



Theater Air Defense Cornerstones

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The Navy, taking a page from previous work on the Aegis Weapon System, undertook an effort in late 1997 to formulate a set of guiding principles for future Theater Air Defense (TAD) Systems development. These principles, known as Cornerstones, were devised to solidify and emphasize the most important system attributes and shape their engineering development. They are enduring and simple expressions of key technical factors that are measurable and stable. This kind of “system-of-systems” development has three critical components: a commitment from Congress and the public to invest in the effort, articulation of the operational needs of the military, and an understanding of the engineering system and design elements needed to create such capabilities. A team of specialists from the acquisition, military, defense research, and academic communities was chartered to develop these Cornerstones, resulting in a three-tiered set: Political-Strategic, Operational-Tactical, and System-Design. The Cornerstones can guide engineering efforts for creating TAD capabilities over a wide spectrum of threat scenarios into the future. (Keywords: Cornerstones, Systems development, Theater Air Defense.)

INTRODUCTION

With regard to military operations, the world can be divided into potential theaters of warfare operations regions that are defined by the political boundaries of potential adversaries and the range to which they can inflict damage within those regions. Today we speak of theater warfare areas associated with Northeast and Southwest Asia and of smaller-scale contingencies in regions such as the Balkans. The need to conduct Theater Air Defense (TAD) for an ally, ourselves, or both within such regions is obvious from recent history. Air threats equipped with warheads of varying levels of destructive capability are becoming weapons of choice,

and TAD must react to the several levels of hostilities being posed. TAD, if capable enough, can act as a deterrent to war by an aggressor state that may view aggressive actions as too risky in the face of a solid defense against air threats.

Emerging threats (e.g., medium- and long-range ballistic and cruise missiles) from both large and small nations can be armed with any of several types of warheads, including those capable of mass destruction. Ballistic missiles use extraordinary speed to challenge TAD capabilities; cruise missiles can use stealth and terrain masking. Together, these missiles—with even

the simplest coordinated attack plan—pose a significant threat to TAD systems.

The United States is developing air defense capabilities in several service branches and intends to unite these forces in a coherent, joint manner, with mobility and flexibility to cover our worldwide interests. Figure 1 illustrates the complexity of the problem, not only in terms of the threat but also the set of sensors, service platforms, communications systems, and tactical data links involved.

The Navy is undergoing a major revolution in ship-board air defense systems and missile development to counter these emerging threats. In response, a 6-month effort beginning in the fall of 1997 was chartered to develop a set of Cornerstones that would define—not only for the Navy, but for the nation as well—a set of guidelines or top-level requirements for TAD. APL led

a government, military, and industry working group effort that produced these Cornerstones.

BACKGROUND

When originally introduced, the Aegis Weapon System marked a leap forward in air defense capability that was the result of fundamental systems engineering guided by a special study commissioned by Secretary of the Navy Paul Nitze in 1964. The effort, known as The Advanced Surface Missile Assessment Group, was led by RADM Frederick S. Withington. In mid-1965 the group issued its findings, which served as a foundation for the development of Aegis and was the genesis for what became known as the “Aegis Cornerstones.” These performance-oriented Cornerstones were simply stated, measurable characteristics that

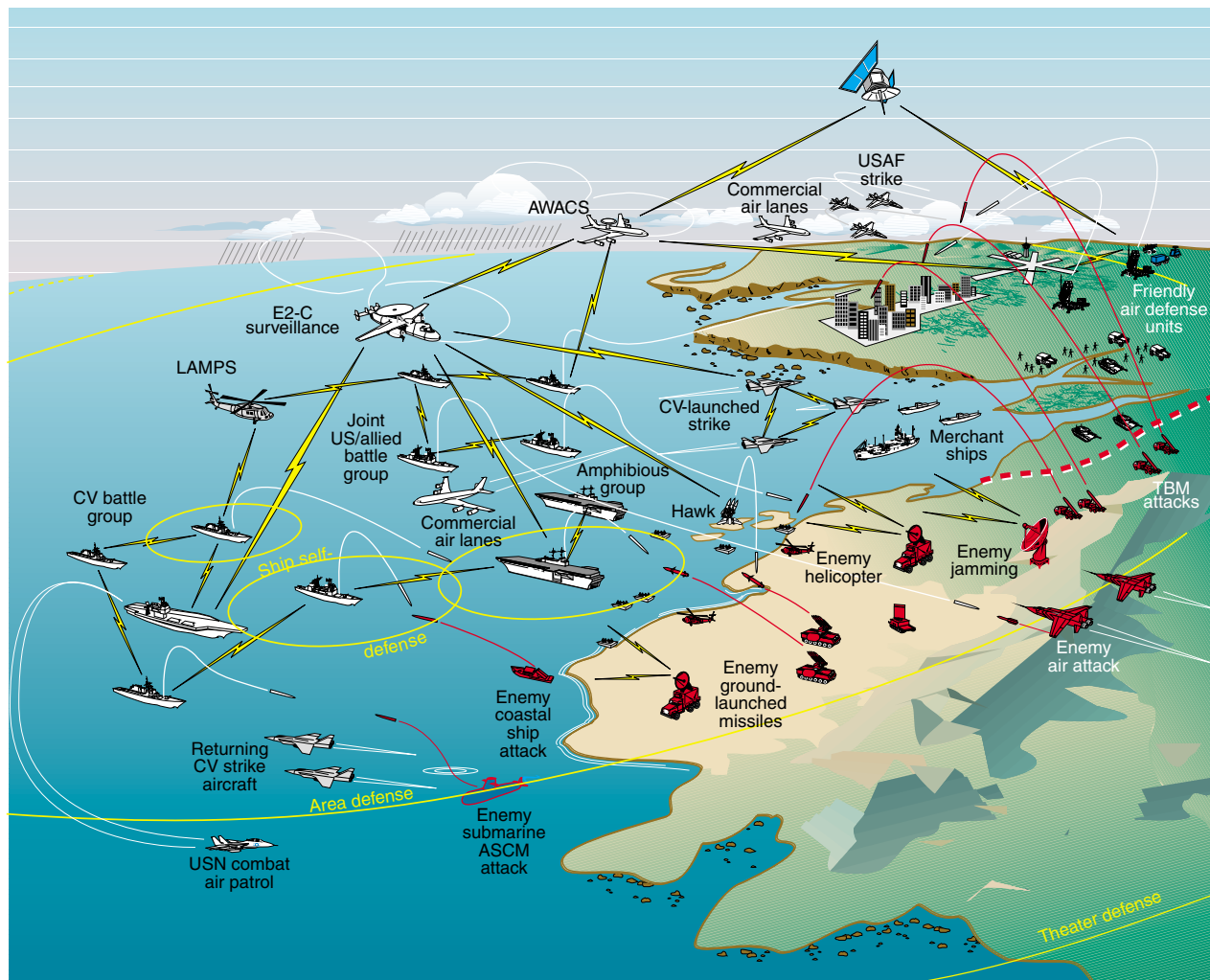


Figure 1. The complexity of the Theater Air Defense environment is illustrated here. Sensor processing systems, communications and command systems, and weapon control systems (not shown) add to the extraordinary complexity. (ASCM = Anti-Ship Cruise Missile, AWACS = Airborne Warning and Control System, CV = Navy aircraft carrier, LAMPS = Light Airborne Multi-Purpose System, TBM = Theater Ballistic Missile.)

included fast reaction, high fire-power, electronic countermeasures and clutter resistance, high availability, and high area coverage.

TAD Cornerstones were to be an extension of those used in Aegis, but with application to the larger regional context of air defense. Driven by a growing set of more robust threats, these cornerstones drew upon the concept of using composite, Jointly operating, fully integrated forces to carry out a revolutionary level of air defense. The level of resources needed to satisfy the TAD vision articulated by the TAD Cornerstones would require acceptance from three important stakeholders: military users, Congress, and the people of the United States. These factors led to the realization that three consistent, interwoven levels of cornerstones were needed to address the entire system development process: Political-Strategic, Operational-Tactical, and System-Design. A primary function of the TAD Cornerstones would be to communicate clearly and succinctly fundamental TAD requirements to the acquisition, warfighter, and engineering development communities.

A team approach was used to develop the TAD Cornerstones, which brought together specialists who had developed, tested, acquired, and used past air defense weapons systems like Aegis. This working team, plus its advisory group and senior review panel, comprised people drawn from the military, industry, service defense research, and academia. APL led the working and review sessions.

CORNERSTONE DEVELOPMENT

RADM Rodney Rempt, while leading the Program Executive Office (PEO) for TAD, initiated the development of the Cornerstones on the basis of a PEO(TAD) charter letter (excerpt shown above). The working group of 21 senior professionals used the first several sessions to scope the approach and develop a language that was brief and to the point and that would gain acceptance at all three levels of stakeholders. The points of view from the military members of the group bounded the operational and tactical aspects of the effort. Those with experience in engineering development addressed the physical realities. National and DoD guidance documentation (e.g., various documents covering national security and military strategies, *Joint Vision 2010*, and *Forward...From the Sea*) provided official Congressional and public perspectives. Additionally, the emerging Joint Doctrine Publications for TAD guided the terminology used by the group. The

TAD Cornerstones
Working Group

Charter Letter

PEO(TAD) Memorandum of 22 April 1997:

One of the keys to the successful engineering and deployment of the Aegis Fleet was the early identification of, and adherence to, key performance characteristics for the Aegis combat system, the Aegis Cornerstones. This upfront thinking paid off dramatically by keeping a wide array of engineering teams focused on overriding system requirements. **Today, we are undergoing the next revolution in air defense.** Area and Theater Ballistic Missile Defense, Overland Cruise Missile Defense, and Offensive and Defensive Counterair missions have occasioned rapid growth of system and operational concepts and capabilities. **The time is right for a reassessment of the key characteristics that drive our air defense concepts and designs in the future.**

flowdown shown in Fig. 2 resulted from these efforts and will be used as a guide for the discussion of TAD Cornerstones throughout the remainder of this article.

As seen in Fig. 2, the TAD Cornerstones have a top-down structure with a three-level hierarchy. Connectivity and requirements taxonomy among the levels are shown to illustrate how expectations at the top level are supported by engineering precepts at the foundation, with appropriate flow through Operational-Tactical concepts in the mid-level set.

Political-Strategic Cornerstones

Viewed from the top, or Political-Strategic level, this set of cornerstones addresses national missions based on formal documents covering national security and military strategies. For example, *Joint Vision 2010* lists dominant maneuver, precision engagement, full dimensional protection, focused logistics, and information dominance as the five hallmarks of military commitment. TAD, primarily associated with full dimensional protection, is also intertwined with the other four elements. In addition, based on the need for both flexibility of movement and “staying power” for a forward theater-level force, the Political-Strategic level embodies concepts derived from *Forward...From the Sea*, i.e., naval expeditionary forces that are tailored to national needs and shaped for Joint operations. Taken together, these concepts, phrased in the language chosen for cornerstone-level communication, formed the basis for the Political-Strategic level.

“National mission,” the top-most cornerstone of the Political-Strategic tier, embraces three goals: enhancing our security with military forces that are ready to fight and win, bolstering America’s economic prosperity, and promoting democracy abroad, all aimed toward achieving regional and global stability. Next comes “forward presence,” which connotes the ability to deploy forces throughout the globe, anytime, anywhere. This requires forces with strategic agility that are

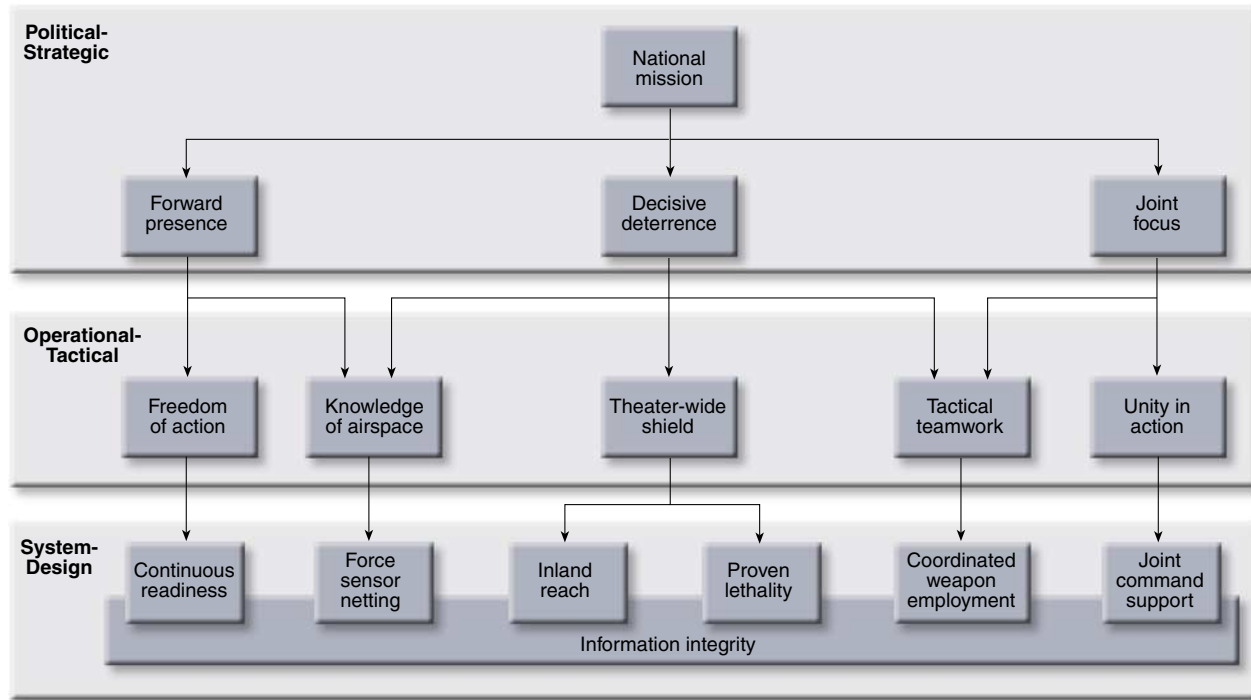


Figure 2. Flowdown of TAD Cornerstones.

capable of sustained response without dependence on land access or host nation support. This capability is intended to be maintained through continuous warfighting improvements, i.e., leveraging past investments by providing required upgrades to current capabilities with the timely introduction of proven, cost-effective technology.

“Decisive deterrence,” together with forward presence, is the capability to deter potential adversaries at a credible level of demonstrated power. It furthermore intends to provide overwhelming air and missile defenses that enable safe conduct of theater-wide military operations, should an adversary not be deterred.

As the U.S. military moves toward more integrated operations, the technology explosion in communications and computer processing enables the sharing of important sensor data that can support operations and forces in combined action against emerging threats. The “Joint focus” cornerstone of the Political-Strategic level means that integrated operations can be brought to bear at any theater level and may include not only all U.S. military services but allied components as well.

Operational-Tactical Cornerstones

The Operational-Tactical level is where warfighter requirements are communicated. The cornerstones of this level are clearly interactive with the System-Design level, but also stand on their own with regard to how the warfighter needs to carry out the conflict,

win decisively, and minimize losses. This level shapes how we fight and which architectural requirements we need to support operational concepts. In this sense it is intended to influence Joint Theater Air and Missile Defense requirements and system design.

The first cornerstone in this set is “freedom of action.” It allows forces to enter a theater and the rapid maneuver of Joint ground, sea, and air forces ultimately within the theater. The flowdown from the forward presence cornerstone discussed earlier includes characteristics that dictate that warfighters have the ability to be continuously ready, mobile, and sustainable, and in turn influence the systems they use to provide this capability. Freedom of action is critical to the diverse set of political and military options over the wide range of future theater operations considered.

Embodied in “knowledge of the airspace” is the implication that a clear, continuous, unambiguous sensor and data link-derived representation of all air tracks within the theater is provided to those having Joint command and control responsibility. This level of clarity is envisioned as a single, authoritative representation. Its import relates to the need for continuous, positive identification of all friendly forces, enemy targets, and neutral platforms. The special capability that the Navy is expected to provide is a robust command and control system that includes an integrated sea-based sensor set capable of flexible and dynamic re-allocation. The ultimate goal here is the knowledgeable application of force.

Together with freedom of action and a high degree of airspace knowledge, the “theater-wide shield” cornerstone is added. This shield is effective through the provision of a high cumulative probability of kill (probability of negation) via integration and coordination of multiple layers of defense. Even when early phases of an operation require operations from outside enemy or adjacent land boundaries, this shield can be achieved with inland reach, defense in depth, mutual control and support, and adequate numbers of highly lethal weapons.

The complexity of a TAD that can include active destruction of threats before they are launched, multiple target engagement, avoidance of redundant engagement, and a coherent priority-defended assets list dictates the need for “tactical teamwork.” Previously mentioned attributes of the naval sea-based capability again contribute, allowing either autonomous action or action under Force-level coordination.

The addition of the “unity in action” cornerstone ensures that the deconfliction and coordination of Theater Air and Missile Defense with other Joint missions will be carried out within the theater as intended. Unity in action addresses the prevention of Blue-on-Blue engagement and ensures the effective and efficient use of Joint resources. Naval strengths include the ability to control or support the development of a single integrated air picture, with robust and accurate combat identification that contributes directly to the capabilities and interoperability of the Joint Task Force Commander, Joint Air Component Commander, and Area Air Defense Commander.

The intent of the Political-Strategic and Operational-Tactical tiers is empty without physical systems that can achieve the needs and mission of a TAD “system of systems.” Therefore, the foundation level of these cornerstones is manifest in the System-Design level. Naval system designs are addressed with appreciation for other military service components. This is where engineering architectures emerge and key performance parameters are identified. These parameters will drive the evolution of TAD system concepts, shape the development of Navy surface and air performance requirements, and influence the design of other Joint TAD components. Like the Aegis Cornerstones before them, TAD Cornerstones are fundamental to achieving mission success that is enduring, understandable, measurable, and testable.

Fundamental to the design and engineering of any complex military system required to accomplish Theater Air and Missile Defense are the reliability of the systems and the readiness of the operators to use them. “Continuous readiness” captures the intent to ensure responsiveness, effectiveness, and sustainability of the Force. This capability depends on designs that degrade “gracefully” and systems that are highly reliable and automated, require a minimum number of highly

trained personnel to operate, and can be supported by sufficient, timely logistics. Such systems must be able to perform continuous operability testing to ensure readiness for combat.

“Force sensor netting” is the essential element that brings the multiservice capabilities together synergistically to provide situational awareness and conduct of command and control over the set of forces for cooperative engagement of hostile targets. Sensor energy and frequency spectrum management, composite sensor target tracking, and data fusion for overlapping coverage are needed to properly identify targets and to provide a single integrated air picture. With these capabilities, the full kinematic range of these weapons can be supported. Implicit in these objectives are requirements for the sophisticated fusion of sensor measurement data; automatic monitoring of the sensor environment with operator feedback; resistance to electronic countermeasures, clutter, and weather; and improved performance of the sensors themselves.

With the scale of operations for large geographic theaters, the capability to extend the battle space well into enemy territory is recognized by the “inland reach” cornerstone of the System-Design level. This capability provides for sustained forcible entry, defense of friendly forces and other land-based assets, and the necessary depth of fire and reach to help deter the use of weapons of mass destruction. Flexibility of ship stationing, engagement through the entire target flight regime, and use of airborne sensors—all operating under flexible rules of engagement—are also intended. Regarding the weapons themselves, “proven lethality” conveys the need for demonstrated air target destruction or neutralization capabilities. This system-level capability covers proven performance over the entire set of detection, control, engagement, and kill assessment functions. It implies high kill probabilities that are provided by a number of engagement opportunities and resistance to countermeasures.

Past systems like Aegis relied on multiship Force-level threat evaluation and weapon control coordination through automated decision aids. Automated doctrine execution continues to be part of these computer-based systems. “Coordinated weapon employment” communicates the need to effectively and efficiently pair weapons to threatening targets in accordance with the Joint Air Defense Doctrine and the Joint Air Defense Plan.

The cornerstone of the System-Design tier that takes advantage of modern computer and communications technologies is “Joint command support.” It encompasses the use of computer-aided tools for military planning and the coordination and execution of tactical operations from afloat to ashore as well as from the shore alone. Ready access to common Joint databases and the integration of non-real-time,

near-real-time, and real-time tactical data to provide appropriate information with the appropriate level of fidelity are required. These in turn conceptually provide the situational awareness and readily understood tactical decision aids to the warfighters. High confidence in displayed information is paramount so that the prediction of engagement outcome (i.e., success) is valid.

The foundation of the System-Design level is "information integrity," i.e., the intent and expectation of being able to conduct rapid and reliable transfer of information between and among all Navy TAD components, Joint Air Defense systems, and other Joint mission areas, both inside and outside the individual service systems. The objective is to have consistent sensor data that are fused and displayed into information useful to command and execution force elements. This capability, which includes counterinformation warfare and information security, is based on flexible and adaptable architectures using a common implementation. Such architectures must be scalable to the task and have a high degree of network availability. Realistic simulation programs are essential to ensure the reliability of information when called upon for full-scale operations.

CONCLUSION

The Navy plans to conduct a large systems study to define the overall architecture required for surface combatants beyond 2010. It will address the mix of weapons, sensors, and combat systems needed for a large number of naval roles, including TAD, and provide guidance for program managers to acquire the required capabilities. TAD government and industry partners can use the TAD Cornerstones to address theater-level air defense in much the same way as Aegis systems developers did in the past. The TAD Cornerstones will provide a consistent, authoritative basis for engineering designs and architectural trade-offs.

The TAD Cornerstones are the foundation for technical studies supporting the formulation of the Navy's long-range roadmap for the future. Addressing the three levels of Political-Strategic, Operational-Tactical, and System-Design is critical for acceptance by the complete set of stakeholders charged with the development and acquisition of systems. These systems necessarily start from the strong capabilities achieved from investments of the past that form the foundation for capabilities of the future.

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