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NETWORK-CENTRIC ANTI-MISSILE DEFENCE SYSTEM OF COOPERATIVE CAPABILITIES

In the 21st Century, the United States is facing a world of uncertainty. For nearly three decades the Cold War symbolized peace and stability through a policy of mutually-assured destruction. The passing of this era has produced a less predictable enemy and an even less stable strategic environment. The proliferation of weapons of mass destruction and the ballistic missiles used to employ them pose the greatest security challenge to the U.S. and her allies. Ballistic missile technology is pervasive in the global market. Most of the emerging threats are Scud missile variants, which operate in the 80-600 kilometer range. The current ballistic missile threat "is largely regional in nature but the trend is clearly in the direction of increasing range, lethality, accuracy and sophistication. Traditionally, active defense measures that have been implemented to counter the ballistic missile threat have focused predominantly on destroying the launch platform or using ground-based ballistic missile defense assets such as the U.S. Army's Patriot system. However, in an era of declining U.S. overseas bases, limited strategic lift capability, and the Army and Air Force operating in an expeditionary role, naval forces will usually be the first units to respond to a crisis. This paper provides an overview of the U.S. Ballistic Missile Defense program

HÁLÓZAT KÖZPONTÚ RAKÉTAELHÁRÍTÓ RENDSZER KOOPERATÍV KÉPESSÉGEKKEL

Az Amerikai Egyesült Államok és a világ bizonytalansággal tekint a 21 század felé. A hidegháború évtizedei egyfajta békét és stabilitást szimbolizáltak a kölcsönös megsemmisítés politikáján keresztül. E korszak lezárulásával kevésbé kiszámítható ellenséggel, és még kevésbé stabil stratégiai környezettel kell számolni a jövőben. Ilyen nemzetközi környezetben a tömegpusztító fegyverek elterjedése, ezen belül is a ballisztikus rakéták okozzák a legnagyobb kihívást az USA-nak és szövetségeseinek. A ballisztikus rakéta technológia széles körben elterjedt a nemzetközi piacon. A legnagyobb veszélyt a különféle Scud rakéta változatok jelentik, amelyek a 80 és a 600 km közötti hatótávolsággal rendelkeznek. A jelenlegi fenyegetés jellegében nagyobbrészt regionális, azonban a tendencia egyértelműen a növekvő hatótávolság és pusztítóerő, valamint az egyre pontosabb és kifinomultabb fegyverek irányába mutat. A hagyományos aktív ballisztikus rakétavédelmi rendszerek túlnyomórészt az ilyen rakéták kilövőálláson történő megsemmisítését preferálják, illetve olyan földi indítású ballisztikus rakétaelhárító rendszereket alkalmaznak, mint az amerikai Patriot rendszer. A csökkenő amerikai tengerentúli jelenlét és a korlátozott stratégiai szállítási kapacitás miatt, a and the Navy's theater ballistic missile defense, along with the Navy's two solutions to the ballistic missile threat, Navy Area Defense and Navy Theater-Wide Defense program. Specifically, it addresses the Network-centric warfare (NCW), which is the Navy's central concept for organizing its efforts to transform itself for military operations in the 21st Century.

haditengerészeti erők jelentősége megnőtt a válságokra történő első reagálással kapcsolatban. Ez a cikk bemutatja és áttekinti az amerikai ballisztikus rakétavédelmi programot, és ezen belül főleg az amerikai haditengerészet ilyen irányú tevékenységét és megoldásait. Kitüntetett figyelmet szentel a cikk, a haditengerészet hálózat központú hadviselésének, (NCW - Network Centric Warfare) amely a központi elemét fogja képezi a Navy katonai műveleteinek a 21. században.

1. INTRODUCTION

In 1961, President John F. Kennedy issued a breathtaking challenge to the U.S.'s scientists, engineers, and taxpayers: to land a man on the moon in under a decade. In 1983, President Reagan just as stunningly announced the Strategic Defense Initiative (SDI), which was to provide a "space shield" over the United States against intercontinental ballistic missiles by the end of the century. In the next few years, in the face of enormous political and technological debate, SDI almost, but not quite, withered away. Even its proponents acknowledged that much of it was not so much technologically audacious as outright impossible.

SDI went underground for a while and retooled its weapons proposals, with its R&D funding cut off or maintained at drastically lower levels. But then came the 1991 Gulf War, whose televised missile battles were like rain on SDI's parched landscape. Ballistic Missile Defense (BMD) program is, since 1993 the new incarnation of SDI. Today's political climate is vastly different from that in the Cold War, the current political arguments are far more deeply interwoven with claims about state-of-the-art and even as yet unknown engineering issues, whereas space technology was proven in slow steps. And, above all, mass death was not an issue. Responsibility for BMD is shared among the U.S. military services and some allies, mainly the United Kingdom and Israel. The Clinton Administration expects to spend $23 billion to develop and deploy battlefield (theater) missile defenses through the year 2003.

The U.S. National defenses include missiles that will take down incoming ones by hitting them, using only their combined kinetic energy for destruction-what the military calls a hit-to-kill or kinetic-energy method. (The warhead of traditional surface-to-air missile explodes near its target, giving it a greater margin of error.) Strategic defense would also be carried out in space, by orbiting lasers-and by kinetic energy destruction of enemy satellites.

Hit-to-kill systems also hold sway in theater-level warfare, the type seen in the Patriot-vs.-Scud encounters of the Gulf War. In addition to defenses against midcourse or reentering tactical missiles and warheads, the Pentagon is funding airborne lasers and kinetic-energy weapons to destroy missiles on launch.

Finally, policy makers cannot discuss missile defenses without nothing that the bipolar, relatively stable world of the Cold War has given way to less certain one where regional powers, sub national groups, and terrorist organizations are no longer constrained by the superpowers. And the technology and know-how to build weapons of mass destruction are more available than ever before.

2. THE BALLISTIC MISSILE DEFENCE (BMD)

The trends in international policy, mostly in the field of the spread of weapons of mass destruction and long-range missile capabilities, represent a threat for the U.S. and Allies. U.S. military leaders worry that in future regional (or so called theater) conflicts their forces may be vulnerable to attack or denied access to bases in allied countries within range of enemy ballistic missiles, and have proposed an impressive plan of layered defenses.

The United States BMD programmed is divided into TMD (Theater Missile Defense) and NMD (National Missile Defense). In addition, the Clinton administration has restarted U.S. efforts to develop a National Missile Defense program, prompted by concerns that so-called rouge states might some day develop missiles with long enough to reach U.S. soil. (The term "rogue states", in current U.S. usage, applies to countries whose behavior does not conform to international norms and may not be deterred by the threat of conventional or nuclear retaliation.)

2.1 Basic ballistics

Most defenses are designed to destroy the warhead on a missile before it can reach its target. Theater missile defenses intercept the warhead during the terminal phase of its flight-after it has reentered the atmosphere. Other defenses under development will attempt to intercept the warhead outside the atmosphere during the midcourse phase. Still others will try to destroy the missile during its boost phase after launch while the rocket motor is still burning.

Once a ballistic missile is launched, the following defensive events occur.

First the infrared sensors on the early-warning satellites in geosynchronous orbits detect the hot exhaust plume of the missile as it rises above the clouds. The satellites alert military commanders that a launch has taken place and indicate the general area toward which the missile is headed. That information can be used to point (cue) the defense's sensors to the right spot for tracking.

Those sensors then track the target and all of its associated clutter and decoys (if any) distinguish which object is the actual warhead (a process called discrimination), and then tell the interceptor where to head so that it will be in a position to intercept the warhead. Midcourse sensors have traditionally been ground-based radar, but to come, radars will be complemented by satellites in low earth-orbits that carry a suite of infrared sensors.

Based on this information, the interceptor flies toward the estimated intercept point, receiving updated estimates along the way. At some point the interceptor's kill vehicle separates from the missile and continues on its trajectory. The kill vehicle will slam into the attacking warhead, it does have small thrusters of its own, but these are used only in the final moments before intercept. When close enough to the target, the interceptor uses its own sensors and guidance algorithms to distinguish it from decoys and clutter, and homes in for the kill.

This intricate dance must be choreographed by a battle management system in exquisite detail and within very tight time constraints. For example, the total flight time of a 300-km-range Scud on a maximum-range trajectory is 4 minutes. Longer-range theater missiles are in flight for 15 minutes or less.

This procedure applies to both theater (tactical) and national (strategic) missile defenses. The only differences between them are the flight times available, the speed of the incoming warheads, and the area must be protected, all of which are greater for national missile defenses. Of course, this picture of how a missile defense would work is idealized.

To improve the odds of destroying warheads, a salvo of two or more interceptors can be shot at each target.

A more efficient tactic is to launch interceptors only at targets surviving the firs intercept attempt-an approach that is called shoot-look-shoot.

The same effect can be achieved by using layered defenses. Interceptors in each of layers can attack a missile during a different part of its trajectory, taking advantage of different vulnerabilities. For example, if missiles are intercepted during the boost phase, the large rocket plume is easy to find. And if the missile is attacked before it has a chance to deploy its warheads, as well as decoys and other countermeasures, the task of the terminal defenses that from the lower layer is greatly simplified.

2.2 U.S. plans for TBMD

The United States plans to use a layered approach to protect its allies against short-range (tactical) ballistic missiles, which have ranges less than 3500 km. See figure 1. The multi-tier (layered) architectures provided the most effective and robust defense due to the large battlespace, coverage and engagement capability. The United States is planning to develop six theater missile defenses:

- the PAC-3 version of the Army's Patriot,
- the Thaad (Theater High Altitude Area Defense),
- the Medium-altitude Extended Area Defense System (Meads),
- the Navy Area defense (also know as Navy Lower Tier),

- the Navy Theater Wide defense (also know as Navy Upper Tier), and
- the Airborne Laser

The land-based defenses will protect troops, ports, and airfields once they have arrived in theater. Sea-based defenses will protect ports and littoral regions until the land-based defenses arrive.

Area defenses such as the land based Theater High Altitude Area Defense (THAAD) and the sea-based upper tier defenses will cover broad areas. Patriot PAC-2 and PAC-3 and the sea-based lower-tier defenses will be a backup for targets missed by the upper tier and protect high-value targets such as airfields, ports, headquarters, and population centers.

The Airborne Laser will aim to destroy missiles during the boost phase, when their rocket motors are burning and before they can deploy warheads, decoys, or submunitions. A theater battle management system will coordinate the sytem's many components.

Four of the six theater systems are terminal defenses: the patriot PAC-3, the Thaad, the Meads and the Navy Lower tier defense. The Thaad system is actually a hybrid system that can operate against the incoming warhead's midcourse and terminal phases. Booth the Navy's Upper Tier defense and the Thaad would intercept missiles in midcourse, the Thaad should also be able to intercept missiles inside the atmosphere. And currently the Pentagon is developing in earnest one boost-phase defense against theater missiles: the Air Force's Airborne Laser. This chemical laser, carried in a Boeing 747 airplane, will be able to intercept missiles from a few hundred kilometers away. But several technical obstacles must be overcome before this revolutionary system can be deployed.

Figure 1.
U.S. Plans for TBMD

3. THE NAVY TBMD PROGRAM

Navy Theater Ballistic Missile Defense (TBMD) combines both Area Defense (Lower Tier) and Theater-Wide (Upper Tier) defense capabilities to protect naval forces during the critical early phases of an armed conflict. The sea-based TBMD contribution to defense of a theater was greatest when the baseline of land-based systems was not fully deployed. In many cases, the U.S. Navy may be the primary line of defense against the actions of an aggressor, such as a ballistic missile attack. TBMD is the most viable near-term response to such a threat. See Figure 2. TBMD builds upon the Navy's existing infrastructure, including the current and future fleet of AEGIS cruisers and destroyers, the AEGIS Command & Control and Weapon System (utilizing the SPY-1 Radar), the MK-41 Vertical

Launch System and the Standard Missile.

Figure 2.
The U.S. Navy's TBMD plan

3.1 The Navy Area Defense (Navy Lower Tier)

The first AEGIS TBMD mission capability will be the Navy Area system, often referred to as the Navy Lower Tier system. The Navy Area Program involves modifications to the integrated equipment and computer programs, which comprise the AEGIS Weapon System (AWS) to enable detection and engagement of theater ballistic missiles in the endoatmosphere and control of the interceptor designed to kill the threat missile.

3.2 The Navy Theater Wide (Navy Upper Tier) Program

The Navy Theater Wide TBMD Program consists of an improved Standard Missile, (the SM-3), modifications to the Vertical Launch System (VLS), and modifications to the AEGIS Weapons System installed on TICONDEROGA class cruisers. The program leverages off knowledge gained during the Terrier LEAP (Lightweight Exo-Atmospheric Projectile).

The Navy Theater Wide TBMD System will allow forward deployed cruisers to protect large geographic areas within a theater from the threat of tactical ballistic missiles. The missile is designed to intercept TBMs in exo-atmospheric flight, and will be guided to hit TBMs using an IR seeker and Divert & Attitude Control System (DACS).

3.3 The Navy TBMD interceptors program

Standard Missile is a key element of TBMD and is evolving to meet the ever-changing threats of aggressors, including advanced aircraft, cruise missiles and tactical ballistic missiles (TBMs). Two new versions of Standard Missile are under development as part of the evolution -- one for each of TBMD's two tiers.

Standard Missile-2, Block IVA will provide area defense against aircraft, cruise missiles and TBMs in the lower atmosphere. Standard Missile-2, Block IVA is a follow-on to the Block IV missile now entering low-rate production. The Block IV booster stack and airframe provide improved velocity and maneuverability required for TBM intercepts. In addition, the Block IV employs an improved warhead to ward off advanced aircraft and cruise missile attacks.

The Standard Missile Lightweight Exoatmospheric Projectile (SM-LEAP) interceptor will provide upper tier, theater-wide defense against medium- and long-range ballistic missiles. The Navy's LEAP flight test program has demonstrated all the critical elements for a successful TBMD, including the high altitude flyout of a Standard Missile; exoatmospheric nose cone and LEAP Kinetic Kill Vehicle (KKV) ejection; third stage propulsion, guidance and control; LEAP seeker acquisition and tracking of a threat target; and LEAP guidance, control and kinetic capability.

4. THE NAVY NETWORK-CENTRIC WAREFARE CONCEPT

The concept of Network-Centric Warfare (NCW) emerged in 1997 and has become the Navy's central concept for organizing its efforts to change and transform itself for 21st Century military operations. NCW focuses on using advanced information technology (IT) - computers, high-speed data links, and networking software - to link together Navy ships, aircraft, and shore installations into highly integrated computer/telecommunications networks. Within these networks, ships, aircraft, and shore installations will share large amounts of critical information on a rapid and continuous basis. It could significantly improve U.S. naval capabilities and lead to substantial changes in naval tactics, doctrine, and organization. The Navy believes that NCW will dramatically improve Navy combat capability and efficiency by helping the fleet to achieve "speed of command" (an ability to generate and execute commands at much higher speeds), which will permit U.S. naval forces to outpace adversary decisionmaking and thereby "lock-out" (i.e., foreclose) potential adversary strategies:

Reliance on NCW is at the heart of the current C4I [command, control, communications, computers, and intelligence] efforts in the Department of the Navy. Network Centric Warfare increases the speed, precision, and effectiveness of Naval forces. NCW enables the Navy to attain information superiority, mass effects instead of forces, and disrupt the enemy's ability to carry out its strategy.

The Navy's effort to implement NCW involves several IT procurement efforts. Key among these are the Cooperative Engagement Capability (CEC) program, the IT-21 investment strategy for procuring the desktop computers, data links, and networking software needed to establish an intranet for transmitting tactical and administrative data within and between Navy ships. And finally the Navy-Marine Corps Intranet (NMCI) which a corporate-style intranet that will link together Navy and Marine Corps shore installations in much the same way that the IT-21 effort will link together Navy ships, when completed in 2003.

This paper overview below only the CEC, because this is the most important element with reference to the Navy TBMD programs.

5. THE COOPERATIVE ENGAGEMENT CAPABILITY (CEC)

The Cooperative Engagement Capability system links U.S. Navy ships and aircraft operating in a particular area into a single, integrated air-defense network in which radar data collected by each platform is transmitted on a real-time (via a line-of-sight, C-band data distribution system) basis to the other units in the network. Each unit in the CEC network fuses its own radar data with data received from the other units. As a result, units in the network share a common, composite, real-time air-defense picture (each unit having essentially the same display of track information on aircraft and missiles). The result is a revolutionary new way of engaging airborne threats - employing multisensor measurement fusion as opposed to single sensor tracks to allow battleforce-centric, rather than platform-centric, engagement. CEC will permit a ship to shoot air-defense missiles at incoming anti-ship missiles that the ship itself cannot see, using radar targeting data gathered by other ships and aircraft. It will also permit airdefense missiles fired by one ship to be guided by other ships or aircraft. Moreover, all of the weapons in the battlegroup, regardless of platform, are available to any authorized commander - in theory, anyway. The Navy has stated that CEC is a "central element" of NCW that provides a revolutionary improvement in battle group air and missile defense capability. CEC also has promising potential for Joint Service application with systems such as the Army Patriot surface-to air missile system and the Air Force Airborne Warning and Control System (AWACS).

The Navy wants to install the system on its aircraft carriers, Aegis-equipped cruisers and destroyers, selected amphibious ships, and Advanced E-2C Hawkeye carrier-based airborne early warning aircraft over the next several years.

The Advanced E-2C Concept takes the current Hawkeye 2000 baseline, and equipped with Northrop Grumman's prototype Surveillance Infrared Search and Track (SIRST) sensor and a new electronically scanned UHF radar. During the flight, the aircraft detected and tracked a theater ballistic missile (TBM). The SIRST is an angle-tracker with no inherent ranging capability. However, it can perform real-time calculations of the launch and splash point of a missile using these measurements in conjunction with simultaneous radar detection. The eventual production version of IRST, in conjunction with data linking, is expected highly accurate three-dimensional location and tracking information for the carrier group and the fleet.

The CEC system, with the new fixes, passed its technical evaluation testing in and moved to final operational evaluation testing in April and May 2001. The Navy expects the fleet to be fully equipped with the sea-based systems by 2008. The airborne-based version of the system was approved for limited production during 2002-2003 in order to conduct early testing and training. Initial testing of some of the next-generation CEC capabilities, such as satellite-based communications, is underway.

5.1 CEC elements

CEC consists of the Data Distribution System (DDS), the Cooperative

Engagement Processor (CEP), and Combat System modifications. The DDS encodes and distributes own ship sensor and engagement data, is a high capacity, jam resistant, directive system providing a precision gridlocking and high throughput of data. The CEP is a high capacity distributed processor, which is able to process force levels of data in near real-time. This data is passed to the ship's combat system as high quality data for which the ship can cue its onboard sensors or use the data to engage targets without actually tracking them.

5.2 Advanced CEC Functions in TBMD

CEC extends the range of countering TBMs threats to the maximum possible distance, providing more time to engage difficult threat missiles.

CEC contributes to theater ballistic missile defense by providing a continuous fire-control quality track on the missile from acquisition through splash. Although each ship is only able to maintain track for part of the missile flight, the CEC composite track, based on all the data, is continuous. Cues based on the composite track allow the downrange ships to detect the target earlier and to maintain track longer. The CEC cues and relay of composite track data will also allow defending ships maximum battle space in which to engage theater ballistic missiles when the SM-2 Block IVA missile becomes available.

Early testing and analysis of CEC against TBMs indicate the potential for a significant contribution in terms of allowing the collection of sensors to maintain a single composite track of sufficient quality for missile intercept, with real-time status of engagements and real-time recommendations of the unit(s) with the highest probability of successful engagement. With future precision sensors capable of supporting precision composite tracking of a TBM, it may be possible to resolve the reentry vehicle from a complex of reentry decoys and debris and even to determine the wobble motion of the target via a new cooperative resolution approach. In this concept, resolution and tracking of the object field could guide a kinetic-kill interceptor to the correct target. This is a CEC target-resolving techniques. The concept is illustrated in Figure 3.

Figure 3.
Tactical ballistic missile cooperative resolution

CEC offers the potential to process data from multiple sensors with very high resolution in one dimension to create a precision map in three dimensions to support kinetic-kill interceptor guidance to the reentry vehicle amidst decoys and debris. The precision and rapid update rate of the mapped objects could also allow the interceptor to account for target wobble or tumble.

6. CONCLUSION

Network Centric Warfare is the concept that linking various systems and sensors together will yield greater military benefit than could be derived from individual ships, aircraft or submarines. Network Centric Warfare provides products and services in the tactical Command and Control Systems segment including on-board command and decision systems, display systems, weapon control systems, and Cooperative Engagement Capability (CEC).

The new Theater Network Integration will integrate two major U.S. Navy combat systems (Cooperative Engagement Capability and Aegis)

CEC is the latest development in a long history of sensor integration efforts. CEC connects sensors and weapon systems in a network to allow many air defense systems of various types to operate as a single entity, but with performance advantages that accrue from their diversities in location and sensor characteristics. These performance advantages include major enhancements to track accuracy, continuity, and consistency in identification. CEC provides a coherent picture to all units in a CEC network, increases battle space, reduces reaction time, and extends engagement ranges through cooperative engagements such as handover of missile control.

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