all of the platforms unclassified operational characteristics were inputted. These included the system's speed, weapons range, height, and basic load of ammunition.

3. Weapon System Inputs

The TOW 2B and the CM are the weapon system variables that were compared as the base and alternates cases within each of the three scenarios. Each weapon system already existed within the Combat Systems Database of the Janus model at TRAC-Monterey, but the characteristics of both were verified with PEO-TM for completeness and accuracy.

For each weapon system, specific data elements that must be defined and inputted include:

- Weapon number/name – Each weapon number is given a number between 1-400 and up to a nine-character name.
- Lay time - Average time, in seconds, required to point or lay the weapon system in the direction of the target.
- Aim time - Average time, in seconds, required to aim the weapon once laid in the direction of the target.
- Reload time – Average time, in seconds, to reload the weapon after all ammunition has been expended.
- Rounds per trigger pull – The number of times the weapon system will fire one round of ammunition once the trigger has been pulled/depressed.

- Trigger pulls/reload – The number of times the trigger may be pulled/depressed before the weapon system must be reloaded.
- Round speed – The average velocity of the round of ammunition, expressed in kilometers per second.
- Minimum single-shot kill probability (SSKP) – This is the minimum probability, expressed in hundredths that one shot will result in one kill. If the model determines that an engagement will not meet the minimum SSKP, then the system will not fire. [Ref. 8]

The Round Guidance criteria determine how the weapon system guides a missile to its intended target. This includes whether or not the missile requires guidance until impact, whether or not it can fire on the move, and the capabilities of the on-board sensor. One critical difference between the TOW 2B and the CM is in this area because the TOW 2B requires wire-carried guidance and thus may not move until target impact. The CM may move prior to target impact due to its “fire-and-forget” capability. Another critical difference is in each weapon system’s range. The TOW 2B was modeled at an effective range of 3.5 KM, while the CM was modeled at 7.0 KM. Additionally, the CM has an organic thermal sensor that provides for increased target detection.

The Janus documentation defines the probabilities of hit (PH) as, “the probabilities that a single round fired by a given weapon at a given range will result in a hit.” [Ref. 8: p. 4-9] Concurrently, the probability of a kill (PK) is defined as, “the probability that, given a hit by a particular weapon on a particular target, the target will be killed.” [Ref. 8: p. 4-11] These probabilities are maintained within Janus in probability data set tables, and are associated with each weapon system in the Combat Systems Database. Unclassified PH/PK probabilities were provided by PEO-TM and inputted for both the TOW 2B and CM weapon systems, and are provided in Appendix B.

4. Sensor System Inputs

The Sensor Section of the Combat Systems Database in Janus supports direct fire optical and thermal sensors. Since both the TOW 2B and the CM are designed to employ ITAS, and this capability is a requirement on the Stryker AT platform, the data elements for their respective on-board sensor capability was the same for both weapon systems. One specific limitation of the Janus model is its inability to replicate the capabilities of the tri-mode seeker in simulations. To account for this limitation, a thermal seeker capability resident in the sensor database was incorporated into the CM weapon system, but this parameter is currently not established within the Janus model. [Ref. 8: p. 4-4]

Other sensor characteristics that must be inputted are the weapon system’s narrow and wide field of view, the system’s spectral band capability, the sensor’s resolvable cycles per milliradian, and the mean values for contrast and temperature. All of these data elements were provided by PEO-TM and are listed in Appendix B for each weapon system.

5. Janus Model Outputs

Janus records several aspects of data throughout each run of a simulation. Results of each run can be replayed or viewed through the Janus Analyst Workstation (JAAWS), or

Janus Plan View Display (JANPVD). The Post Processing program is used to formulate several different types of reports to support analysis. During each run of a simulation, Janus will record such data as direct fire shots, movement routes, kills, hits and misses, etc. To support the MOEs of lethality, survivability, and engagement range, two reports were compiled for the 25 runs in both the base cases and alternate cases to form the basis for the statistical analysis in Chapter 5. The Coroner's Report depicted the kills made by each side (Blue and Red) in each run of the simulation and supported the analysis for MOEs I and II. It identifies the victim by name, unit, location, and type of kill. The killer is listed with the same information with the addition of the range at which it killed the victim and the type of weapon system used. The second report to be complied and used was the Engagement Range analysis to support MOE III. This report lists each of the Red platforms killed and fired upon within each run of the simulation, and provides an average killing range and engagement range by vehicle type for further analysis. A sample of each report is provided in Appendix C. [Ref. 8]

C. RESEARCH ASSUMPTIONS, LIMITATIONS, AND SENSITIVITIES

For the purpose of modeling and conducting analysis of the CM and the TOW 2B missile systems within Janus, three scenarios depicting realistic tactical scenarios were developed. As in all modeling and simulation efforts, the research was subject to certain assumptions, limitations, and sensitivities in order to facilitate the research effort and to conduct the analysis.

1. Assumptions

To effectively measure the capabilities of each missile system, it was assumed that the Stryker AT company would conduct operations as a pure company, using only the three AT platoons. Each platoon was deployed organically into battle positions in each scenario, and each vehicle's position was enhanced with the ability to fight from a full-vehicle or partial-vehicle defilade position. Each Stryker ATGM platform had the capability to observe assigned sectors of fire from the full defilade position. If a Stryker ATGM platform exhausted its supply of ammunition, it had the capability to remain in the full defilade position for the rest of the simulation run. In order to accurately meet the requirements for each MOE, supplementary fighting positions were not incorporated into scenario development. Instead, each simulation run was terminated when either Blue or Red forces were no longer in a position to engage each other, or either side had been completely destroyed.

No other aspect of the SBCT was incorporated into the three scenarios. All of the simulation runs were conducted in ideal weather conditions to facilitate optimal employment of each weapon system at their maximum engagement ranges. No combat multipliers such as indirect fire support, obscurants, or close air support were incorporated into the scenarios. This allowed the research to focus solely on the performance of each missile system without having to account for other systems or environmental factors.

2. Limitations

This research effort was limited to the current capabilities of the Janus program. For example, while the CM is proposed to possess a tri-mode seeker capability, Janus is currently unable to model that aspect of the missile system. Another key limitation is that all weapon parameters inputted into Janus were limited to unclassified system information for the purpose of keeping this research effort unclassified.

3. Sensitivities

There were certain sensitivities identified during scenario development and subsequent test runs. A key sensitivity is how the use of prepared vehicle fighting positions affected MOE II, Survivability. This area is subject to sensitivity since survivability is not measured solely as a function of the Stryker ATGM platform’s armor protection, but rather as a function of its ability to optimize the employment of full or partial defilade. Another sensitivity identified was the use of inter-visibility lines in the Janus model. Inter-visibility lines limit line-of-sight in what appears to be open terrain, but is in fact rolling or gently sloping. While the terrain depicted is characterized by contour lines at specified intervals, certain areas that appeared to be open did not have line-of-sight capability. This was an important consideration that was accurately incorporated into scenario development and the locations selected for each platoon battle position. One other sensitivity to be noted is that the mobility of the Stryker ATGM platform was not a factor in the analysis of the operational effectiveness of each missile system, as each scenario established the SBCT AT company in a defensive situation. This optimized the line-of-sight and engagement capability of each missile system to support the analysis of their respective operational effectiveness.

D. SCENARIO OVERVIEW

Three scenarios were created for this study, incorporating several data aspects as reflected throughout this study. Within each scenario, a base case (TOW 2B) and an alternate case (CM) consisting of 25 runs were conducted, resulting in 150 runs being conducted in total. Each of the terrains selected represent potential real-world locations to which the SBCT, upon IOC, may be deployed in the future, based upon recent history or current events.

The friendly force structure consisted of nine Stryker ATGM platforms, representing the SBCT AT company. In the base cases, the TOW 2B missile system was incorporated on each platform, while the CM system was incorporated on each platform in the alternate cases. The company was deployed in sector in platoon battle positions consisting of three Stryker ATGM platforms each. Each vehicle had the capability to employ full or partial defilade, depending upon the threat situation. Each platoon was deployed upon the most likely axis of advance of the enemy threat, and designated with overlapping fields of fire that maximized each platform’s line-of-sight from that position. While other combat multipliers such as artillery, obstacles, detailed reconnaissance, and aviation would normally augment or support the Stryker AT company, all were excluded to facilitate sole focus and analysis upon the missile systems being compared.

While the SBCT is not designed to be employed against a significant armored threat, one was replicated in this study for statistical analysis purposes to reflect the maximum capabilities of both the TOW 2B and the CM weapon systems. The threat force used in this study consisted of a generic opposing force (OPFOR) threat battalion consisting of two T-72 tank companies and one BMP-2 mechanized infantry company. [Ref. 26] Each tank company had ten platforms mounted with an AT-11 ATGM and six missiles, capable of engaging and destroying vehicles at 4.0 KM. The infantry company had 12 platforms armed with an AT-5 ATGM and four wire-guided missiles, also effective to 4.0 KM; additionally, each BMP-2 incorporated a 30mm machine gun with 500 rounds. Each of the companies initiated their attack outside the effective range of the Blue Force, advancing in a pre-battle formation, and transitioning to a battle formation upon contact, stopping only to fire their weapon(s), and then continuing movement. Each threat vehicles followed a pre-designated axis of advance until all of the Blue or Red platforms were destroyed.

1. Scenario I

The first scenario was conducted on terrain representative of the Balkans region. It consists of areas with significant elevation and vegetation, bordered by intermittent open areas and valleys with streams and rivers. There are several major urban areas as depicted by the yellow and white regions. The Blue force is established in a defensive position overlooking several major routes leading into and out of one of the large urban areas. The western-most, or left, platoon is oriented on both the open area and potential avenues leading to the flanks of the company position. The central platoon is solely oriented on the major open area and routes leading to the city, while the eastern-most or right platoon is focused both on supporting the central platoon and on potential avenues coming out of the mountains.

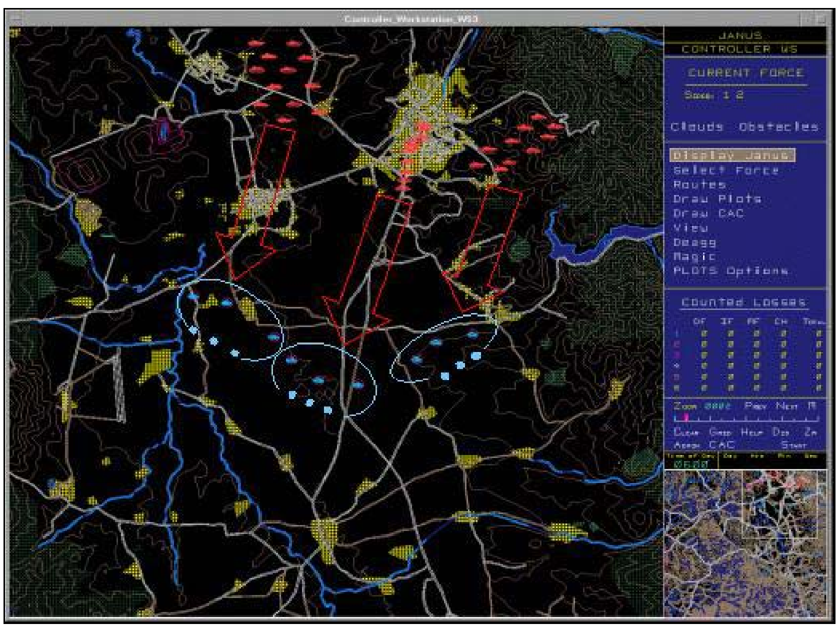

Figure 12. Janus Display of Scenario I – Balkans

The Red force is deployed into three companies, attacking in pre-battle formation cross-country. As the central Red Force clears the urban area, it begins to deploy into battle formation. The western-most or left, Red company is attacking both in the open area and in the west, trying to expose the Blue force flank. The eastern-most Red company is the battalion reserve, and attacks once both of the other Red companies are committed and a potential weakness in the Blue force’s defense is exposed.

2. Scenario II

The second scenario was conducted on terrain representative of Southwest Asia (SWA). The terrain is extremely wide open, has several major routes throughout the sector, and is characterized by very few key terrain features. With the exception of inter-visibility lines throughout the area, line of sight is unrestricted for several kilometers. The Blue force is again deployed in sector in platoon battle positions, forming a U-shaped ambush designed to protect a series of key intersections on major avenues of approach to the rear of the Blue force defense. Each platoon is deployed along inter-visibility lines with partial or full defilade capability, and has overlapping fields of fire with its adjacent unit to ensure complete coverage of the engagement area.

The Red force is attacking as a combined arms force in echelon with two companies abreast and one in trail as the reserve. The Red battalion has deployed two combat reconnaissance patrols consisting of two BMP-2s and one T-72 each to identify the Blue force positions. The southern-most company has a two-vehicle section of BMP-2s in order to penetrate or bypass the Blue force’s southern flank. All three companies are attacking in battle formation.

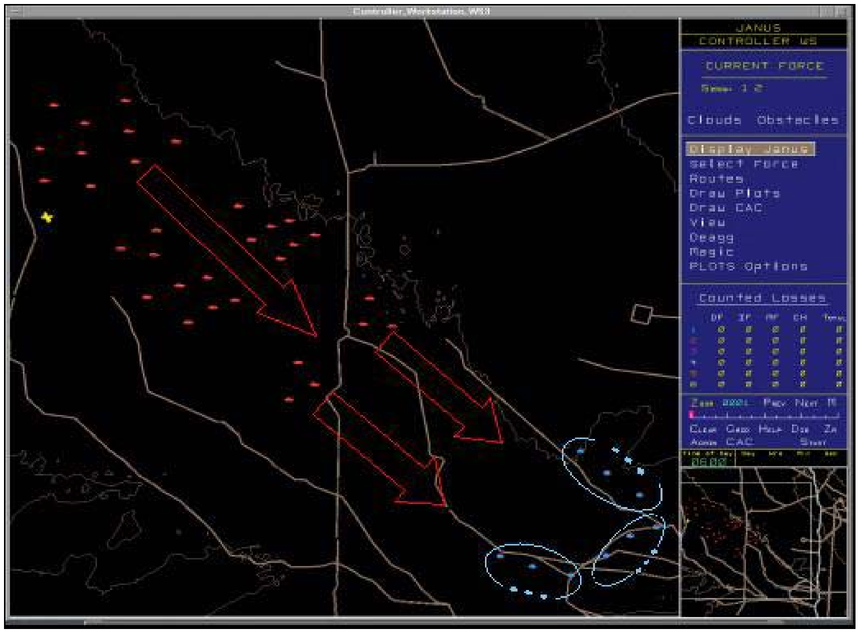

Figure 13. Janus Display of Scenario II - SWA

3. Scenario III

The third and final scenario was conducted in terrain representative of Eastern Europe. The terrain is characterized by rolling hills, extensive vegetation, streams, rivers, and extensive road networks. This close, compartmented terrain was also used by the PEO-TM and CM Project Office in support of the program's Analysis of Alternatives (AoA). The Blue force company is deployed in sector in platoon battle positions, defending key river crossing sites against the Red force. Each platoon is responsible for defending one key crossing site, but also shares overlapping fires with the adjacent platoons to shift and provide support if necessary. The Blue force is maximizing the line-of-sight capability provided by the river and the adjacent open area, but this close, compartmented terrain does not support the maximum effective ranges of either the TOW 2B or CM weapon system.

The Red force is attacking to seize the river crossing sites with three companies abreast. The close, compartmented terrain does not support transition to battle formation or cross-country maneuver, so each company is deploying in a staggered column on various routes going in various directions in an attempt to confuse the Blue force as to the main thrust of the attack.

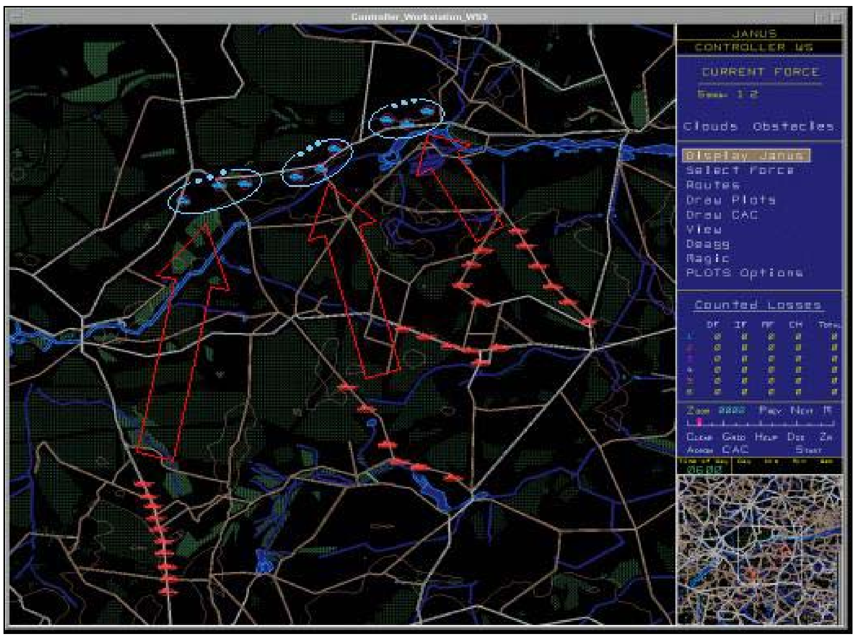

Figure 14. Janus Display of Scenario III - Europe

E. MEASURES OF EFFECTIVENESS OVERVIEW

Three MOEs were selected as the basis for analyzing the data produced by both the Coroner's Report and the Engagement Analysis Report from the Janus Post Processor files. Specifically, an MOE is defined as:

> A quantifiable measure used in comparing systems or concepts or estimating the contribution of a system or concept to the effectiveness of a military force. It expresses the extent to which a combat system accomplishes or supports a military mission. [Ref. 14: p. 28]

1. MOE I: Lethality

The CM is envisioned to possess lethality that is equal to or greater than the TOW 2B missile system. The capability to defeat the most advanced, heavily-armored threats has been designated a potential KPP. [Ref. 6] Subsequently, the MOE for lethality is defined by the following measure:

- Lethality – The total number of threat platforms destroyed by each missile system in the base and alternate cases of each scenario.

2. MOE II: Survivability

The SBCT was designed as a medium-weight force to support the power projection capability of the U.S. Army. Given the lesser amount of armor protection available on the Stryker platform as compared to an M1A1 Abrams tank or M2/M3 Bradley/Cavalry Fighting Vehicle, the degree to which each missile system contributes to platform and force survivability is a critical issue. Therefore, the MOE for survivability is defined by the following measure:

- Survivability – The total number of Stryker AT platforms destroyed by threat platforms in the base and alternate cases of each scenario.

3. MOE III: Engagement Range

The CM is envisioned to provide friendly forces increased stand-off range in both an air-ground capability and a ground-ground capability. Increased stand-off range is defined as the capability to engage threat systems outside of their weapon's capability. The ability to engage at greater distances also incorporates the capability to detect and identify threat forces at greater ranges. The Engagement Range Analysis Report produced by

Janus measures both the average distance at which threat platforms were destroyed, as well as the average distance threat platforms were fired upon. Subsequently, this MOE has two components and is defined from both perspectives by the following measures:

- Engagement Range, Part (a) (Kills) - The average range threat platforms were destroyed at by each missile system in the base and alternate cases of each scenario.
- Engagement Range, Part (b) (Engagements) - The average range threat platforms were fired upon by each missile system in the base and alternate cases of each scenario.

F. END-OF-BATTLE ANALYSIS OVERVIEW

In addition to analyzing the three MOEs, a separate component of analysis applied end-of-battle criteria to each simulation run in the base and alternate cases of each scenario. Using these criteria, an average run from both the base and alternate cases of each scenario was selected and analyzed using a scatter-plot graph. The resulting scatter-plots clearly display for each missile system the distribution of shots and kills as a function of range over time. This analysis will further assist in determining the potential for increased operational effectiveness of the CM over the TOW 2B.

IV. DATA PRESENTATION

The purpose of this chapter is to present the raw data to be analyzed in Chapter V. Each of the following tables presents the raw data per MOE, by scenario, as it corresponds to each simulation run. In support of MOE I – Lethality, Table 3 presents the total number of threat (Red) platforms destroyed in each scenario. In support of MOE II – Survivability, Table 4 presents the total number of friendly (Blue) platforms destroyed in each scenario. Finally, Tables 5 and 6 present the raw data necessary to evaluate both components of MOE III – Engagement Range Analysis. Table 5 presents the average range of enemy platforms destroyed per scenario, per missile system, while Table 6 presents the average engagement range enemy platforms were fired upon, per scenario, per missile system.

A. MOE I – LETHALITY DATA

Run #	Balkans		Southwest Asia		Eastern Europe	
	TOW 2B	CM	TOW 2B	CM	TOW 2B	CM
1	24	32	20	32	20	29
2	24	32	20	32	24	32
3	19	31	28	32	15	30
4	20	32	27	32	19	29
5	27	32	14	32	17	29
6	26	32	10	32	19	30
7	21	32	18	32	19	29
8	11	32	17	32	11	28
9	21	31	22	32	11	31
10	28	32	26	32	13	32
11	19	32	20	32	11	30
12	21	32	23	32	11	29
13	12	31	21	32	19	29
14	23	31	30	32	13	32
15	13	32	21	32	21	29
16	21	32	25	32	12	31
17	21	32	17	32	15	30
18	13	32	20	32	19	29
19	26	32	21	32	24	29
20	18	32	21	32	24	28
21	18	32	14	32	11	29
22	17	30	18	32	17	30
23	26	31	18	32	11	29
24	28	32	10	32	24	28
25	11	31	20	32	19	30

Table 3. Data Table for MOE I - Lethality

B. MOE II – SURVIVABILITY DATA

Run #	Balkans		Southwest Asia		Eastern Europe	
	TOW 2B	CM	TOW 2B	CM	TOW 2B	CM
1	7	1	9	0	6	3
2	7	0	7	0	4	0
3	8	0	6	3	8	2
4	6	1	6	2	5	1
5	4	1	9	2	5	2
6	6	0	9	2	6	1
7	6	1	8	0	6	1
8	9	1	9	2	7	2
9	6	0	6	0	7	2
10	5	1	8	0	8	1
11	8	1	9	0	7	2
12	6	0	8	0	9	3
13	8	1	8	3	5	0
14	7	2	6	1	8	1
15	7	1	7	1	5	0
16	6	0	9	1	7	0
17	7	1	9	1	8	2
18	7	0	9	2	5	0
19	6	2	7	0	4	1
20	9	0	8	2	2	3
21	8	1	9	2	7	3
22	8	3	8	2	5	2
23	6	0	8	2	7	0
24	5	1	9	2	4	3
25	9	1	9	1	8	2

Table 4. Data Table for MOE II – Survivability

C. MOE III - ENGAGEMENT RANGE ANALYSIS DATA

1. Part (a) – Average Kill Range

Run #	Average Kill Range					
	Balkans		Southwest Asia		Eastern Europe	
	TOW 2B	CM	TOW 2B	CM	TOW 2B	CM
1	2.982	4.012	3.037	4.110	2.870	3.898
2	3.019	3.839	2.761	4.154	2.908	3.896
3	2.921	3.978	3.071	4.129	2.956	3.640
4	2.889	4.063	2.972	3.972	2.997	3.437
5	3.141	4.136	2.899	3.994	3.059	3.792
6	2.959	4.061	3.106	4.162	2.897	3.546
7	3.016	4.114	2.694	4.137	3.132	4.021
8	3.137	4.081	3.041	4.162	2.826	3.894
9	3.016	4.094	2.907	4.110	2.956	3.465
10	3.032	4.057	2.993	4.186	2.971	3.704
11	2.946	4.063	3.037	4.223	2.826	3.398
12	3.016	4.051	2.909	4.137	2.993	3.898
13	2.943	4.168	2.818	4.129	2.787	3.747
14	3.015	3.980	2.983	3.966	2.971	3.704
15	3.143	3.930	2.953	3.898	2.824	3.916
16	3.016	4.061	3.016	4.156	2.793	3.644
17	3.102	4.041	3.041	4.156	2.956	3.628
18	3.143	4.117	3.042	3.972	2.787	3.747
19	2.959	4.100	2.953	4.137	2.908	4.060
20	3.002	4.117	2.818	4.201	2.909	4.017
21	3.118	4.081	2.899	4.201	2.826	3.898
22	2.865	4.168	2.630	4.225	3.059	3.571
23	2.956	3.838	2.694	4.371	2.956	3.916
24	3.032	4.031	3.106	4.371	2.908	4.017
25	3.137	4.172	3.037	4.089	2.721	3.628

Table 5. Data Table for MOE III(a) – Average Kill Range

2. Part (b) – Average Engagement Range

Run #	Average Engagement Range					
	Balkans		Southwest Asia		Eastern Europe	
	TOW 2B	CM	TOW 2B	CM	TOW 2B	CM
1	3.004	4.031	3.092	4.194	3.052	3.947
2	3.111	3.964	3.077	4.259	3.124	4.012
3	2.968	3.956	3.200	4.325	2.997	3.700
4	2.981	4.146	3.128	4.031	2.989	3.537
5	3.202	4.023	3.140	4.152	3.124	3.866
6	2.978	4.128	3.293	4.272	2.820	3.665
7	3.156	4.276	3.016	4.236	3.175	4.116
8	3.268	4.064	3.240	4.272	3.025	3.818
9	3.156	4.137	3.013	4.194	2.564	3.647
10	3.032	4.199	3.080	4.278	2.636	3.815
11	3.029	4.146	3.092	4.313	3.025	3.628
12	3.156	4.173	2.986	4.236	2.928	3.947
13	3.000	4.299	3.014	4.325	2.809	3.768
14	3.089	4.080	3.187	4.139	2.636	3.815
15	3.258	4.046	3.126	4.017	2.973	4.057
16	3.156	4.128	3.005	4.272	2.765	3.871
17	3.100	4.157	3.240	4.272	2.997	3.679
18	3.258	4.111	3.248	4.031	2.809	3.768
19	2.978	4.107	3.126	4.236	3.124	4.088
20	3.062	4.111	3.014	4.387	2.941	4.008
21	3.108	4.064	3.140	4.387	3.025	3.947
22	2.980	4.100	2.923	4.290	3.124	3.669
23	3.068	3.991	3.016	4.495	2.564	4.057
24	3.032	4.120	3.293	4.495	3.124	4.008
25	3.268	4.226	3.092	4.257	2.746	3.679

Table 6. Data Table for MOE III(b) – Average Engagement Range

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V. DATA ANALYSIS

The purpose of this research effort is to determine the potential increase in operational effectiveness within the Stryker Brigade Combat Team (SBCT) of the CM system over the TOW 2B missile system. This analysis includes the three MOEs and additional data characteristics that holistically provide additional depth from which to derive conclusions and recommendations. The first part of the analysis will encompass the statistical analysis of the data sets for each MOE as presented in Chapter IV, while the subsequent analysis will review and analyze the application of the end-of-battle criteria.

A. DATA ANALYSIS METHODOLOGY

In order to effectively compare the data generated by Janus for each MOE, a statistical add-in for Microsoft Excel, called Analyse-it, was used in order to graphically compare the results of each base and alternate case within each scenario. The post processor reports from Janus generated the data tables within Chapter IV, which were then entered into Excel spreadsheets in order to use the Analyse-it application. This Excel add-in uses descriptive statistics to analyze the data in terms of mean, standard deviation, parametric range, median, inter-quartile range, outliers, and confidence intervals. Specifically, for this research effort, comparative continuous descriptive statistics were analyzed. Per the Analyse-it software index, these statistics are used “…to indicate the central tendency and the scatter/dispersion of the observations.

Vertical box-whisker plots are shown side-by-side for easy comparison of differences between the variables." [Ref. 1] The box-whisker plots depict both parametric and non-parametric comparative descriptive statistics. As seen in Figure 15, the blue diamond depicts the mean of the data and the specified confidence interval, which was 95% in all cases. The blue line with notches on both ends depicts the specified parametric percentile range.

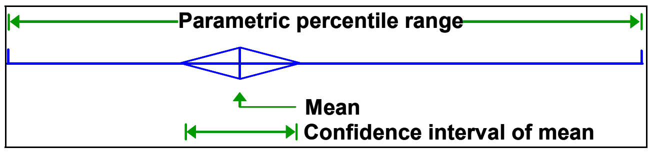

Figure 15. Parametric Statistics Legend [Ref. 1]

The non-parametric statistics legend is depicted in Figure 16. The notched box depicts the median, lower and upper quartiles, and the specified confidence interval around the median, which was 95% in all cases. The nearest observations within 1.5 of the inter-quartile ranges (IQRs) are depicted with a dotted line. Possible outliers between 1.5 and 3.0 IQRs are depicted with red crosses, while outliers greater than 3.0 IQRs away are indicated with a red circle. Lastly, the blue vertical lines depict the specified non-parametric percentile range.

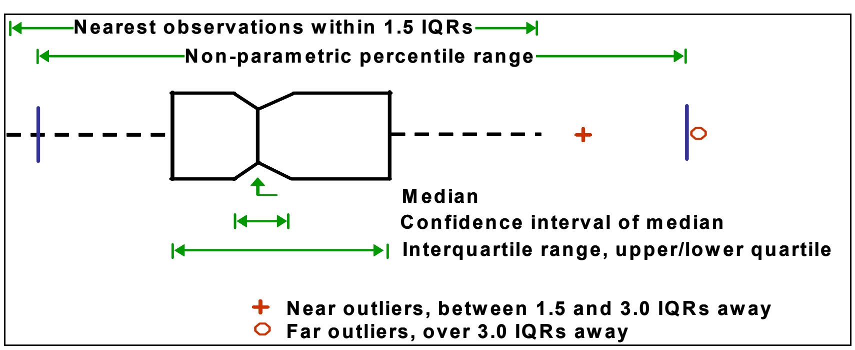

Figure 16. Non-Parametric Statistics Legend [Ref. 1]

B. MOE I – LETHALITY COMPARATIVE ANALYSIS

The lethality measure of effectiveness is defined as the total number of Red kills within the base and alternate cases of each scenario. The box-whisker plot for this MOE is depicted in Figure 17, which graphically depicts the performance of each missile system within each scenario. While the performance of each missile system is fairly consistent in all three scenarios, the number of Red vehicles destroyed by the CM is clearly increased versus the TOW 2B. In the Southwest Asia (SWA) CM scenario, 32 out of 32 Red vehicles were destroyed in each of the 25 runs. Due to a software limitation, Analyse-it could not display the descriptive statistics due to this lack of standard deviation in Red kills. To correct for this, the value of 31.999, instead of 32, was manually entered into Run 1 of the SWA CM scenario, which then facilitated the computation of the statistical analysis. This explains the outlier depicted in that case. The remaining outliers normally occurred as seen per the data in Chapter IV.

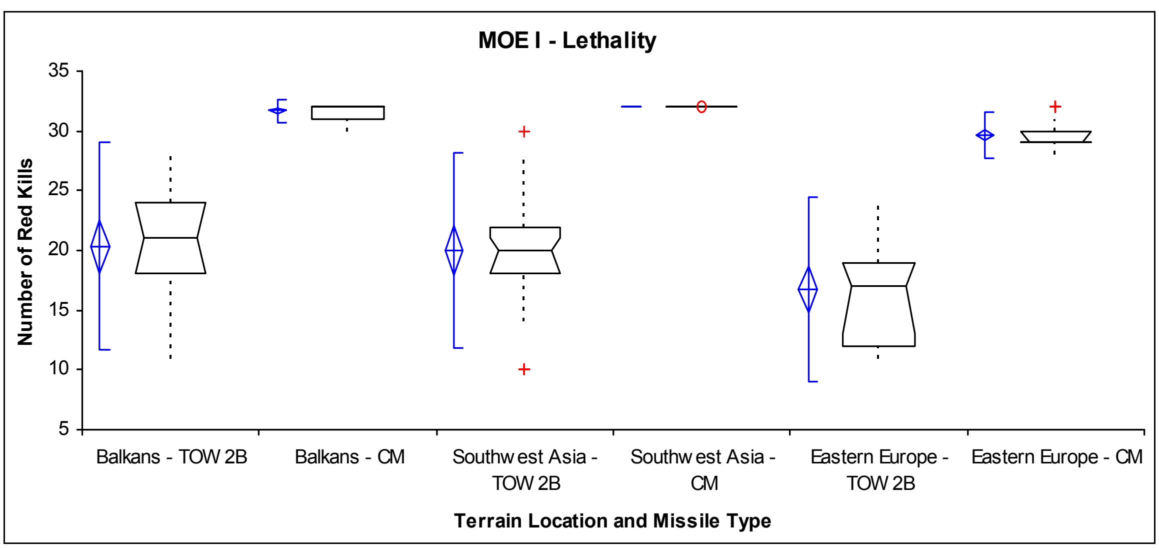

Figure 17. Comparative Box-Whisker Plots for MOE I - Lethality

Closer analysis of the descriptive statistics in Table 7 indicates that the greatest improvement of the CM over the TOW 2B is in the Eastern Europe scenario with a 78% increase in the mean Red kills. The SWA scenario was second best with a 60% improvement in the mean, while the Balkans scenario had a 56% improvement. Concurrently, the median percentage improvement was 71% for the Eastern European scenario, 60% for SWA, and 52% for the Balkans scenario. As shown below in Table 7, the standard deviation and inter-quartile range for the CM is much smaller than that of the TOW 2B, which is indicative of the CM's high level of predictability in achieving the mean or median number of Red kills.

Terrain / Missile	n	Mean	SD	95% CI of Mean	Median	IQR	95% CI of Median
Balkans - TOW 2B	25	20.320	5.2893	18.137 to 22.503	21.000	6.000	18.000 to 24.000
Balkans - CM	25	31.680	0.5568	31.450 to 31.910	32.000	1.000	32.000 to 32.000
Southwest Asia - TOW 2B	25	20.040	4.9706	17.988 to 22.092	20.000	4.000	18.000 to 21.000
Southwest Asia - CM	25	32.000	0.0000	32.000 to 32.000	32.000	0.000	32.000 to 32.000
Eastern Europe - TOW 2B	25	16.760	4.6751	14.830 to 18.690	17.000	7.000	13.000 to 19.000
Eastern Europe - CM	25	29.640	1.1860	29.150 to 30.130	29.000	1.000	29.000 to 30.000

Table 7. Descriptive Statistics for MOE I - Lethality

C. MOE II - SURVIVABILITY COMPARATIVE ANALYSIS

The survivability measure of effectiveness is defined as the total number of Blue platforms destroyed by threat platforms in the base and alternate cases of each scenario. This particular MOE is also affected by the use of full and partial defilade vehicle positions, which contributed to each platform's survivability. Per Figure 18, the CM is clearly depicted as contributing to increased survivability for the friendly forces in each scenario as compared to the TOW 2B. The largest number of Blue platforms destroyed in any CM scenario was three platforms, one of which is depicted as an outlier in the Balkan scenario. Both the graphical and descriptive statistics indicate that the TOW 2B lost an average of six or more platforms in each scenario, which is at least two platoons or two-thirds of the AT company's combat power. Conversely, the mean number of Blue platforms lost in the CM scenarios ranged from 0.8 to 1.5. Graphically, the greatest dispersion between the TOW 2B and the CM appears to be in the SWA scenario, while the least dispersion appears to be in the Eastern European scenario. This is attributable to the engagement range of both missile systems in each scenario. The CM was able to maximize its engagement range capability in SWA due to the open terrain, which indirectly contributed to the increase in Blue survivability. The differences between the TOW 2B and CM were less in Eastern Europe, as engagement ranges were confined to the close, complex nature of the terrain, and the loss of Blue platforms was therefore greater as compared to the other two scenarios.

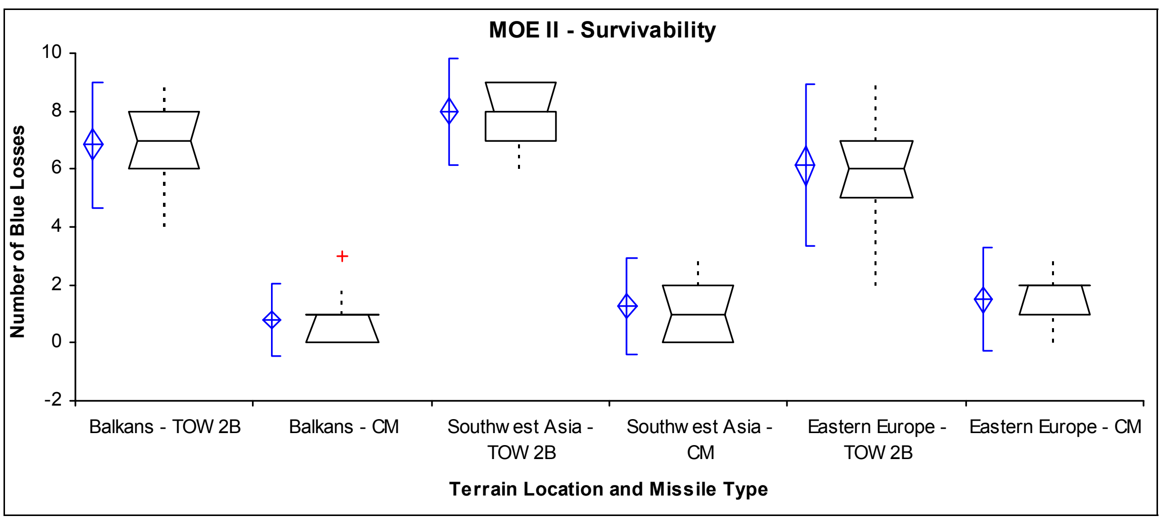

Figure 18. Comparative Box-Whisker Plots for MOE II – Survivability

An examination of the descriptive statistics also reveals significant improvement in survivability for the

Blue platforms equipped with the CM. The largest percent decrease in Blue losses was reflected in the Balkans scenario, with an 88% improvement over the TOW 2B. This was followed by SWA with an 85% mean improvement, and lastly the Eastern European scenario had a 76% mean improvement. The median percentage decrease in Blue losses followed a similar pattern with an 86% improvement for the Balkans scenario, an 88% improvement for the SWA scenario and a 67% improvement for the Eastern European scenario. These overall percentage decreases in Blue losses translate directly to a significant increase in survivability.

Terrain / Missile	n	Mean	SD	95% CI of Mean	Median	IQR	95% CI of Median
Balkans - TOW 2B	25	6.840	1.3128	6.298 to 7.382	7.000	2.000	6.000 to 8.000
Balkans - CM	25	0.800	0.7638	0.485 to 1.115	1.000	1.000	0.000 to 1.000
Southwest Asia - TOW 2B	25	8.000	1.1180	7.538 to 8.462	8.000	2.000	8.000 to 9.000
Southwest Asia - CM	25	1.240	1.0116	0.822 to 1.658	1.000	2.000	0.000 to 2.000
Eastern Europe - TOW 2B	25	6.120	1.6912	5.422 to 6.818	6.000	2.000	5.000 to 7.000
Eastern Europe - CM	25	1.480	1.0847	1.032 to 1.928	2.000	1.000	1.000 to 2.000

Table 8. Descriptive Statistics for MOE II - Survivability

D. MOE III – ENGAGEMENT RANGE COMPARATIVE ANALYSIS

The engagement range measure of effectiveness is divided into two components: 1) Engagement Range, Part (a) (Kills) are the average range threat platforms were destroyed by each missile system in the base and alternate cases of each scenario; and 2) Engagement Range, Part (b) (Engagements) are the average range threat platforms were fired upon by each missile system in the base and alternate cases of each scenario. For the purpose of this analysis, these components were examined separately.

1. Engagement Range Analysis, Part (a) (Kills)

The CM displayed a significant increase over the TOW 2B mean and median kill ranges throughout all three scenarios, as displayed in Figure 19. The CM shows significant increase in average kill range over that of the TOW 2B in both the Balkans and SWA scenarios, but less of an increase in the Eastern Europe scenario. This is attributable to the line-of-sight and engagement range capabilities of the CM. The CM attempted to take full advantage of its six-kilometer engagement range capability in SWA due to few terrain features or other natural impediments; however, it was limited to the inter-visibility characteristics of the SWA terrain. As introduced in Chapter III, inter-visibility lines limit line-of-sight capability in apparently open terrain that is actually rolling or gently sloping. While the terrain depicted is characterized by contour lines at specific intervals, certain areas that appeared to be open did not have line-of-sight capability.

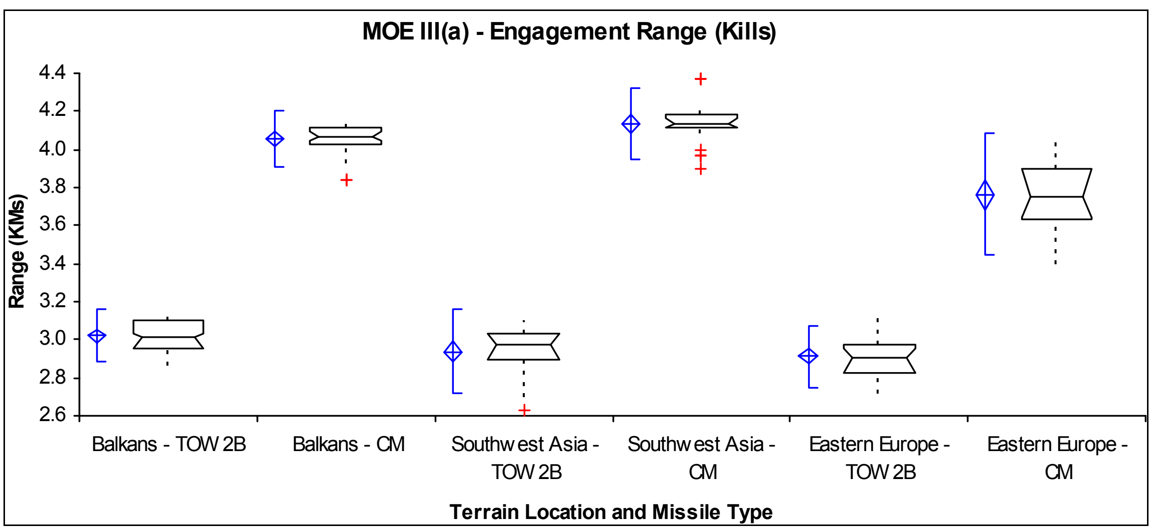

Figure 19. Comparative Box-Whisker Plots for MOE III(a) – Engagement Range (Kills)

The outliers depicted in the SWA CM scenario can be attributed to these SWA terrain inter-visibility characteristics, behind which the Red forces were able to maximize the opportunity to mask their movement. The outlier in the TOW 2B SWA scenario can also be attributed to inter-visibility. On the other hand, both the TOW 2B and the CM were severely restricted in Eastern Europe due to the close, complex terrain with little opportunity for long range shots. This restriction is reflected in the graph above, which depicts a greater variability in the engagement range for both missile systems in the Eastern European scenario.

The descriptive statistics per Table 9 confirm the mean and median improvement of the CM over the TOW 2B. In the Balkans scenario, the CM had a 34% increase over the TOW 2B in the mean engagement range for kills, a 41% increase in SWA, and a 29% increase in Eastern Europe. Table 9 below indicates a greater standard deviation and inter-quartile range for the CM and the TOW 2B in Eastern Europe when compared to the other two scenarios. This is indicative of how the limited long-range capabilities inherent in the Eastern European terrain affected the predictability of the average engagement range in this scenario.

Terrain / Missile	n	Mean	SD	95% CI of Mean	Median	IQR	95% CI of Median
Balkans - TOW 2B	25	3.0202	0.08284	2.9860 to 3.0544	3.0160	0.1430	2.9590 to 3.0320
Balkans - CM	25	4.0541	0.08794	4.0178 to 4.0904	4.0630	0.0830	4.0410 to 4.1000
Southwest Asia - TOW 2B	25	2.9367	0.13341	2.8816 to 2.9918	2.9720	0.1380	2.8990 to 3.0370
Southwest Asia - CM	25	4.1339	0.11225	4.0876 to 4.1803	4.1370	0.0760	4.1100 to 4.1620
Eastern Europe - TOW 2B	25	2.9118	0.09874	2.8711 to 2.9526	2.9080	0.1450	2.8260 to 2.9560
Eastern Europe - CM	25	3.7633	0.19434	3.6831 to 3.8435	3.7470	0.2700	3.6400 to 3.8980

Table 9. Descriptive Statistics for MOE III(a) – Engagement Range (Kills)

2. Engagement Range Analysis, Part (b) (Engagements)

As compared to the analysis of Part (a) above, the engagement range analysis for Part (b) depicts similar findings both graphically and statistically. Per Figure 20, the CM clearly engaged at a much longer range than that of the TOW 2B in all three scenarios. The greatest disparity between the two missile systems is in the SWA scenario, with the CM engaging the threat at an average of 4.25 kilometers, as compared to the TOW 2B engaging at an average of 3.11 kilometers, a difference of approximately 1.1 kilometers. Both the CM and the TOW 2B depict little variation around the mean and median in the Balkans and SWA scenarios, but there is significant variation around the mean and median for both missile systems in the Eastern Europe scenario. As in Part (a), this variation is attributed to the terrain limitations of the Eastern Europe scenario, where neither missile system had the ability to engage at their maximum range capability with any consistency.

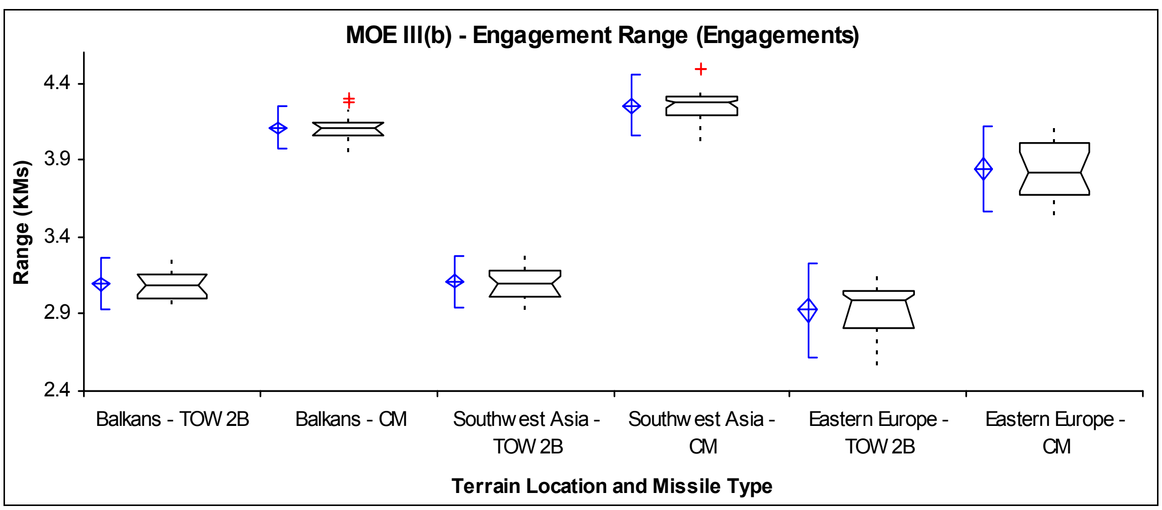

Figure 20. Comparative Box-Whisker Plots for MOE III(b) – Engagement Range (Engagements)

Analysis of the parametric statistics in Table 10 reveals that the CM had a 33% increase in the mean engagement range in the Balkans scenario, a 37% increase in the SWA scenario, and a 31% increase in the Eastern Europe scenario. There was also a 33% increase in the median for the CM over the TOW 2B in the Balkans scenario, 38% increase in SWA, and 28% increase in Eastern Europe. As in the engagement range analysis for kills, the CM shows a distinct improvement over the TOW 2B in the average range at which a missile was fired against a threat vehicle.

Terrain / Missile	n	Mean	SD	95% CI of Mean	Median	IQR	95% CI of Median
Balkans - TOW 2B	25	3.0959	0.10020	3.0546 to 3.1373	3.0890	0.1520	3.0290 to 3.1560
Balkans - CM	25	4.1113	0.08593	4.0759 to 4.1468	4.1110	0.0820	4.0640 to 4.1460
Southwest Asia - TOW 2B	25	3.1112	0.10130	3.0694 to 3.1531	3.0920	0.1710	3.0160 to 3.1400
Southwest Asia - CM	25	4.2546	0.12174	4.2043 to 4.3048	4.2720	0.1190	4.2360 to 4.2900
Eastern Europe - TOW 2B	25	2.9238	0.18785	2.8463 to 3.0014	2.9890	0.2430	2.8090 to 3.0250
Eastern Europe - CM	25	3.8445	0.16718	3.7755 to 3.9135	3.8180	0.3290	3.7000 to 3.9470

Table 10. Descriptive Statistics for MOE III(b) – Engagement Range (Engagements)

E. END-OF-BATTLE ANALYSIS

As first introduced in Chapter III, the end-of-battle analysis was conducted to further assess the operational effectiveness of the CM as compared to the TOW 2B. This section will first describe the methodology used to apply the end-of-battle criteria and subsequently analyze the results for each scenario.

1. End-of-Battle Analysis Methodology

The purpose of the end-of-battle analysis is to graphically depict the distribution of shots and kills as a function of range over time for both missile systems. One representative run from both the base and alternate cases in each scenario was used to create a scatter-plot graph from the raw data in an Excel spreadsheet. To determine a representative run from the base and alternate cases in each scenario, end-of-battle criteria was assumed to be 25% Blue losses (or three Blue platforms destroyed) or 30% Red losses (or ten Red platforms destroyed), whichever came first in each of the 25 simulations in each base and alternate case. These percentages were used based upon both guidance from PEO-Tactical Missiles and previous modeling and simulation efforts conducted for the CM. [Ref. 27] Once the end-of-battle criteria were applied to the 25 simulation runs in each case, the end-of-battle run times were averaged. The simulation run with the closest end-of-battle game time to this average was used as a representative run for that particular case. In each case, the Blue forces achieved end-of-battle criteria first by destroying ten Red platforms. The shots and kills data from the Engagement Range Analysis Post Processing Reports were input into the Excel spreadsheet and a scatter-plot graph was then created. Each scatter-plot graphically portrays the base and alternate case representative runs by scenario. The maximum effective ranges for each missile system are indicated with a blue horizontal line at 3.5 kilometers for the TOW 2B and a red horizontal line at six kilometers for the CM. Additionally, a vertical blue line indicates the end-of-battle time for the TOW 2B, and a vertical red line represents the end-of-battle time for the CM.

2. Scenario I End-of-Battle Analysis

For Scenario I - Balkans, Run 6 was selected as the representative run for the TOW 2B base case, while Run 14 was selected for the CM alternate case. The resulting scatter-plot is seen in Figure 21. The end-of-battle time for the TOW 2B was determined to be 13 minutes and 41 seconds (13:41), while the CM end-of-battle time was 11:49, which is a difference of just under two minutes. The graph clearly displays a high concentration of shots and kills for the CM occurring much earlier in the run than those of the TOW 2B, with virtually every engagement over 3.5 kilometers. If the one CM shot and one kill that occurred at the end-of-battle time were eliminated, the resulting end-of-battle time for the CM would have been under ten minutes, with a difference of just over four minutes. The overall trends in the graph depict that the CM reached end-of-battle quicker and at a greater range than the TOW 2B, whose shots and kills are much more dispersed over a longer period of time and at less range. However, the TOW 2B was capable of engaging and destroying threat targets at its maximum effective range of 3.5 kilometers consistently throughout the run, while in its run the majority of CM’s shots and kills occurred between four and five kilometers.

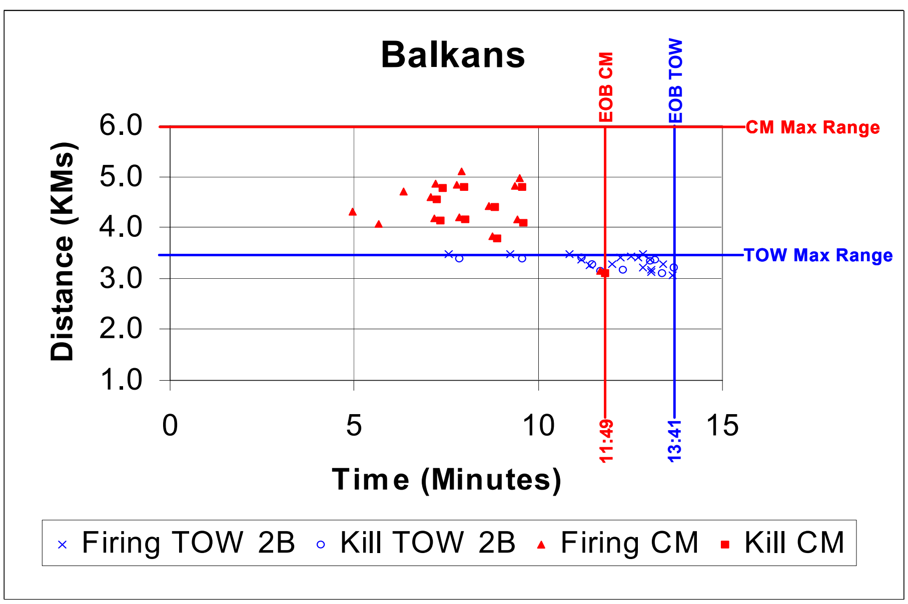

Figure 21. End-of-Battle Scatter-plot for Scenario I – Balkans

3. Scenario II End-of-Battle Analysis

For Scenario II – SWA, Run 23 was selected as the representative run for the TOW 2B base case, while Run 22 was selected for the CM alternate case, with the resulting scatter-plot displayed in Figure 22. The most noticeable pattern is the lack of shots and kills between 19 and 25 minutes. This is most likely due to the doctrinal employment of the Red force. The reconnaissance element was comprised of six vehicles that were initially destroyed in each case, and is indicated by the first groupings of shots and kills. The main body was comprised of 26 platforms, of which only four more had to be destroyed in order to reach the end-of-battle criteria of ten Red vehicles.

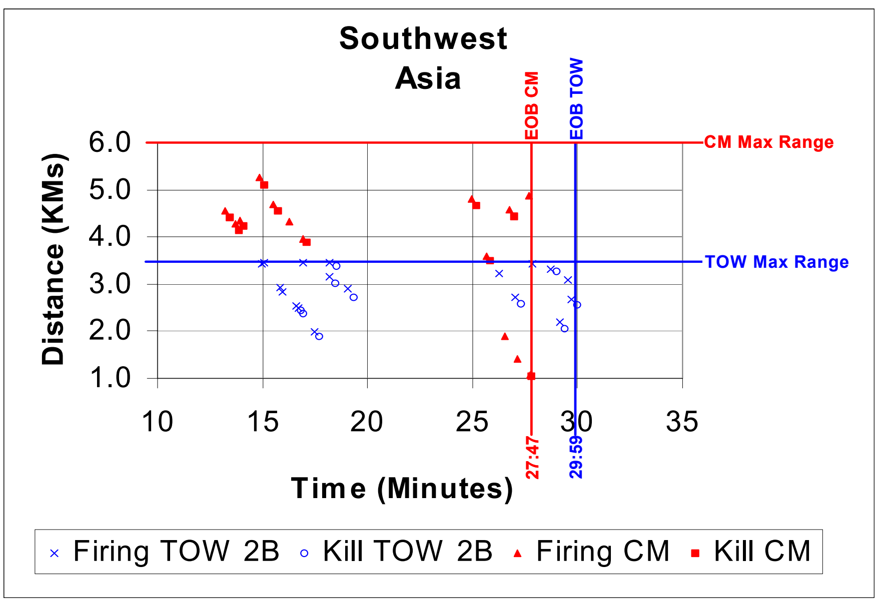

Figure 22. End-of-Battle Scatter-plot for Scenario II – SWA

The end-of-battle time for the TOW 2B was determined to be 29:59, while the CM end-of-battle time was 27:47, which is a difference of just over two minutes. The primary reason for the different time scale in the SWA scatter-plot is due to the increased distance the threat travels in the scenario prior to engaging the Blue force.

The shots and kills for the CM are again consistently between four and five kilometers, with only two shots and one kill occurring at less than two kilometers. This is also attributable to the inter-visibility characteristics of the SWA terrain, which the Red forces utilized to mask their movement. The TOW 2B had several shots in excess of three kilometers, but overall, the shots and kills were dispersed between two and 3.5 kilometers.

4. Scenario III End-of-Battle Analysis

For Scenario III – Eastern Europe, Run 6 was selected as the representative run for the TOW 2B base case, while Run 18 was selected for the CM alternate case. Figure 23 depicts the resulting scatter-plot. The end-of-battle time for the TOW 2B was determined to be 17:43, while the CM end-of-battle time was 15:31, which is again a difference of just over two minutes. Due to the close, complex nature of the Eastern Europe terrain, the CM shots and kills occurred mostly between eight to 15 minutes, with the TOW 2B shots/kills occurring between eight and 18 minutes.

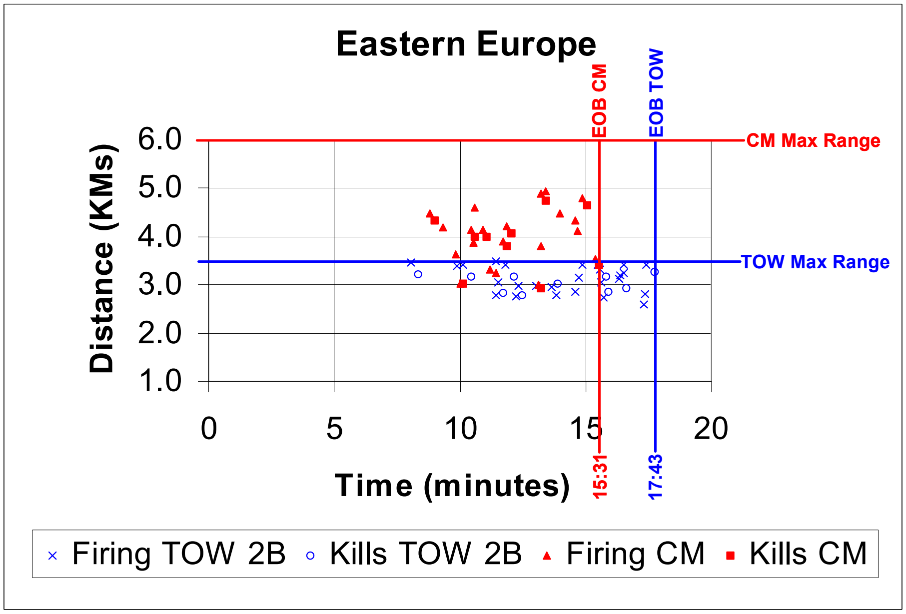

Figure 23. End-of-Battle Scatter-plot for Scenario III – Eastern Europe

The majority of the CM shots are tightly concentrated between 3.5 to nearly five kilometers, while the TOW 2B shots/kills are mostly concentrated between 2.5 and 3.5 kilometers. The channeling of the threat onto the complex road networks afforded both missile systems with only a narrow opportunity of time to engage and destroy the Red forces, which further explains the clusters of shots/kills for each missile system.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. Primary Research Question Review

- Within the context of the Stryker ATGM platform in a Janus simulation, which missile system provides the most operational effectiveness?

In each of the three scenarios modeled within Janus, the CM displayed significant improvement over the TOW 2B in all measures of effectiveness – lethality, survivability, and engagement range capability – as well as in the end-of-battle analysis. The percentage increases presented with the analysis of each MOE are summarized in Table 11.

Scenarios/ Measures of Effectiveness	Scenario I Balkans	Scenario II SWA	Scenario III Eastern Europe
MOE I - Lethality	56%	60%	78%
MOE II - Survivability	88%	85%	76%
MOE III(a) - Engagement Range (Kills)	34%	41%	29%
MOE III(b) - Engagement Range (Engagements)	33%	37%	31%

Table 11. Summary of CM Performance Versus TOW 2B

The greatest improvement is found in MOE II – Survivability, which ranges from a 76% to 88% improvement across all three scenarios. This is a critical aspect that could provide a significant improvement to the current capabilities of the SBCT. The increase in survivability of the Stryker ATGM platform equipped with the CM is attributable to the increased maximum effective range. Since the CM was able to engage the threat beyond the threat's direct fire capabilities, both platform-level and force-level survivability was improved for the Blue force. The next highest improvement is evidenced in MOE I – Lethality, with a range of 56%-78% improvement over the TOW 2B across all three scenarios. Significant improvement was also seen in both kills and engagements for MOE III – Engagement Range, ranging from a 29% to 41% improvement.

The end-of-battle analysis demonstrated the capability of the CM to engage further and earlier than the TOW 2B in each of the representative runs presented, thus strengthening and corroborating the analysis of all three MOEs. The capability to engage further and earlier represents the potential opportunity to maximize the combat power of the SBCT's AT company, facilitating its availability for follow-on missions, while significantly improving both force and platform survivability.

2. Subsidiary Questions Review

- How did the variation of terrain between scenarios affect the performance of the missile systems?

While the CM outperformed the TOW 2B in all three terrain locations, both missile systems were sensitive to various factors. One particular advantage the CM possesses over the TOW 2B is its fire-and-forget capability, which allowed the system to engage and immediately re-occupy its defilade position. Conversely, the wire-guided command guidance system of the TOW 2B required the Blue platform to remain exposed until the TOW missile reached its target.

This difference was a critical factor in the performance of each missile system in each terrain, especially in the scenarios characterized by significant terrain features; this factor also impacts both force and platform survivability.

In SWA, both missile systems were able to engage at or near their maximum effective ranges, facilitating a greater number of Red kills compared to the other scenarios. The only factor restricting either missile system in SWA was the presence of inter-visibility lines, which limited their line-of-sight and detection capabilities. In the Balkans scenario, the significant terrain features channeled the threat into a well-defined engagement area, in which the Blue force was able to concentrate their fires by employing both missile systems. Additionally, the urban and intermittent open areas facilitated the establishment of a comprehensive Blue force defense. The Eastern Europe scenario limited both missile systems due to the close, complex nature of the terrain. This factor limited detection and engagement capabilities, resulting in fewer Red kills and higher Blue losses compared to the other two scenarios. This was especially detrimental for the TOW 2B and its wire-guided command system, leaving the Blue platform exposed until the missile impacted the target.

- What are the specific advantages of employing the CM system rather than the TOW 2B within the SBCT AT company?

The demonstrated performance advantage of the CM over the TOW 2B in this research effort supports the conclusion that the CM will bring increased force effectiveness to both the SBCT and the AT company. As modeled, the extended engagement range, fire-and-forget capability, and increased lethality of the CM comprise three technological advantages that clearly overmatch the TOW 2B. As the primary long-range anti-armor element of the SBCT, these increased capabilities will greatly contribute to increased force and platform survivability.

B. RECOMMENDATIONS

In order to provide value-added additional research for the CM program, all of the model inputs should be replaced with the actual classified data to enhance the results of this effort and other projects, and to strengthen the requirement for the CM system.

From an operational perspective, the following considerations should be implemented into future efforts:

- Additional combat multipliers of the SBCT should be incorporated into the scenarios. These include, but are not limited to, attack aviation, indirect fire, and other maneuver units. A methodology for assessing and measuring contributions to increased force effectiveness must be defined and implemented in order to ascertain the correct force structure and employment doctrine for each multiplier.
- As one of the key survivability factors for this brigade is situational awareness and understanding, this capability must be integrated into future SBCT modeling efforts. This is critical to ensure the timely employment of the AT company, or other SBCT elements, in an operational environment representative of that in which the SBCT will operate.

From a modeling perspective, the following considerations for Janus include:

- Model the SBCT, AT company, and CM in varied force structures on different terrain locations, with a different mix of threat structures and equipment. Incorporate emerging technologies such as reactive armor or other counter-measures to assess their effect upon the CM.

- Develop a scenario for the AT company that incorporates soldiers and officers from one of the SBCTs for execution with the added capabilities of the CM. Allow the "players" to interactively war-game the scenario in accordance with established doctrine and standard operating procedures.
- Develop the capability for the tri-mode seeker (imaging infrared (I^2R), semi-active laser (SAL), and millimeter wave (MMW)) and multi-mode warhead in Janus and other combat models.

C. POTENTIAL AREAS FOR FURTHER RESEARCH

The following areas for potential further study are based upon the conclusions of this research effort:

- Conduct a cost-benefit analysis of the added capabilities the CM could offer to the SBCT. These include, but are not limited to, an evaluation of the extended range, lethality, and fire-and-forget capabilities as they impact upon the operational and organizational construct of the SBCT.
- Re-run the model and these scenarios with a varied force structure to determine the optimum mix of Stryker ATGM platforms the AT company should possess. For example, what would be the increase in operational effectiveness, as compared to this research effort, if each platoon were to have four Stryker ATGM platforms, for a total of 12 in the AT company?
- Develop and execute a scenario that task organizes an AT platoon, equipped with the CM, down to an infantry battalion or the Reconnaissance, Surveillance, and Target Acquisition (RSTA) Squadron of the SBCT, in order to assess its operational effectiveness when employed as part of a combined arms force.

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APPENDIX A. SUMMARY OF IAV REQUIREMENTS

A. IAV COMMON REQUIREMENTS

ORD Section	ORD Requirement
Base ORD KPPs	1. Interoperable with existing and planned Army communications systems 2. C-130 transportable
General Requirements	1. Operate effectively, day and night 2. Vehicular intercom system 3. Maximum commonality between all variants 4. Operable in hot, temperate, and cold climates
Mobility Requirements	1. Sustained hard surface speeds of 40 MPH 2. Climb vertical 18-inch obstacles 3. Cruising range of 300 miles 4. Capable of fording a water obstacle 5. Climb and descend hard surface 60% frontal slope with no degradation in steering 6. Negotiate a hard surface 30% side slope with no degradation in steering 7. Capable of crossing gaps (Approx. ¼ vehicle length)
Survivability Requirements	1. Dash speed of 50m in less than 8 seconds 2. All around 7.62 protection 3. 14.5mm protection with add-on, scaleable armor 4. Overhead protection from 152mm 5. All around AP mines protection 6. Universal gun mount that elevates from –20 to +60^o and traverses 360^o 7. Rapid multi-spectral self-obscuration

	8. Spall lining to contain/limit fragment penetration of crew compartment
Sustainability Requirements	1. Capable of towing and being towed; self-recovery capability 2. NATO slave receptacle and slave start capability 3. Rapid refueling (NLT 50 gallons per minute) in 4 minutes or less; rapid fuel transfer 4. Auxiliary power source, battery charging, and power management capabilities
Logistics and Readiness Requirements	1. Easy access to prime train power components 2. Equipped with standard tie-down and lifting provisions for air, rail, & sea movement without shackles 3. Reliability of 1000 mean miles between critical failures 4. Equipped with built-in test (BIT) or built-in test equipment (BITE) 5. If wheeled, must be equipped with central tire inflation & run flat tires 6. If tracked, have the capacity to run short track with a minimum of one road wheel arm incapacitated on either side 7. Equipped with interactive electronic technical manuals 8. Maintenance must use common tools & not require special tools not currently available 9. Equipped with lifetime oil filters, on-board oil changers, and AC/DC power generation 10. Utilize standard fuel (JP-8) and standard lubricants for primary operations

	11. Equipped with outside cargo straps & hooks
Other System Characteristics	1. Able to accomplish OMS/MP critical functions while in NBC contaminated environments and within 15 minutes following HEMP environments 2. Integrated NBC sensor suite to provide detection of chemical, biological agents, and toxic industrial materials 3. Joint chemical agent alarm (JCAD) first sensor to be integrated, followed by biological and follow-on smaller chemical and radiological detectors 4. Carry on-board items necessary to conduct immediate and operational decontamination procedures within 15 minutes 5. Equipment re-bootable and IAV re-startable and returned to full operational capability within 15 minutes after HEMP burst 6. Able to host existing and future GPS capabilities into an integrated, self-contained, externally referenced positioning/navigation system 7. Fire detection and suppression system capable of both automatic sensing and extinguishing and manual activation 8. Equipped with a water ration heater with the same capacity and capability as those installed in the M2 ODS and M2A3 Bradley

Table 12. IAV ORD Common Requirements [Ref. 23: pp. 6-18]

B. ICV REQUIREMENTS

ICV KPP Requirement	1. IAV ICV infantry carrier and engineer squad configurations must carry an infantry squad with individual equipment.
General Requirements	1. Capable of hosting mission equipment packages for all other configurations 2. Accommodate a minimum of two crewman with individual equipment 3. Doors/hatches that facilitate rapid ingress/egress of soldiers 4. Provide a squad leader display for ICV and ESV applications 5. Provide armament capable of day/night operation to ID/defeat enemy troops in the open & in hastily prepared fighting positions at 1500m 6. Armament elevation of -20^o to $+60^o$ or more 7. Armament system can be fired mounted/dismounted; capable in day/night of ID and defeating light armored vehicles at 1500m 8. Carry a full basic load of ammunition for primary and secondary armament systems 9. Stowed missiles separated from onboard personnel 10. ICV and RV must enter/exit water obstacle w/o preparation and swim 11. All ICV configurations must carry one standard NATO litter 12. ICV, ATGM, RV, CV, and FSV provided with scaleable armor packages to protect against 14.5mm and HHH up to RPG-7

Table 13. ICV Requirements [Ref. 23: Annex A, pp. 1-4]

C. ATGM REQUIREMENTS

ATGM Requirements	1. Based on the ICV variant 2. Capable of integrating TOW 2B and IBAS/ITAS or equivalent capability 3. Capable of mounting a minimum of 2 ready missiles 4. Minimum storage of 8 missiles 5. Same armament as the ICV 6. Launcher capable of rapid reloading by an individual crewman with minimum exposure 7. Crew of four

Table 14. ICV Requirements [Ref. 23: Annex C, pp. A-2-1 – A-2-2]

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APPENDIX B. SYSTEMS DATABASE INPUTS

The purpose of this appendix is to present the basic database parameters that were entered for both the Blue and Red platforms and systems prior to conducting the simulations. All information is unclassified and was reviewed/approved by PEO-TM prior to executing the simulation runs.

A. BLUE SYSTEM DATABASE INPUTS

BLUE SYSTEMS GENERAL CHARACTERISTICS

Sys Num	Sys Name	Max Rd Speed (KM/Hr)	Max Visbl (KM)	Wpn Rng (KM)	Sens Hght (m)	Crew Size	Elemt Space (m)	Chem Xmit Fctr	Gra Sym	Cls Sym	Host Cap
80	LAV TOW	70	7.0	6.0	3	4	100	1.0	55	126	1
82	LAV GCM	70	6.0	3.5	3	4	100	1.0	55	126	1

BLUE SYSTEMS FUNCTIONAL CHARACTERISTICS

Sys Num	Sys Name	Lsr Dsg	Min Dsp	Eng Typ	Fir Cat	Fly Typ	Log Typ	Mov Typ	Rdr Typ	Smk Dsp	Srv Typ	Swm Typ
80	LAV TOW	1		4	1			2		2		
82	LAV GCM	1		4	1			2		2		

BLUE SYSTEMS DETECTION DATA

		DETECT Dimensions (Meters)			SENSORS					
Sys Num	Sys Name	Lngth	Width	Hght	Prim	Alt	Defil	Popup	BCIS Type	BCIS Func
80	LAV TOW	7.20	2.80	3.30	23	23	23	1		
82	LAV GCM	7.20	2.80	3.30	23	23	23	1		

OPTICAL AND THERMAL CONTRAST DATA

			Thermal Contrast	
Sys Num	Sys Name	Optical Contrast	Exposed	Defilade
80	LAV TOW	0.3600	1.800	0.500
82	LAV GCM	0.3600	1.800	0.500

SENSOR FIELD of VIEW (FOV) and BAND

Sensor Number	Narrow	Wide	Narrow-to-Wide Factor	Specral Band	(1,2 = Optical 3,4 = Thermal)
23	15.00			1	
2	9.00	15.00	0.60	3	

CYCLES per MILLIRADIAN versus TEMPERATURE or CONTRAST

Optical Sensor Number: 23

Pair	Cycles	TMP/CON	Pair	Cycles	TMP/CON
1	0.000	0.020	11	10.620	0.400
2	3.816	0.030	12	10.950	0.450
3	4.776	0.040	13	11.256	0.500
4	5.400	0.050	14	11.544	0.550
5	7.128	0.100	15	11.814	0.600
6	8.112	0.150	16	12.072	0.650
7	8.814	0.200	17	12.318	0.700
8	9.378	0.250	18	12.792	0.800
9	9.846	0.300	19	13.248	0.900
10	10.254	0.350	20	13.686	1.000

CYCLES per MILLIRADIAN versus TEMPERATURE or CONTRAST

Thermal Sensor Number: 2

Pair	Cycles	TMP/CON	Pair	Cycles	TMP/CON
1	0.225	0.050	11	0.709	0.410
2	0.311	0.075	12	0.750	0.540
3	0.363	0.080	13	0.773	0.600
4	0.407	0.090	14	0.803	0.750
5	0.450	0.100	15	0.833	0.900
6	0.494	0.150	16	0.863	1.050
7	0.539	0.200	17	0.891	1.200
8	0.583	0.250	18	0.919	1.300
9	0.626	0.300	19	0.947	1.400
10	0.668	0.370	20	0.975	2.000

WEAPONS/ORDNANCE for BLUE SYSTEM TOW 2B

Wpn/Ord Number Relative (1-15)	Absolute (1-250)	Wpn/Ord Name	Basic Load	Upload Time (Minutes)	Rel Wpn/Ord to use if Ammo Expended (1-15)
13	5	TOW	10	2.0	

WEAPONS/ORDNANCE for BLUE SYSTEM CM DF

Wpn/Ord Number Relative (1-15)	Absolute (1-250)	Wpn/Ord Name	Basic Load	Upload Time (Minutes)	Rel Wpn/Ord to use if Ammo Expended (1-15)
13	90	CM DF	10	2.0	

BLUE WEAPON/ROUND CHARACTERISTICS

Wpn Num	Wpn Name	Lay Time (Sec)	Aim Time (Sec)	Reload Time (Sec)	Rnds / Trggr Pull	Trggr Pulls / Reload	Round Speed (KM/Sec)	Min. SSKP
5	TOW 2B	7.0	6.0	5.0	1	1	0.180	5
90	CM DF	6.0	6.0	10.0	1	1	0.400	5

BLUE WEAPON/ROUND GUIDANCE DATA

Fire on: 0 = Yes, no restrictions. 1 = Stop, can move before impact.
the Move: 3 = Reduce speed to fire. 2 = Stop, only move after impact.

Wpn Num	Wpn Name	Guidance Mode	Fire on the Move	On-board Sensor	Critical Altitude (meters)
5	TOW 2B	1	2		
90	CM DF		1	2	

HIT and KILL DATA SET NUMBERS for BLUE WEAPON TOW 2B

RED Tgt Sys Num	RED Tgt Sys Name	PH Data Set	PK Data Set
389	T-72	509	509
397	BMP-2	511	511

HIT and KILL DATA SET NUMBERS for BLUE WEAPON CM DF

RED Tgt Sys Num	RED Tgt Sys Name	PH Data Set	PK Data Set
389	T-72	100	100
397	BMP-2	100	100

PROBABILITY of HIT DATA SET: 0509

Range (m) →	500	1313	2125	2938	3750
Posture:					
SSDF	0.95000	0.95000	0.95000	0.95000	0.95000
SSDH	0.95000	0.95000	0.95000	0.95000	0.95000
SSEF	0.95000	0.95000	0.95000	0.95000	0.95000
SSEH	0.95000	0.95000	0.95000	0.95000	0.95000
SMDF (not used)	0.95000	0.95000	0.95000	0.95000	0.95000
SMDH (not used)	0.95000	0.95000	0.95000	0.95000	0.95000
SMEF	0.95000	0.95000	0.95000	0.95000	0.95000
SMEH	0.95000	0.95000	0.95000	0.95000	0.95000
MSDF					
MSDH					
MSEF					
MSEH					
MMDF (not used)					
MMDH (not used)					
MMEF					
MMEH					

PROBABILITY of HIT DATA SET: 0511

Range (m) →	500	1313	2125	3500	3750
Posture:					
SSDF	0.95000	0.95000	0.95000	0.95000	0.95000
SSDH	0.95000	0.95000	0.95000	0.95000	0.95000
SSEF	0.95000	0.95000	0.95000	0.95000	0.95000
SSEH	0.95000	0.95000	0.95000	0.95000	0.95000
SMDF (not used)	0.95000	0.95000	0.95000	0.95000	0.95000
SMDH (not used)	0.95000	0.95000	0.95000	0.95000	0.95000
SMEF	0.95000	0.95000	0.95000	0.95000	0.95000
SMEH	0.95000	0.95000	0.95000	0.95000	0.95000
MSDF					
MSDH					
MSEF					
MSEH					
MMDF (not used)					
MMDH (not used)					
MMEF					
MMEH					

PROBABILITY of HIT DATA SET: 0100

Range (m) →	500	3000	6000	9000	12000
Posture:					
SSDF	0.94000	0.94000	0.94000	0.94000	0.94000
SSDH	0.94000	0.94000	0.94000	0.94000	0.94000
SSEF	0.94000	0.94000	0.94000	0.94000	0.94000
SSEH	0.94000	0.94000	0.94000	0.94000	0.94000
SMDF (not used)	0.94000	0.94000	0.94000	0.94000	0.94000
SMDH (not used)	0.94000	0.94000	0.94000	0.94000	0.94000
SMEF	0.94000	0.94000	0.94000	0.94000	0.94000
SMEH	0.94000	0.94000	0.94000	0.94000	0.94000
MSDF	0.94000	0.94000	0.94000	0.94000	0.94000
MSDH	0.94000	0.94000	0.94000	0.94000	0.94000
MSEF	0.94000	0.94000	0.94000	0.94000	0.94000
MSEH	0.94000	0.94000	0.94000	0.94000	0.94000
MMDF (not used)	0.94000	0.94000	0.94000	0.94000	0.94000

PROBABILITY of KILL DATA SET: 0509

Range (m) →	500	1313	2125	2938	3750
Posture:					
M/ DF	0.59900	0.63310	0.65380	0.66810	0.66400
M/ DH	0.55030	0.56440	0.56980	0.58140	0.57430
M/ EF	0.57500	0.61780	0.63880	0.65650	0.66400
M/ EH	0.55850	0.57780	0.59040	0.59110	0.57430

PROBABILITY of KILL DATA SET: 0511

Range (m) →	500	1313	2125	3500	3750
Posture:					
M/ DF	0.74800	0.75800	0.76680	0.78290	0.76800
M/ DH	0.74370	0.75390	0.77300	0.79760	0.78460
M/ EF	0.75900	0.76480	0.77150	0.77860	0.76800
M/ EH	0.76170	0.76590	0.77970	0.79200	0.78460

PROBABILITY of KILL DATA SET: 0100

Range (m) →	500	3000	6000	9000	12000
Posture:					
M/ DF	0.80000	0.80000	0.80000	0.80000	0.80000
M/ DH	0.80000	0.80000	0.80000	0.80000	0.80000
M/ EF	0.80000	0.80000	0.80000	0.80000	0.80000
M/ EH	0.80000	0.80000	0.80000	0.80000	0.80000

B. RED SYSTEM DATABASE INPUTS

RED SYSTEMS GENERAL CHARACTERISTICS

Sys Num	Sys Name	Max Rd Speed (KM/Hr)	Max Visbl (KM)	Wpn Rng (KM)	Sens Hght (m)	Crew Size	Elemt Space (m)	Chem Xmit Fctr	Gra Sym	Cls Sym	Host Cap
389	T-72	60	6.0	5.0	2	3	50	1.00	1	122	
397	BMP-2	60	6.0	4.0	2	4	100	1.00	2	123	2

RED SYSTEMS FUNCTIONAL CHARACTERISTICS

Sys Num	Sys Name	Lsr Dsg	Min Dsp	Eng Typ	Fir Cat	Fly Typ	Log Typ	Mov Typ	Rdr Typ	Smk Dsp	Srv Typ	Swm Typ
389	T-72			3	1			2		3		
397	BMP-2			4	1			2		3		1

RED SYSTEMS DETECTION DATA

		DETECT Dimensions			SENSORS					
		(Meters)								
Sys Num	Sys Name	Lngth	Width	Hght	Prim	Alt	Defil	Popup	BCIS Type	BCIS Func
389	T-72	5.48	3.15	2.25	23	37	17	1		
397	BMP-2	4.90	2.79	2.02	23	37	17	1		

OPTICAL AND THERMAL CONTRAST DATA

			Thermal Contrast	
Sys Num	Sys Name	Optical Contrast	Exposed	Defilade
389	T-72	0.360	2.000	0.500
397	BMP-2	0.360	2.000	0.500

SENSOR FIELD of VIEW (FOV) and BAND

Sensor Number	Narrow	Wide	Narrow-to-Wide Factor	Specral Band	(1,2 = Optical 3,4 = Thermal)
23	15.00			1	
37	4.40	8.80	0.50000	4	
17	8.70			1	

CYCLES per MILLIRADIAN versus TEMPERATURE or CONTRAST

Sensor Number: 23

Pair	Cycles	TMP/CON	Pair	Cycles	TMP/CON
1	0.000	0.020	11	10.620	0.400
2	3.816	0.030	12	10.950	0.450
3	4.776	0.040	13	11.256	0.500
4	5.400	0.050	14	11.544	0.550
5	7.128	0.100	15	11.814	0.600
6	8.112	0.150	16	12.072	0.650
7	8.814	0.200	17	12.318	0.700
8	9.378	0.250	18	12.792	0.800
9	9.846	0.300	19	13.248	0.900
10	10.254	0.350	20	13.686	1.000

CYCLES per MILLIRADIAN versus TEMPERATURE or CONTRAST

Sensor Number: 37

Pair	Cycles	TMP/CON	Pair	Cycles	TMP/CON
1	0.260	0.005	11	2.864	0.194
2	0.521	0.009	12	3.125	0.285
3	0.781	0.014	13	3.385	0.430
4	1.042	0.019	14	6.646	0.669
5	1.302	0.027	15	3.906	1.088
6	1.562	0.037	16	4.167	1.871
7	1.823	0.050	17	4.427	3.493
8	2.083	0.069	18	4.688	7.477
9	2.344	0.096	19	4.948	21.750
10	2.604	0.136	20	5.208	999.999

CYCLES per MILLIRADIAN versus TEMPERATURE or CONTRAST

Sensor Number: 17

Pair	Cycles	TMP/CON	Pair	Cycles	TMP/CON
1	0.000	0.020	11	14.280	0.400
2	5.184	0.030	12	14.728	0.450
3	6.472	0.040	13	15.136	0.500
4	7.304	0.050	14	15.520	0.550
5	9.616	0.100	15	15.880	0.600
6	10.928	0.150	16	16.224	0.650
7	11.872	0.200	17	16.552	0.700
8	12.616	0.250	18	17.184	0.800
9	13.248	0.300	19	17.792	0.900
10	13.792	0.350	20	18.384	1.000

WEAPONS/ORDNANCE for RED SYSTEM T-72

Wpn/Ord Number Relative (1-15)	Absolute (1-250)	Wpn/Ord Name	Basic Load	Upload Time (Minutes)	Rel Wpn/Ord to use if Ammo Expended (1-15)
10	378	AT-11	6	2.0	13

WEAPONS/ORDNANCE for RED SYSTEM BMP-2

Wpn/Ord Number Relative (1-15)	Absolute (1-250)	Wpn/Ord Name	Basic Load	Upload Time (Minutes)	Rel Wpn/Ord to use if Ammo Expended (1-15)
1	391	2A42 30mm	500	2.0	
3	371	AT-5	4	2.0	1

RED WEAPON/ROUND CHARACTERISTICS

Wpn Num	Wpn Name	Lay Time (Sec)	Aim Time (Sec)	Reload Time (Sec)	Rnds / Trggr Pull	Trggr Pulls / Reload	Round Speed (KM/Sec)	Min. SSKP
371	AT-5	7.0	7.0	40.0	1	1	0.270	5
378	AT-11	6.9	3.0	10.0	1	1	0.350	5
391	2A42 30mm	8.3	2.7	120.0	5	36	1.300	5

RED WEAPON/ROUND GUIDANCE DATA

Fire on: 0 = Yes, no restrictions. 1 = Stop, can move before impact.
the Move: 3 = Reduce speed to fire. 2 = Stop, only move after impact.

Wpn Num	Wpn Name	Guidance Mode	Fire on the Move	On-board Sensor	Critical Altitude (meters)
371	AT-5	2	2		
378	AT-11	2	1		
391	2A42 30mm				

HIT and KILL DATA SET NUMBERS for RED WEAPON AT-5

BLUE Tgt Sys Num	BLUE Tgt Sys Name	PH Data Set	PK Data Set
80	LAV TOW	779	779
82	LAV GCM	779	779

HIT and KILL DATA SET NUMBERS for RED WEAPON AT-11

BLUE Tgt Sys Num	BLUE Tgt Sys Name	PH Data Set	PK Data Set
80	LAV TOW	738	738
82	LAV GCM	738	738

HIT and KILL DATA SET NUMBERS for RED WEAPON 2A42 30mm

BLUE Tgt Sys Num	BLUE Tgt Sys Name	PH Data Set	PK Data Set
80	LAV TOW	654	654
82	LAV GCM	654	654

PROBABILITY of HIT DATA SET: 738

Range (m) →	250	1188	2125	3063	4000
Posture:					
SSDF	0.45750	0.45750	0.45750	0.45750	0.45750
SSDH	0.43830	0.43830	0.43830	0.43880	0.43830
SSEF	0.91640	0.91640	0.91640	0.91660	0.91640
SSEH	0.90480	0.90480	0.90480	0.90500	0.90480
SMDF (not used)	0.38260	0.38220	0.37790	0.37640	0.37480
SMDH (not used)	0.36000	0.35960	0.35520	0.35360	0.35200
SMEF	0.87540	0.87520	0.87210	0.87100	0.86990
SMEH	0.85410	0.85380	0.85000	0.84870	0.84730
MSDF					
MSDH					
MSEF					
MSEH					
MMDF (not used)					
MMDH (not used)					
MMEF					
MMEH					

PROBABILITY of HIT DATA SET: 779

Range (m) →	100	1075	2050	3025	4000
Posture:					
SSDF	0.46140	0.46130	0.46070	0.46220	0.46370
SSDH	0.44770	0.44770	0.44770	0.44860	0.45020
SSEF	0.91800	0.91790	0.91770	0.91830	0.91890
SSEH	0.90980	0.90980	0.90950	0.91020	0.91090
SMDF (not used)	0.35120	0.35120	0.35040	0.35210	0.35800
SMDH (not used)	0.32630	0.32630	0.32550	0.32720	0.32880
SMEF	0.86740	0.86740	0.86690	0.86800	0.86910
SMEH	0.81590	0.81590	0.81530	0.81660	0.81790
MSDF					
MSDH					
MSEF					
MSEH					
MMDF (not used)					
MMDH (not used)					
MMEF					
MMEH					

PROBABILITY of HIT DATA SET: 654

Range (m) →		700	1400	2100	2800
Posture:					
SSDF	0.50150	0.27820	0.11330	0.60600	0.03490
SSDH	0.46780	0.25740	0.10420	0.05530	0.03050
SSEF	0.99230	0.92890	0.74700	0.54610	0.40100
SSEH	0.99020	0.91690	0.70530	0.50260	0.36020
SMDF (not used)	0.48250	0.22000	0.07850	0.03600	0.01790
SMDH (not used)	0.44920	0.20270	0.07170	0.03180	0.01670
SMEF	0.99120	0.89850	0.64250	0.42220	0.27690
SMEH	0.98830	0.87410	0.59420	0.37920	0.24610
MSDF	0.50150	0.27820	0.11330	0.60600	0.03490
MSDH	0.46780	0.25740	0.10420	0.05530	0.03050
MSEF	0.99230	0.92890	0.74700	0.54610	0.40100
MSEH	0.99020	0.91690	0.70530	0.50260	0.36020
MMDF (not used)	0.48250	0.22000	0.07850	0.03600	0.01790
MMDH (not used)	0.44920	0.20270	0.07170	0.03180	0.01670

PROBABILITY of KILL DATA SET: 738

Range (m) →	250	1188	2125	3063	4000
Posture:					
MOBDF	0.98020	0.97980	0.98080	0.98080	0.98080
MOBDH	0.97860	0.97830	0.97910	0.97910	0.97910
MOBEF	0.98370	0.98330	0.98320	0.98440	0.98440
MOBEH	0.98820	0.98790	0.98780	0.98790	0.98790
FRPDF	0.98970	0.98940	0.99010	0.99010	0.99010
FRPDH	0.98880	0.98860	0.98920	0.98920	0.98920
FRPEF	0.97880	0.97820	0.97820	0.97810	0.97950
FRPEH	0.98170	0.98130	0.98120	0.98120	0.98260
M/ DF	0.98990	0.98950	0.99030	0.99030	0.99030
M/ DH	0.98900	0.98880	0.98940	0.98940	0.98940
M/ EF	0.98520	0.98480	0.98480	0.98580	0.98580
M/ EH	0.98980	0.98940	0.98930	0.98940	0.98940
KK DF	0.06200	0.06200	0.06200	0.06200	0.06200
KK DH	0.06200	0.06200	0.06200	0.06200	0.06200
KK EF	0.22360	0.21620	0.21530	0.23790	0.23760
KK EH	0.22420	0.21670	0.21590	0.23760	0.23730

PROBABILITY of KILL DATA SET: 779

Range (m) →	100	1075	2050	3025	4000
Posture:					
MOBDF	0.97960	0.97960	0.97960	0.97960	0.97970
MOBDH	0.97820	0.97820	0.97820	0.97830	0.97830
MOBEF	0.98310	0.98310	0.98310	0.98310	0.98320
MOBEH	0.98650	0.98650	0.98650	0.98650	0.98650
FRPDF	0.98930	0.98930	0.98920	0.98930	0.98930
FRPDH	0.98870	0.98870	0.98870	0.98880	0.98880
FRPEF	0.97800	0.97800	0.97800	0.97800	0.97810
FRPEH	0.98090	0.98090	0.98090	0.98100	0.98090
M/ DF	0.98940	0.98940	0.98940	0.98940	0.98940
M/ DH	0.98890	0.98890	0.98890	0.98900	0.98890
M/ EF	0.98470	0.98470	0.98470	0.98470	0.98470
M/ EH	0.98810	0.98810	0.98810	0.98810	0.98810
KK DF	0.06200	0.06200	0.06200	0.06200	0.06200
KK DH	0.06200	0.06200	0.06200	0.06200	0.06200
KK EF	0.21570	0.21570	0.21540	0.21610	0.21670
KK EH	0.21300	0.21300	0.21280	0.21340	0.21400

PROBABILITY of KILL DATA SET: 654

Range (m) →		700	1400	2100	2800
Posture:					
MOBDF	0.20570	0.22290	0.21100	0.19670	0.20790
MOBDH	0.20590	0.22290	0.20950	0.19870	0.21090
MOBEF	0.09520	0.07480	0.03660	0.00830	0.00130
MOBEH	0.11980	0.09780	0.05830	0.00880	0.00210
FRPDF	0.40580	0.42010	0.42150	0.44040	0.44620
FRPDH	0.40800	0.40000	0.42400	0.44810	0.48380
FRPEF	0.06100	0.05280	0.03970	0.02430	0.01790
FRPEH	0.05960	0.05430	0.04000	0.02530	0.01890
M/ DF	0.40580	0.42010	0.42150	0.44040	0.44620
M/ DH	0.40800	0.42000	0.42400	0.44810	0.48380
M/ EF	0.11810	0.09770	0.06100	0.02880	0.01820
M/ EH	0.14550	0.12310	0.08330	0.02920	0.01920
KK DF					
KK DH					
KK EF	0.02570	0.02060	0.01020	0.00320	0.00040
KK EH	0.01960	0.01440	0.00870	0.00420	0.00130

APPENDIX C. SAMPLE POST-PROCESSING REPORTS

The purpose of this appendix is to present examples of the Coroner's Report and Engagement Range Analysis Report produced by Janus. The Coroner's Report, depicted below in Figure 24, displays the victim, killer, location, type weapon, and range for each shot that resulted in a kill. The top portion displays the Blue kills that support MOE II – Survivability, and the bottom portions displays the Red kills that support MOE I – Lethality.

CORONER'S REPORT

Run 01 - 25 of Scenario Number 1 - LAV TOW Balk

SIDE: 1 RUN NUMBER: 1

GAME	KILL	----VICTIM----					----KILLER----					
TIME	Mec/Cat	UNIT/SIDE	NAME	X	Y	Loss	UNIT/SIDE	NAME	X	Y	RANGE	PRJ/WPN/MF
00:00:14:52	DF K	2 1	LAV TO	106.6	116.7	1	15 2	T72	109.1	117.9	2.76	AT-11
00:00:17:02	DF K	4 1	LAV TO	108.9	114.5	1	13 2	BMP-2	110.2	117.9	3.67	AT-5
00:00:17:55	DF K	8 1	LAV TO	113.9	115.2	1	19 2	T72	113.9	118.9	3.69	AT-11
00:00:19:44	DF K	3 1	LAV TO	108.2	115.4	1	30 2	BMP-2	110.3	118.3	3.57	AT-5
00:00:20:56	DF K	9 1	LAV TO	115.2	115.5	1	21 2	T72	113.0	118.9	3.99	AT-11
00:00:24:59	DF K	7 1	LAV TO	113.3	114.6	1	22 2	T72	113.5	117.7	3.15	AT-11
00:00:28:52	DF K	6 1	LAV TO	111.2	113.6	1	32 2	T72	109.2	115.4	2.75	AT-11

CORONER'S REPORT

Run 01 - 25 of Scenario Number 1 - LAV TOW Balk

SIDE: 2 RUN NUMBER: 1

GAME	KILL	----VICTIM----					----KILLER----					
TIME	Mec/Cat	UNIT/SIDE	NAME	X	Y	Loss	UNIT/SIDE	NAME	X	Y	RANGE	PRJ/WPN/MF
00:00:08:43	DF K	10 2	BMP-2	112.0	118.0	1	8 1	LAV TO	113.9	115.2	3.42	TOW
00:00:09:34	DF K	8 2	BMP-2	113.2	118.5	1	8 1	LAV TO	113.9	115.2	3.40	TOW
00:00:11:07	DF K	9 2	BMP-2	113.6	118.5	1	9 1	LAV TO	115.2	115.5	3.36	TOW
00:00:11:14	DF K	6 2	T72	112.8	118.2	1	8 1	LAV TO	113.9	115.2	3.24	TOW
00:00:11:36	DF K	14 2	BMP-2	106.2	119.9	1	2 1	LAV TO	106.6	116.7	3.16	TOW
00:00:11:44	DF K	2 2	T72	110.5	117.2	1	4 1	LAV TO	108.9	114.5	3.18	TOW
00:00:12:15	DF K	4 2	T72	111.2	117.3	1	7 1	LAV TO	113.3	114.6	3.42	TOW
00:00:12:33	DF K	1 2	T72	110.5	117.1	1	4 1	LAV TO	108.9	114.5	3.08	TOW
00:00:13:11	DF K	5 2	T72	110.5	117.5	1	3 1	LAV TO	108.2	115.4	3.13	TOW
00:00:14:07	DF K	3 2	T72	110.6	116.8	1	6 1	LAV TO	111.2	113.6	3.34	TOW
00:00:14:13	DF K	7 2	BMP-2	109.4	117.8	1	4 1	LAV TO	108.9	114.5	3.29	TOW
00:00:15:48	DF K	15 2	T72	109.0	117.6	1	3 1	LAV TO	108.2	115.4	2.34	TOW
00:00:17:02	DF K	12 2	BMP-2	106.4	118.9	1	1 1	LAV TO	105.4	117.0	2.13	TOW
00:00:17:35	DF K	11 2	BMP-2	110.2	118.1	1	3 1	LAV TO	108.2	115.4	3.33	TOW
00:00:18:20	DF K	16 2	T72	109.6	116.9	1	5 1	LAV TO	109.8	113.7	3.18	TOW
00:00:19:34	DF K	28 2	BMP-2	110.2	118.1	1	3 1	LAV TO	108.2	115.4	3.33	TOW
00:00:19:45	DF K	17 2	T72	112.6	117.7	1	7 1	LAV TO	113.3	114.6	3.21	TOW
00:00:19:53	DF K	31 2	T72	106.1	118.7	1	1 1	LAV TO	105.4	117.0	1.83	TOW
00:00:20:07	DF K	25 2	BMP-2	113.5	117.5	1	9 1	LAV TO	115.2	115.5	2.69	TOW
00:00:20:32	DF K	27 2	BMP-2	106.3	117.9	1	1 1	LAV TO	105.4	117.0	1.24	TOW
00:00:20:54	DF K	18 2	T72	112.7	117.8	1	7 1	LAV TO	113.3	114.6	3.34	TOW
00:00:21:37	DF K	13 2	BMP-2	109.6	116.5	1	5 1	LAV TO	109.8	113.7	2.75	TOW
00:00:24:00	DF K	21 2	T72	112.7	117.7	1	7 1	LAV TO	113.3	114.6	3.25	TOW
00:00:24:55	DF K	30 2	BMP-2	109.7	116.7	1	5 1	LAV TO	109.8	113.7	2.93	TOW

Figure 24. Sample Coroner's Report from Scenario I

The Engagement Range Analysis report shows the average kill range for each type of threat platform used in the scenario. The top portion of Figure 25 displays the numbers of T-72s destroyed for Run 1, Scenario I, while the bottom portion displays the number of shots fired in the same run. For the Engagement Range analysis, the kill ranges of both platform types were averaged to support part (a) of MOE III, and the engagement ranges of both platform types were averaged to support part (b) of MOE III.

ENGAGEMENT RANGE ANALYSIS

Run 01 - 25 of Scenario Number 1 - LAV TOW Balk

**** SIDE 1 system LAV TOW killing SIDE 2 system T72 □□ ****

RUN NUMBER 1

GAME	KILL	VICTIM				KILLER				
TIME	TYPE	UNIT	SIDE	NAME	LOSS	UNIT	SIDE	NAME	RANGE	PRJ/WPN/MF
00:00:11:14	DF	6	2	T72	1	8	1	LAV TO	3.241	TOW
00:00:11:44	DF	2	2	T72	1	4	1	LAV TO	3.178	TOW
00:00:12:15	DF	4	2	T72	1	7	1	LAV TO	3.420	TOW
00:00:12:33	DF	1	2	T72	1	4	1	LAV TO	3.079	TOW
00:00:13:11	DF	5	2	T72	1	3	1	LAV TO	3.129	TOW
00:00:14:07	DF	3	2	T72	1	6	1	LAV TO	3.342	TOW
00:00:15:48	DF	15	2	T72	1	3	1	LAV TO	2.343	TOW
00:00:18:20	DF	16	2	T72	1	5	1	LAV TO	3.181	TOW
00:00:19:45	DF	17	2	T72	1	7	1	LAV TO	3.210	TOW
00:00:19:53	DF	31	2	T72	1	1	1	LAV TO	1.834	TOW
00:00:20:54	DF	18	2	T72	1	7	1	LAV TO	3.339	TOW
00:00:24:00	DF	21	2	T72	1	7	1	LAV TO	3.253	TOW

Total number of kills = 12 Average Range = 3.046

ENGAGEMENT RANGE ANALYSIS

Run 01 - 25 of Scenario Number 1 - LAV TOW Balk

**** SIDE 1 system LAV TOW firing at SIDE 2 system T72 ****

RUN NUMBER 1

GAME	FIRER				TARGET								
TIME	UNIT	SIDE	NAME	SPEED	UNIT	SIDE	NAME	SPEED	STAT	NFIR	SSKP	RANGE	WEAPON
00:00:10:56	8	1	LAV TO	.0	6	2	T72	25.0	SMEF	1	.63	3.327	TOW
00:00:11:26	4	1	LAV TO	.0	2	2	T72	25.0	SMEH	1	.55	3.274	TOW
00:00:11:56	7	1	LAV TO	.0	4	2	T72	25.0	SMEF	1	.63	3.473	TOW
00:00:12:16	4	1	LAV TO	.0	1	2	T72	25.0	SMEH	1	.56	3.178	TOW
00:00:12:54	3	1	LAV TO	.0	5	2	T72	25.0	SMEF	1	.63	3.205	TOW
00:00:13:05	4	1	LAV TO	.0	3	2	T72	25.0	SMEH	1	.55	3.279	TOW
00:00:13:48	6	1	LAV TO	.0	3	2	T72	25.0	SMEH	1	.55	3.492	TOW
00:00:13:52	5	1	LAV TO	.0	3	2	T72	25.0	SMEH	1	.55	3.302	TOW
00:00:14:49	3	1	LAV TO	.0	15	2	T72	.0	SSEH	1	.56	2.642	TOW
00:00:15:35	3	1	LAV TO	.0	15	2	T72	25.0	SMEH	1	.56	2.443	TOW
00:00:15:35	4	1	LAV TO	.0	15	2	T72	25.0	SMEH	1	.56	3.212	TOW
00:00:16:39	4	1	LAV TO	.0	16	2	T72	25.0	SMEH	1	.56	3.051	TOW
00:00:17:42	8	1	LAV TO	.0	17	2	T72	25.0	SMEF	1	.63	3.434	TOW
00:00:18:01	5	1	LAV TO	.0	16	2	T72	25.0	SMEH	1	.55	3.321	TOW
00:00:19:00	9	1	LAV TO	.0	17	2	T72	25.0	SMEF	1	.63	3.492	TOW
00:00:19:26	7	1	LAV TO	.0	17	2	T72	25.0	SMEH	1	.55	3.296	TOW
00:00:19:42	1	1	LAV TO	.0	31	2	T72	25.0	SMEF	1	.60	1.873	TOW
00:00:20:34	7	1	LAV TO	.0	18	2	T72	25.0	SMEH	1	.55	3.471	TOW
00:00:20:38	9	1	LAV TO	.0	18	2	T72	25.0	SMEF	1	.63	3.471	TOW
00:00:23:41	7	1	LAV TO	.0	21	2	T72	25.0	SMEH	1	.55	3.383	TOW
00:00:25:20	6	1	LAV TO	.0	32	2	T72	25.0	SMEF	1	.63	3.493	TOW
00:00:25:26	5	1	LAV TO	.0	32	2	T72	25.0	SMEH	1	.56	2.926	TOW
00:00:26:14	5	1	LAV TO	.0	32	2	T72	25.0	SMEH	1	.56	2.612	TOW

Total number of firings = 23 Average Range = 3.159

Figure 25. Sample Engagement Range Analysis Report from Run 1, Scenario I for T-72s Destroyed and Fired Upon

Similar to Figure 25, the top portion of Figure 26 displays the number of BMP-2s destroyed for Run 1, Scenario I, while the bottom portion displays the number of shots fired against BMP-2s for Run 1, Scenario I.

ENGAGEMENT RANGE ANALYSIS

Run 01 - 25 of Scenario Number 1 - LAV TOW Balk

**** SIDE 1 system LAV TOW killing SIDE 2 system BMP-2 □□ ****

RUN NUMBER 1

GAME	KILL	VICTIM				KILLER				
TIME	TYPE	UNIT	SIDE	NAME	LOSS	UNIT	SIDE	NAME	RANGE	PRJ/WPN/MF
00:00:08:43	DF	10	2	BMP-2	1	8	1	LAV TO	3.415	TOW
00:00:09:34	DF	8	2	BMP-2	1	8	1	LAV TO	3.401	TOW
00:00:11:07	DF	9	2	BMP-2	1	9	1	LAV TO	3.363	TOW
00:00:11:36	DF	14	2	BMP-2	1	2	1	LAV TO	3.157	TOW
00:00:14:13	DF	7	2	BMP-2	1	4	1	LAV TO	3.292	TOW
00:00:17:02	DF	12	2	BMP-2	1	1	1	LAV TO	2.131	TOW
00:00:17:35	DF	11	2	BMP-2	1	3	1	LAV TO	3.327	TOW
00:00:19:34	DF	28	2	BMP-2	1	3	1	LAV TO	3.327	TOW
00:00:20:07	DF	25	2	BMP-2	1	9	1	LAV TO	2.687	TOW
00:00:20:32	DF	27	2	BMP-2	1	1	1	LAV TO	1.244	TOW
00:00:21:37	DF	13	2	BMP-2	1	5	1	LAV TO	2.745	TOW
00:00:24:55	DF	30	2	BMP-2	1	5	1	LAV TO	2.926	TOW

Total number of kills = 12   Average Range = 2.918

ENGAGEMENT RANGE ANALYSIS

Run 01 - 25 of Scenario Number 1 - LAV TOW Balk

**** SIDE 1 system LAV TOW firing at SIDE 2 system BMP-2 ****

RUN NUMBER 1

GAME	FIRER				TARGET								
TIME	UNIT	SIDE	NAME	SPEED	UNIT	SIDE	NAME	SPEED	STAT	NFIR	SSKP	RANGE	WEAPON
00:00:07:33	8	1	LAV TO	.0	10	2	BMP-2	.0	SSEF	1	.74	3.482	TOW
00:00:08:24	8	1	LAV TO	.0	10	2	BMP-2	.0	SSEF	1	.74	3.482	TOW
00:00:09:15	8	1	LAV TO	.0	8	2	BMP-2	25.0	SMEF	1	.74	3.487	TOW
00:00:10:48	9	1	LAV TO	.0	9	2	BMP-2	25.0	SMEH	1	.75	3.485	TOW
00:00:11:18	2	1	LAV TO	.0	14	2	BMP-2	25.0	SMEH	1	.75	3.306	TOW
00:00:13:55	4	1	LAV TO	.0	7	2	BMP-2	25.0	SMEH	1	.75	3.388	TOW
00:00:14:38	2	1	LAV TO	.0	27	2	BMP-2	25.0	SMEH	1	.75	3.239	TOW
00:00:14:54	1	1	LAV TO	.0	12	2	BMP-2	.0	SSEF	1	.73	2.522	TOW
00:00:15:40	1	1	LAV TO	.0	12	2	BMP-2	.0	SSEF	1	.73	2.522	TOW
00:00:16:20	3	1	LAV TO	.0	13	2	BMP-2	25.0	SMEH	1	.75	3.376	TOW
00:00:16:50	1	1	LAV TO	.0	12	2	BMP-2	25.0	SMEF	1	.73	2.168	TOW
00:00:17:16	3	1	LAV TO	.0	11	2	BMP-2	25.0	SMEH	1	.75	3.473	TOW
00:00:17:34	1	1	LAV TO	.0	27	2	BMP-2	25.0	SMEH	1	.74	2.264	TOW
00:00:18:17	1	1	LAV TO	.0	27	2	BMP-2	25.0	SMEH	1	.74	1.995	TOW
00:00:19:00	1	1	LAV TO	.0	29	2	BMP-2	25.0	SMEF	1	.73	1.834	TOW
00:00:19:14	3	1	LAV TO	.0	28	2	BMP-2	25.0	SMEH	1	.75	3.473	TOW
00:00:19:51	9	1	LAV TO	.0	25	2	BMP-2	25.0	SMEF	1	.74	2.738	TOW
00:00:20:24	1	1	LAV TO	.0	27	2	BMP-2	25.0	SMEF	1	.73	1.277	TOW
00:00:21:03	1	1	LAV TO	.0	29	2	BMP-2	25.0	SMEF	1	.73	1.253	TOW
00:00:21:21	5	1	LAV TO	.0	13	2	BMP-2	25.0	SMEH	1	.75	2.835	TOW
00:00:24:38	5	1	LAV TO	.0	30	2	BMP-2	25.0	SMEH	1	.75	3.017	TOW
00:00:24:43	7	1	LAV TO	.0	23	2	BMP-2	25.0	SMEH	1	.75	3.471	TOW
00:00:28:41	6	1	LAV TO	.0	23	2	BMP-2	25.0	SMEF	1	.74	3.454	TOW

Total number of firings = 23   Average Range = 2.849

Figure 26. Sample Engagement Range Analysis Report from Run 1, Scenario I for BMP-2s Destroyed and Fired Upon

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