TOMAHAWK STOPS THE ATTACKING REGIMENTS

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Abstract

Tomahawk Stops the Attacking Regiments (TSTAR) is the latest upgrade to the Tomahawk Weapon System (TWS). It expands the existing mission capabilities of the conventional Tomahawk Land Attack Missile (TLAM) submunition dispensing variants to include real-time engagements with mobile armored forces, either en route to the battlefield or stationary in assembly areas. TSTAR will combine real-time targeting / retargeting and smart submunition performance with the long-range, precision attack capability already planned for Block IV Tomahawk. Thus, TSTAR is a "system of systems" weapon that consists of a surveillance system, a mission control agency, a communications link for re-targeting, and the cruise missiles delivery vehicle. This integrated "system of systems" functions to detect and localize enemy forces, execute timely launch of coordinated flights of missiles, and to refine submunition dispense locations and attack patterns during missile fly-out. The tactical information and connectivity provided by various sensors and data links support immediate actions that respond effectively to enemy unit maneuvers. The result is a highly capable weapon system for engaging moving targets behind enemy lines without risking loss of pilots and their aircraft.

Introduction

The current Defense Planning Guidance (DPG) states that the first priority in responding to an invasion or any other attack is to minimize the initial territory lost to the aggressor. Disrupting, damaging, or destroying the ability to employ combined arms forces is the first and most important task. Success in this effort minimizes the loss of territory and facilities critical to a reinforcement effort that the invader can capture or destroy.* The respite gained in the disruption of an armored invasion or attack allows U.S. and friendly forces to mobilize and deploy to the theater, establish an assured defense, and then seize the initiative for the execution of a counter-offensive that achieves the desired military and political objectives.

A new variant of the proven Tomahawk Cruise Missile known as Tomahawk Stops the Attacking

Regiments (TSTAR) has been designed to address this need to counter mobile armored forces early in a regional conflict. TSTAR combines selected elements of the planned Joint Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) infrastructure with the Tomahawk Block IV system expanded to employ smart submunitions. This integrated weapon system is officially designated Tomahawk Block IV Phase II and Initial Operation Capability (IOC) is planned for the end of fiscal year 2005.

When TSTAR is installed on major combatants, Naval forces deployed on forward presence missions will be able to halt or significantly disrupt massed armored invasions on the scale that most Third World nations will be able to mount in the foreseeable future. Tactical air assets will support friendly ground forces directly engaged with the enemy while TSTAR missile attacks will interdict the enemy units whose objectives are to break through friendly forward defenses and capture ports and facilities vital to strategic movement efforts. Once the enemy thrust is halted, ground and air forces will be called upon to defeat the enemy in detail and force a retreat. Employing TSTAR would result in significantly reduced risk to friendly forces while simultaneously maximizing U.S. and Allied warfighting capability.

Figure 1 demonstrates the contribution of TSTAR to the number of armored vehicle kills when operated in support of other tactical capabilities. The analysis shows that an assured level of defense could be achieved against a particular armored invasion in as little as four days when TSTAR is coupled with tactical air support compared to a best case of seven days for tactical air power alone.

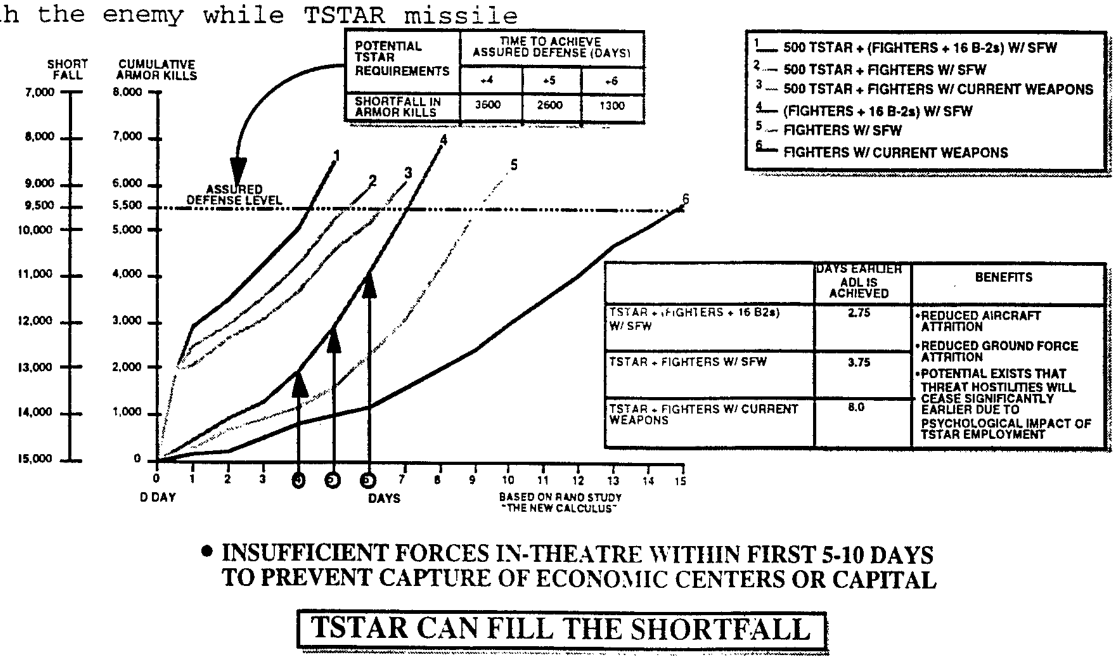

Figure 1 - Warfighting Improvement from TSTAR

This paper describes the TSTAR weapon system, discusses the C4ISR capabilities necessary for mission success, and illustrates its operational capabilities.

The TSTAR Weapon System

TSTAR is a "system of systems" that combines the cruise missile capabilities of the Tomahawk program with the Joint C4ISR capabilities now being fielded to yield a highly effective weapon system that can attack massed armored units either stationary or on the move. The "system of systems" consists of two fundamental elements; cruise missiles equipped with smart submunitions and a supporting C4ISR infrastructure. The C4ISR infrastructure includes a mission control agency, communication links between the control agency and the cruise missiles, and a surveillance system.

TSTAR Cruise Missiles

TSTAR cruise missile is an advanced version of the Block IV Tomahawk missiles. Block IV airframe, avionics, and UHF SATCOM communications systems are supplemented with a jam-resistant Link 16 transceiver and a GPS-aided inertial navigation system. Submunition payloads will provide both direct attack and area denial capabilities. Brilliant Anti-Tank (BAT), Sensor Fused Weapon (SFW), and Sense And Destroy Armor (SADARM) are candidates for the direct attack payload. Wide Area Munition (WAM) is currently the only candidate for area denial payload.

BAT is presently in Engineering and Manufacturing Development (EMD) for the Army Tactical Missile System (ATACMS). TSTAR will launch 16 BAT at medium altitude, each of which will search a unique sector with acoustic sensors. The weapon automatically searches for known acoustic patterns of a variety of targets over a pre-determined land area. When a target has been identified, the weapon glides to the attack area and activates an infra-red (IR) seeker. The IR seeker determines the hottest point on the targeted vehicle, usually the engine compartment, and then guides the BAT to impact. Because of its glide capability, BAT does not have to be dispensed directly above the target area but can be employed in a stealthy attack from the enemy flanks. BAT has demonstrated high accuracy and lethality. Collateral damage is minimized by targeting unique acoustic signatures.

SFW is currently in production for the Air Force and is designed for low altitude release directly over the target area. TSTAR will dispense 16 SFW launch canisters, each of which will contain four skeet. Once ejected from the launch canister, each skeet searches for IR sources such as engines. Once such a source is located, an Explosively Formed Projectile (EFP) is fired which achieves kinetic penetration of homogeneous rolled steel or reactive armor, thus destroying the target. SFW has a large field of regard which is coupled with a highly accurate sensor resulting in a high probability of kill.

SADARM is also designed for low altitude release directly over the target area. TSTAR will carry 32 SADARM, each equipped with a suite of three sensors: an IR sensor, an active millimeter wave sensor, and a passive radiometer. These sensors provide a fused input to the attack logic that provides anti-countermeasure robustness. Once the attack conditions are satisfied, the SADARM fires an EFP to penetrate the top of the target.

Area denial will be accomplished with the dispersal of WAMs alongside or across attack routes projected to be used by enemy armor or mechanized units. This weapon will be distributed over fairly large areas and remain dormant until heavy vehicles are detected through seismic activity. Upon detecting moving vehicles, WAMs determine relative direction and launch a projectile (similar to SFW) toward the movement. The projectile employs an IR sensor to localize vehicles. When an IR signature has been located, a EFP detonates over the vehicle destroying the target.

Supporting C4ISR Infrastructure

TSTAR will fit easily into the combat organization for regional conflict. Fundamentally, TSTAR is an indirect fire support system that responds to the needs of the Joint Task Force Commander. TSTAR is a Naval Service weapon which complements the existing set of tactical assets. As such, TSTAR will be employed in a coordinated battle plan and, consequently, the TSTAR combat organization will be tailored to fit the requirements of that battle plan. The combat organization employs surveillance capabilities that could be either dedicated to TSTAR mission control agencies or assigned to provide support for specified missions at specified times. Once that surveillance information becomes available, the mission is executed through a mission control agency by assigning a target attack location, complete with submunition dispense points and patterns. That assignment will be updated and refined as the missiles proceed to the target area and additional information becomes available. The mission execution is complete upon submunition impact on the designated targets.

Surveillance and targeting information will be provided by JSTARS, U-2R, ASAS, P-3 AIP, GUARDRAIL, and other sensors as availability allows. JSTARS is an integral link because of its Moving Target Indicator (MTI) technology which provides the capability of tracking targets over long periods of time at long stand-off distances from the battle field. JSTARS information has already been linked to both Navy and Army surface units and, based on demonstrations of JSTARS data distribution to Navy platforms, would be incorporated into the TSTAR C4ISR infrastructure with little change or modification. Unmanned Aerial Vehicles (UAVs) along with Special Operation Forces (SOF), Army, and Marine Corp forward observers, can also provide surveillance. Both medium altitude and high altitude UAV platforms will be employed in support of TSTAR. Any of these assets can support the TSTAR mission which results in a highly flexible combat capability. A unique requirement for surveillance assets employed in support of TSTAR is that target location information must be provided to the mission control agency throughout the mission from target designation to submunition dispense. Figure 2 displays the elements of a possible TSTAR C4ISR infrastructure.

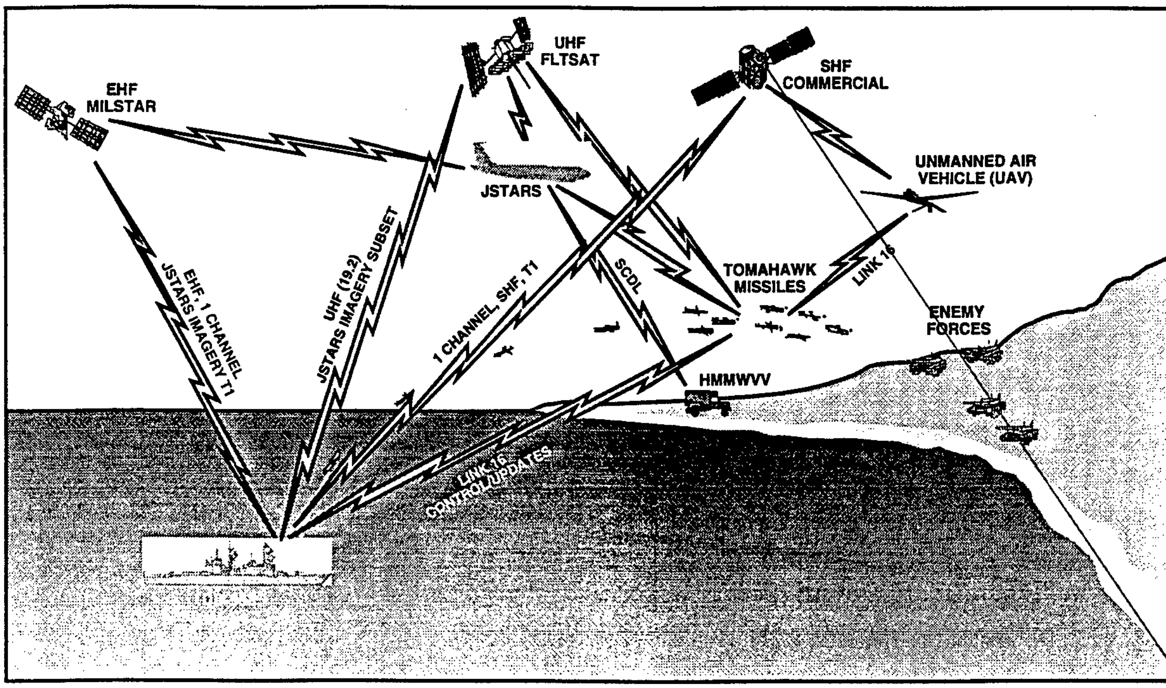

Figure 2 - TSTAR C4ISR Infrastructure

The mission control agency may be any one of a number of combat organizations on any level of command from a unit in the field to the Joint Task Force Commander's Staff. It is likely, though not essential, that the mission control agency will be integral to the cruise missile launch platform which includes destroyers (DD), guided missile destroyers (DDG), guided missile cruisers (CG & CGN), and submarines (SSN). The proposed Arsenal Ship is a potential launch platform that will not likely host a mission control agency. Provisions for remote control of all Arsenal Ship weapons will be developed as that program development proceeds.

Launch control for TSTAR will be integrated into the existing Advanced Tomahawk Weapon Control System (ATWCS) which will be hosted on TAC-4 work stations. Sensor data from the above sources will fused at the TAC-4 terminals and provided to the mission commander for the mission planning process. Little time will be required for mission planning because the missiles will fly to the target via GPS/INS guidance only. The recently deployed Afloat Planning System (APS) will be capable of performing all the necessary mission planning tasks. Emerging C4I technologies such as the Battlefield Awareness Data Distribution (BADD) system, will be incorporated into the TSTAR mission planning and control as they become available. Direct communication to the Tomahawk missiles in flight will be accomplished via the data links established for Tomahawk Block IV Phase I.

Required Performance of C4ISR Infrastructure

The fundamental difference between TSTAR and earlier members of the Tomahawk family is that TSTAR is conceived as a weapon to engage moving targets. This will be a significant step forward but will also require a concomitant step forward in C4ISR operations. Heretofore, moving targets were the province of manned aircraft because there was no capability to coordinate the flight of missiles with enemy maneuvers with sufficient probability of kill. However, the advent of smart submunitions and the current revolution in C4ISR affairs has cleared the way for such engagements without a pilot in the loop. The critical capability that must be demonstrated is that the C4ISR infrastructure can support this mission from detection to impact. In other words, what are the C4ISR requirements for TSTAR mission success and can those requirements be met by the infrastructure currently in development?

To be effective, the TSTAR weapon system must deliver the submunition payload with sufficient accuracy for its lethal footprint to encompass the target. Submunition delivery accuracy is, to a great extent, limited by the ability of the mission control agency to predict the target location at cruise missile time of dispense. Payload dispense point selection is a multistep process. Targeting data is collected from sensors and used to predict likely target route. A mission is then developed that will deliver the payload to a predicted target location at target arrival time. Target location uncertainty, due to unanticipated target maneuvers and noisy targeting data, limits the accuracy of the target route predictions. In addition, it can be shown that target route prediction error grows with time after the last target measurement update is collected. For this reason, it is generally desirable to minimize C^4ISR delays.

TSTAR employs two simple strategies to obtain robust system performance relative to targeting uncertainty. The first strategy employs submunition payloads with large lethal footprints. The second strategy is to exploit the emerging C4ISR infrastructure in order to deliver and exploit measured target location data rapidly. This strategy leads the TSTAR development team to identify communication networks that will meet TSTAR needs and to develop capabilities for mission control agencies that support rapid tactical response and expeditious mission planning. System requirements for those capabilities can be identified through analyses of the trade-offs between the size of submunition lethal footprint and the accuracy of the cruise missile dispense point. Given a specific smart submunition, how close to the target must it be placed in order to achieve kill? Given that acceptable dispense location error, how fast must the C4ISR infrastructure execute its tasking in order to achieve that acceptable error? These questions can be addressed through trade-offs between system latency and system accuracy.

Several scenarios were selected to assess trade-offs between system latency and system accuracy. Here the term, system latency, refers to the time that elapses between the collection of targeting data by the sensor and the time that this information is used to redirect missiles to a new dispense location. The objective of the analysis was to determine the maximum system latency, T_{MAX}, that would allow a significant portion (75%) of the target set to be contained within the lethal footprint of the payload. Four missiles were used to attack three battalions of tanks in column, traveling on a straight road in the x direction at a ground target speed of 60 km/hr. Target maneuver uncertainty was treated parametrically by simulating armored column stops and starts at random intervals. All modeled errors were constrained to a line containing the road because perfect knowledge of the road location was assumed.

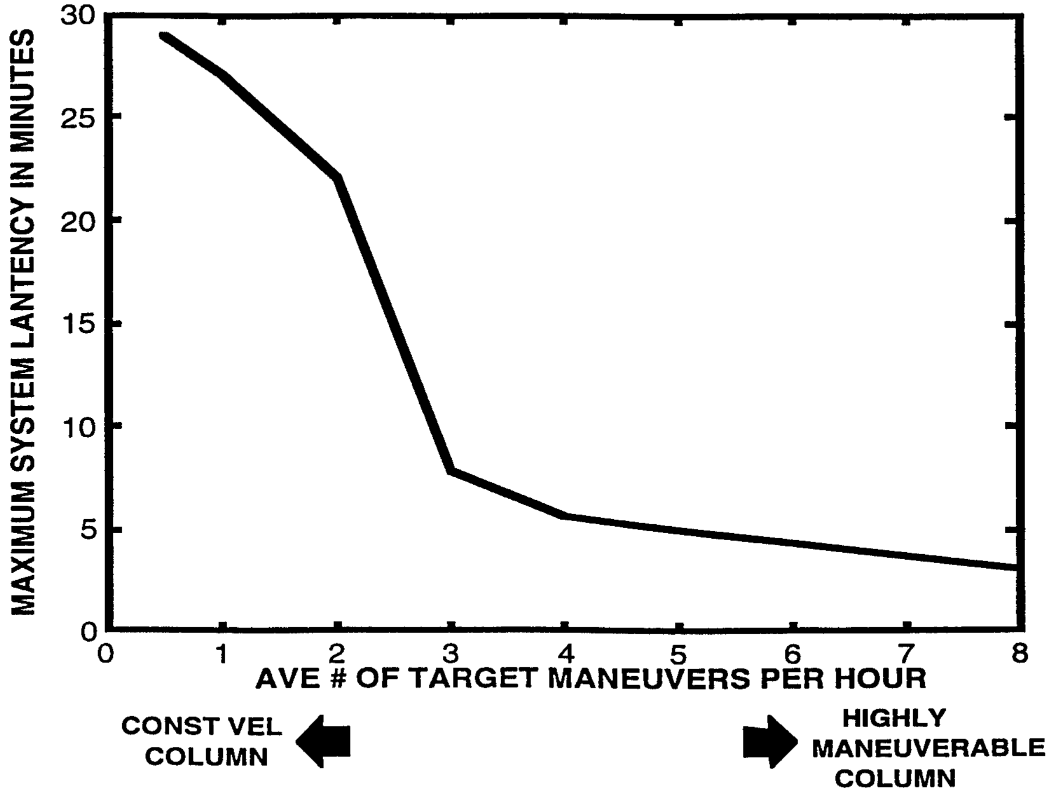

Figure 3 - Allowable C4ISR System Latency for TSTAR Effectiveness

The analysis considers required performance of TSTAR submunitions and calculates the maximum allowable system latency. A summary of this analysis is shown in Figure 3. The horizontal axis in this figure indicates the frequency of target stops and starts. The vertical axis indicates the maximum system latency that meets the defined requirement for a given target maneuver rate. TSTAR can tolerate T_{max} of approximately 25 minutes for constant velocity vehicles and 4 minutes for highly maneuverable targets.

Concept of Operations

TSTAR has been designed to halt or drastically disrupt the combined armor and mechanized force invasion that usually initiates a regional conflict. A typical scenario involving TSTAR commences with surveillance platforms deployed near some belligerent country which is massing armored and mechanized units on its border with a nation friendly to the U.S. Ships and submarines equipped with TSTAR are deployed to the potential region of conflict. Because there is significant risk of damage to non-combatant civilians, refugees, or valuable national assets, e.g., oil fields, the surveillance platforms remain on station around the clock in order to monitor the situation. As the threat of invasion increases, specific mission planning commences. When the armor and/or mechanized units move out toward the border, the engagement plans are finalized and attack times and locations are identified. Once the hostile action has been confirmed and authorization for launch received, TSTAR missiles are loaded with expected GPS coordinates of the targets and then fired. Sufficient missiles would be launched to disrupt or halt the invading force. Because the exact route and destination of the attacking units will likely not be known, JSTARS or UAVs will continue surveillance to provide real time updates on position and target identification throughout the TSTAR flight. Modifications to target location and attack patterns will be transmitted to the missile over Link-16 or UHF radio. These real-time transmissions will guide the missile to the final intercept/attack point.

Figure 4 displays such a scenario. Four groups of vehicular traffic are detected at locations designated 1 to 4 in Figure 4. Vehicles at 1 and 2 are identified as hostile, while those at 3 and 4 are determined to be neutral. There are three high value areas which are estimated to be the goal(s) of the attacking force. These vulnerable areas are accessible via routes which pass through acceptable kill zones A, B, and C. Since the roads branch at two locations (designated 5 and 6 in Figure 4), constant surveillance of the advancing enemy units is maintained. An assessment of the situation leads the Joint Force Commander to believe that the oil field is the most likely target and therefore zone A is the most likely place to engage the enemy. TSTARs are launched to the expected position, kill zone A, for intercept at the enemy's estimated arrival time. Arrival time is estimated by the speed of the advancing enemy forces and past demonstrated tactical behavior.

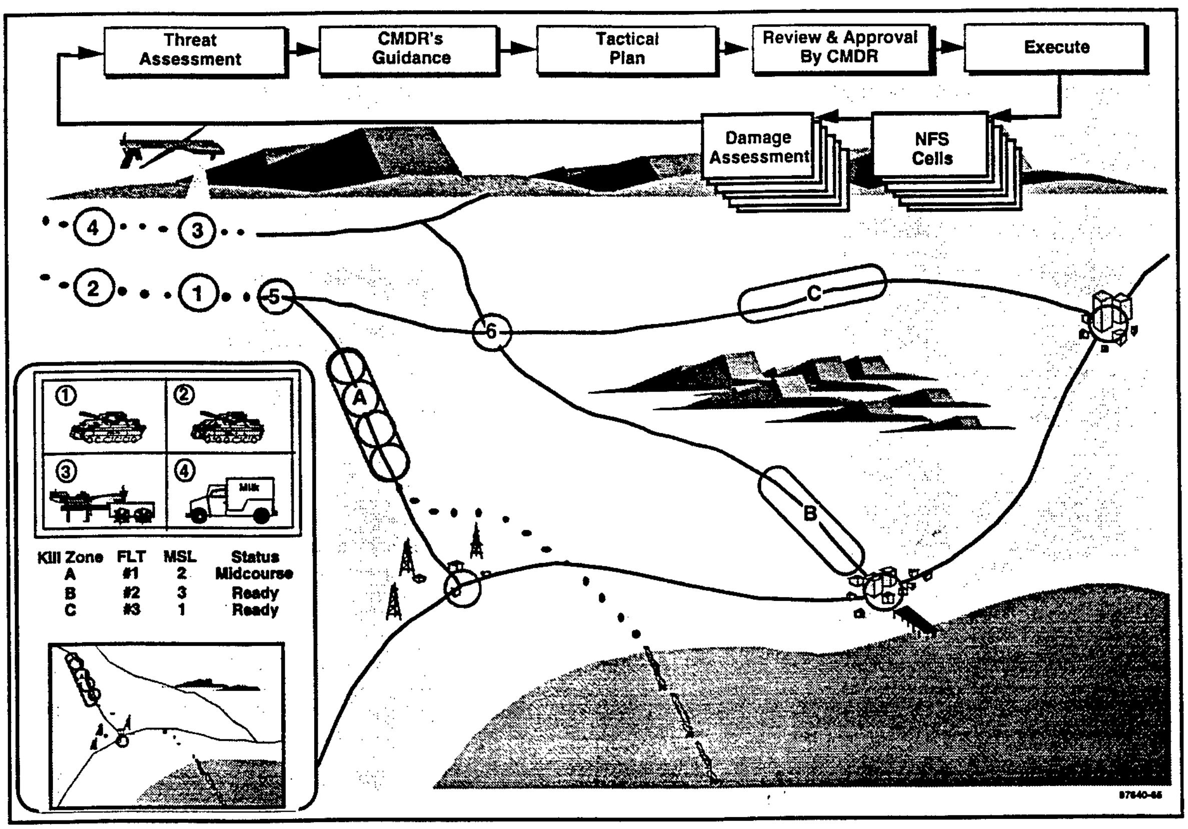

Figure 4 - Scenario for TSTAR

During the flyout of the first flight of missiles, some of the advancing enemy units break off from the expected attack and proceed toward the other two vulnerable target areas. Zone B is estimated to be the most likely intercept point for some of the in-flight TSTARs. Missiles from the first flight, sufficient to engage the threat, are diverted to zone B. Real time targeting updates are provided whenever required. When the advancing armor units reach point 6, another splinter attack group forms to approach the last vulnerable area. On-scene surveillance platforms provide information required to predict where the attacking units will be at a designated time. At this point, missiles from the second flight are diverted to zone C. As target position changes, real-time information is provided to the missiles in flight to successfully engage each threat.

Upon completion of the attack, surveillance of the battle areas determines if the objectives were met. If not, another attack is planned. One of the goals of the TSTAR program is a capability to plan and launch a mission in a matter of minutes. Because real time target updates are provided and the submunitions to be used have a wide attack area, only approximate positions of the enemy forces need to be known at launch time. The ability to directly communicate with a Tomahawk missile during flight has already been programmed for Tomahawk Block IV Phase I (also known as Tomahawk Baseline Improvement Program) and several smart submunitions have been demonstrated which are either in EMD or production. All of the technologies necessary for TSTAR system success are available today.

Summary

TSTAR will introduce a new capability: the use of cruise missiles as an effective long range weapon against mobile forces. TSTAR can be fired from either surface or submarine combatants. The Strike Cells necessary for engagement control can be located either ashore or afloat; access to the appropriate communication resources to support both surveillance and TSTAR retargeting are the only limitations to Strike Cell location.

The technologies required for TSTAR are already in place or under development:

- Connectivity between Naval combatants and joint surveillance sensors

- In-flight cruise missile targeting updates using a rapid mission planning capability

- Smart submunitions with area coverage, designed for the engagement of mobile targets.

Successful implementation of TSTAR will provide an important capability for surge attack against massed armor on the move at times when TACAIR assets are overloaded, depleted, or unavailable, and in the presence of heavy air defense.

TSTAR builds on existing investments in Tomahawk, remote surveillance and targeting (e.g., JSTARS, P-3 (AIP), and UAVs) technologies, and munitions (SFW, BAT, and WAM). TSTAR will use a Tomahawk Block IV missile airframe upgraded with a new data link and submunition payload. Primary aircraft and sensor systems would remain unchanged. This combination of Tomahawk and joint overhead sensors, such as JSTARS, P-3 (AIP), and UAVs, establishes a new joint military capability that uses existing training, logistics, and maintenance infrastructures.

References

* Defense Planning Guidance, Fiscal Years 1997-2001, 9 May 1995, Classified SECRET

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