THREAT-RESPONSIVE SURVIVABILITY AND SPACE WARFARE AT HIGH ALTITUDES

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ABSTRACT

The US is being denied effective use of space systems for tactical support of combat operations because of doubts regarding the survivability of space missions in hostilities. Space systems survivability has been the object of widespread analysis and development for fifteen years. Because survivability is expensive, the decision to make the necessary substantial investments for high-altitude satellites will be postponed until there is tangible evidence that the threat is developing into anti-satellite weapon systems. Therefore, space system development and acquisition must be formulated so that the appropriate survivability investment can be made as the physical attack threat at high altitudes eventually emerges.

INTRODUCTION

The US is being denied effective use of space systems for tactical support of combat operations because of doubts regarding the survivability of space missions in hostilities. Although space systems survivability has been the object of widespread analysis and development for fifteen years, military space systems continue to be viewed as suitable only for peacetime operations.

The degree of vulnerability and corresponding survivability requirements vary from mission to mission. For the missions to survive, all of the system elements, including satellites, ground stations, links, and operation centers, must be protected against threats that include physical attack, electronic warfare, and collateral degradation from nuclear detonations. Some of the postulated threats, such as the high-altitude ASAT, do not exist as weapon systems.

Comprehensive, yet costly, survivability techniques have been identified and developed for both existing and postulated threats. Any potential survivability investment depends on the US acceptance of space systems for warfighting purposes. The prevailing barrier to this acceptance is the concern that satellites will always remain vulnerable to orbital interceptors even if the other threats to the space mission are neutralized.

These pervasive doubts regarding the physical vulnerability of satellites are rooted in two problems:

- The high-altitude ASAT does not exist and can emerge as one of several options.
- The long development and acquisition process for US space systems will render them obsolete relative to the emerging threat..

The solution to this problem is a threat-responsive survivability strategy. The approach for space system development and acquisition for high-altitude missions must be formulated so that the appropriate survivability response can be tailored to the threat as it eventually emerges.

THE PROBLEM

The Soviet Union began testing an anti-satellite (ASAT) interceptor in 1967, and, as we enter the 1980s, US space systems at low altitude remain vulnerable to this threat. With a few exceptions, implementation of survivability for physical attack into US space systems is still years away, if ever to come. Somewhat better progress is being made relative to the ECM threat and ground station threats.

It is widely recognized that space-based C^3I, navigation, and meteorology systems provide a real-time, global capability far superior to their terrestrial counterparts. However, the operational use of space systems to support military activities during hostilities has been thwarted by the space system survivability issue.

The current dependability of space mission support during hostilities is a real problem although the threats and the resultant vulnerabilities of space systems are usually overstated. In general, technical means to protect space systems in a variety of plausible scenarios have been identified and developed. Why then is the progress towards implementing these survivability concepts so agonizingly slow?

The factors that contribute to this dilemma can be logically ordered as follows:

1. Countermeasures are often threat-dependent.
2. Threat characteristics are unknown or are evolving.

3. Space system development cycles are 5 to 10 years or longer.
4. Survivability is an expensive investment.
5. The projected effectiveness of survivability is debatable under the above conditions.
6. Therefore, the investment cannot be justified.

If the Soviet Union and US were to engage in sporadic space warfare protracted over many months or years, then priorities would change and comprehensive survivability implementation may occur. However, with the series of low-level crises that we currently experience, it is unlikely that survivability will be implemented as a substantial characteristic of space systems without the advent of a high-altitude anti-satellite weapon system.

Because we have been singularly unsuccessful in having survivability incorporated into either ongoing or new systems, it appears that a different approach must be taken. This approach must be "threat responsive", in that the survivability measures implemented will depend to some extent on the threat that eventually emerges. The process by which this countermeasure vs counter-countermeasure development occurs is illustrated in Figure 1. The key features are:

- A system concept that can be augmented with survivability characteristics if and when needed.
- Development of appropriate threat-tolerant and threat-avoidant technology.
- The specification of low-level survivability requirements to account for existing and near-term threats.

There is a technical issue regarding the capability to respond with countermeasure implementation on a time scale comparable to development of the threat counter-countermeasure. A major objective of current design efforts for space systems should be to identify the practical degree of threat-responsive survivability.

WHAT WILL THE THREAT BE?

Two threat characteristics must be known for effective survivability implementation: The specific threat weapon systems selected for development and the deployment schedule. Unfortunately, insufficient data are available to formulate a threat assessment with the accuracy needed to respond with a survivability implementation plan for US space systems that is acceptable to decision makers.

Current threat assessments are necessarily limited to sizing potential Soviet threat systems. The Soviets will not develop and deploy all of the threats thus identified. What they will do depends upon their military objectives, the US use of military space systems, and the long-term international situation. These motivating factors are unclear or unknown, and will remain so until the Soviets take specific and detectable actions. This observation of Soviet behavior highlights the need for a flexible and responsive survivability implementation strategy.

Threats can be classified in terms of three development timelines (Table 1):

- Existing
- Short Development
- Long Development

Existing threats are those that are certain to occur during hostilities, such as high-altitude nuclear detonations that will affect communication links.

A short development threat can be tested and fielded on a time scale that may not be possible to match with survivability countermeasure implementation. A nuclear warhead on a ground-controlled missile is an example of such a threat.

Long development threats are major weapon systems that require a development cycle commensurate with a large-scale space system. The preeminent example of long-term development for operation against targets in high-energy orbits is the homing non-nuclear orbital interceptor. Figure 2 shows the development schedule of such a threat relative to a typical development schedule of a US space system.

Table 1 provides categorization in terms of development time for threats against space systems in high-energy orbits. The message is fairly straightforward: An enduring space system with satellites in high-energy orbits must be fielded with the capability to sustain attacks by ground-controlled nuclear ASATs, to tolerate interference from modest RF or laser sources, to survive the loss of ground stations, especially overseas, and to operate in global and space environments that have been perturbed by many nuclear detonations.

When the system is deployed, it must have the flexibility to be modified or augmented with countermeasures tailored for a specific physical attack threat. This threat may be a ground-controlled nuclear ASAT system supported by real-time global C^3I, a homing interceptor, a space-based laser, a space mine, or any other sophisticated weapon system that can perform an end-game engagement with a high degree of autonomy.

For RF or laser interference at the maximum threat assessment levels, it may be practical to field a space system at the onset with threat-tolerant countermeasures that can defeat any projected threat. This is a judgement that must be made during the system engineering and design phases of the space system development.

When the decision is made to develop a space system, it is impossible to specify for design purposes the threats to which the system will be exposed during its operational lifetime, because eventual threats will be influenced by unpredictable future events. An analysis of system vulnerability to all possible threats will identify the “easy” ones that can be disposed of with certainty. Any threat that severely stresses the system will have to be countered on a case-by-case basis. The space system concept must be able to accommodate the requisite countermeasures as the specific threats and appropriate responses are identified.

THREAT-RESPONSIVE SURVIVABILITY: IS IT FEASIBLE?

A major stumbling block in survivability implementation is uncertainty concerning the threat. National opinion juxtaposes skepticism regarding threat materialization against doubt that appropriate countermeasures could ever be implemented.

A solution to this problem is a survivability strategy that is responsive to threat development. The feasibility of this approach depends upon a space system deployment and acquisition program that can accommodate change on a time scale commensurate with threat development.

The most stressing threat is direct attack by a sophisticated ASAT. It is likely that other threats can be neutralized by a combination of countermeasures and system architectures. The technical requirements for protecting satellites from the entire spectrum of orbital ASATs have received considerable analysis. However, little consideration has been given to the production, test, and deployment of satellites for combat operation in which it is reasonable to expect losses.

Regardless of whether the survivability approach is reconstitution, proliferation, or other countermeasures, military space systems must be capable of being deployed and operated in combat. Current satellite programs are obviously not formulated for producing military hardware that is expendable in battle, and are not capable of being modified in response to changes in the threat without a DSARC, congressional debate, and a system block change,

Classification of survivability concepts, principal technology requirements, and threat-responsive characteristics are provided in Table 2. The five broad classifications of survivability share common characteristics. For example, if hostilities occur and the survivability concept is exercised, more satellites will be built than for peacetime operations.

The second common element of these survivability concepts, with the exception of pure reconstitution, is the technology development needed to demonstrate proof of concept for each case.

The third common element is the need for operations analysis of the survivability concepts and the decision process that will lead to selecting the concept, or combination of concepts, that will provide a space mission performance with an acceptable level of survivability or endurance. Specific features of each concept are provided as follows:

Survivable Launch Reconstitution - A major problem for this concept is the technology that will provide the synoptic coverage needed for missions such as missile surveillance. If these technologies can be developed and demonstrated, the system could be designed more or less independently of the ASAT threat characteristics. There is an issue of whether this system could be developed, acquired, and exercised on a time scale comparable to the development of an ASAT system of nuclear warheads on direct ascent boosters. There is also the issue of the relationship of this system with SALT.

Reconstitution - This concept uses responsive launches to replace lost satellites or to augment operational satellites. Responsive launches require launch-ready satellites and boosters. The flexibility of the shuttle is advantageous in this context. Reconstitution impacts production rates and requirements for storing and maintaining launch-ready satellites. Reconstitution would probably be used in conjunction with proliferation, stealth, and on-board countermeasures. There is an operational issue regarding the use of manned shuttle flights to reconstitute high-altitude satellites during a regional or theater conflict.

Proliferation - This concept has commonality with survivable launch in terms of production rates and surveillance capability. Launch constraints for proliferation are obviously not as severe as for survivable launch. Proliferated satellites may have some modest degree of countermeasures to preclude cheap shots.

Threat-Avoidant And Threat-Tolerant Countermeasures - Satellites intended for use with onboard countermeasures must have power, weight, and volume contingencies to accommodate countermeasures. These excess resources could be used prior to the advent of a high-altitude ASAT for flight tests of other development items, such as sensor improvements. A generic set of countermeasures must be developed for the range of ASAT options that the Soviets have available for development.

The acquisition and deployment approach for a countermeasured system must be responsive to the possible emergence of a high-altitude ASAT. This entails optimizing countermeasures relative to the specific threat being developed and adjusting procurement and launch schedules to be prepared with countermeasured satellites when the threat becomes operational. Command and control will probably be critical for on-board countermeasures. The requisite surveillance, command, and control will also have to be in place and exercised prior to operational readiness of the threat.

Stealth - This concept requires developing difficult technology. If the stealth concept consists of covering normally operational satellites, then the impacts on the acquisition and deployment approach are similar to those for on-board countermeasures. If the stealth concept consists of deploying entirely different satellites than those used for routine operations, then the approach is similar to that of survivable launch; namely, the system is developed, acquired, and deployed as an adjunct to the peacetime space system.

CONCLUSION

In summary, the major issue regarding the threat-responsive survivability approach is whether the space system acquisition process can be made responsive to the emergence of a sophisticated ASAT system that operates in a high-energy orbit.

However, in the final analysis, the success of proceeding with survivable US military space systems depends first on convincing national-level decision makers that the improved capabilities are worth the investment.

It is the responsibility of space system developers to formulate a dynamic and effective survivability strategy that will convince the US decision makers that space systems can be made dependable enough to support military operations at all conflict levels.

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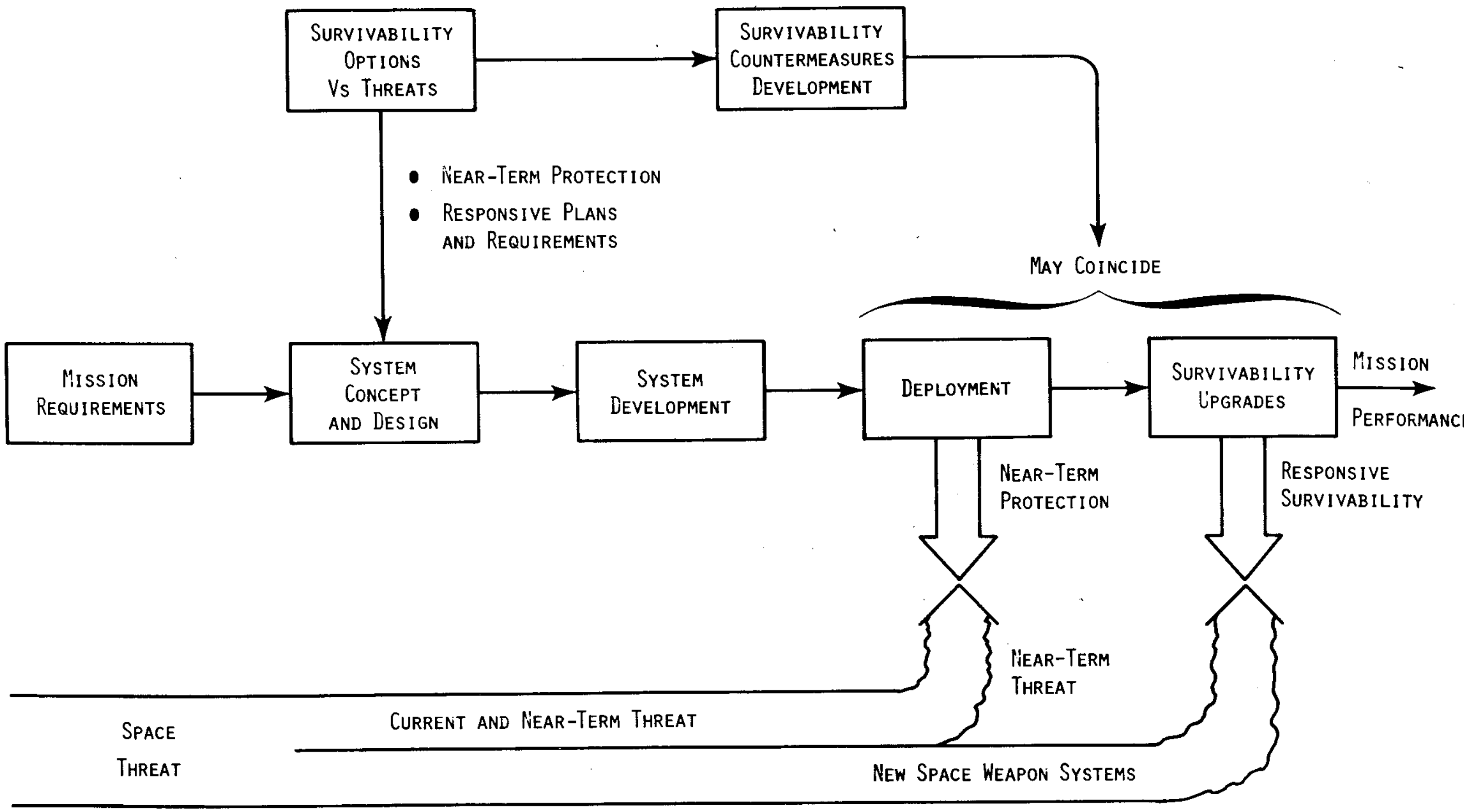

FIGURE 1. THREAT-RESPONSIVE SURVIVABILITY STRATEGY MUST BE INCORPORATED INTO CONCEPT DEVELOPMENT AND SYSTEM DESIGN

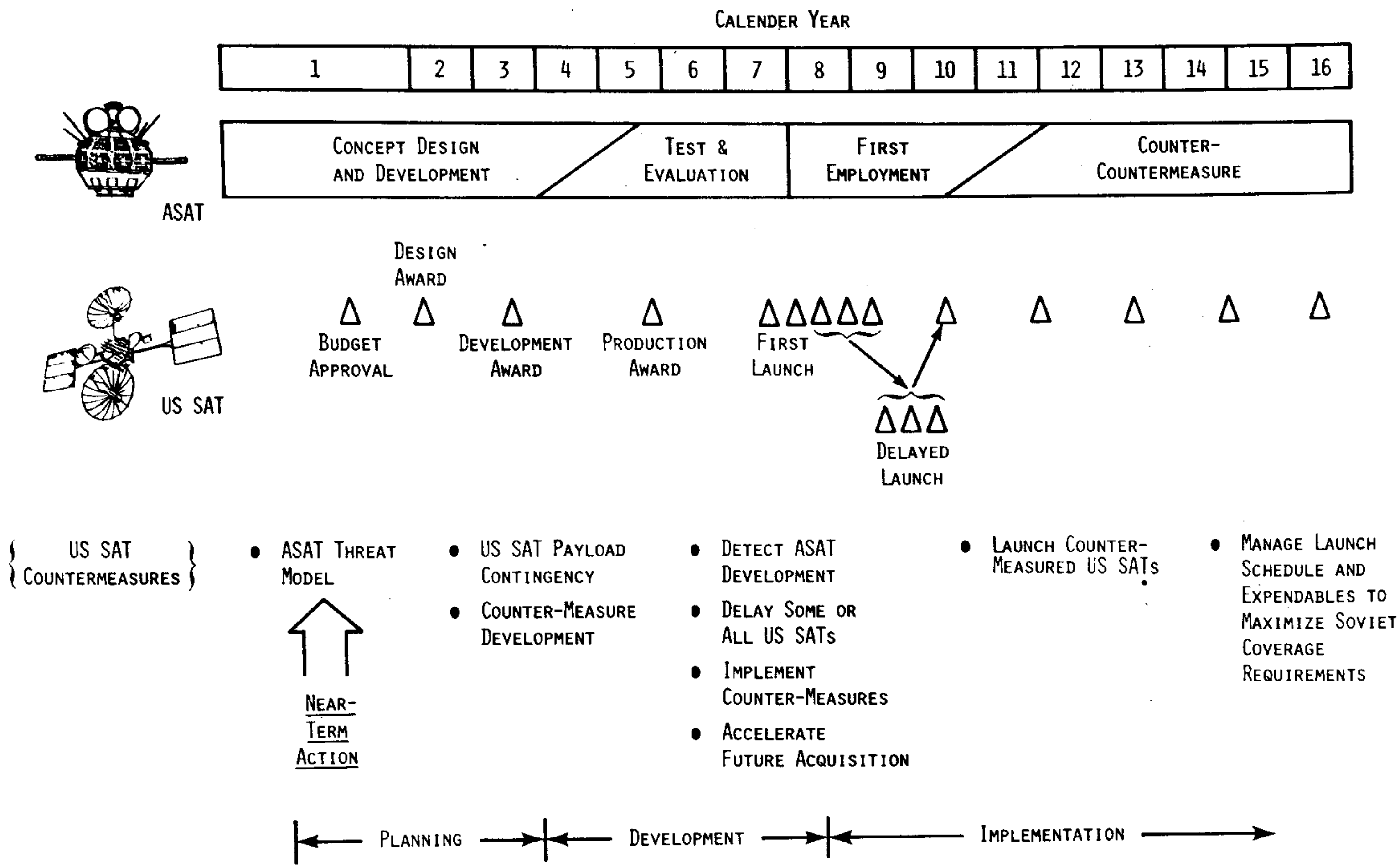

FIGURE 2. RELATIVE SCHEDULES OF A HIGH-ALTITUDE ASAT DEVELOPMENT VERSUS A THREAT-RESPONSIVE SURVIVABILITY IMPLEMENTATION

TABLE 1. DEVELOPMENT TIME FOR THREATS AGAINST HIGH ENERGY ORBITS.

THREAT	CHARACTERISTICS	DEVELOPMENT TIME
NUCLEAR ASAT	GROUND CONTROLLED	SHORT
LASER ASAT	LESS THAN 200 Kw POWER, GROUND BASED	SHORT
LASER ASAT	MAX THREAT ASSESSMENT, GROUND BASED	LONG
LASER ASAT	MAX THREAT ASSESSMENT, SPACE BASED	LONG
NON-NUCLEAR INTERCEPTOR	HOMING	LONG
SPACE-MINE	NON-NUCLEAR	LONG
SPACE SURVEILLANCE	CONSU BASED	EXISTS OR SHORT
SPACE SURVEILLANCE	GLOBAL, PEAL TIME	LONG
RF JAMMING	INTERFERENCE WITH CURRENT CAPABILITIES	EXISTS OR SHORT
RF JAMMING	MAX THREAT ASSESSMENT, X-BAND OR HIGHER FREQUENCY	LONG
COLLATERAL NUCLEAR DETONATIONS	ENDO- AND EXO-ATMOSPHERIC	EXISTS
GROUND STATION ATTACK	OVERT OR COVERT	EXISTS

TABLE 2. THREAT RESPONSIVE CHARACTERISTICS OF SURVIVABILITY CONCEPTS.

SURVIVABILITY CONCEPT	TECHNOLOGY DEVELOPMENT REQUIREMENTS	THREAT RESPONSE	COVERT STRATEGY
SURVIVABLE LAUNCH RECONSTITUTION	SMALL PAYLOAD, ADEQUATE COVERAGE	ACQUIRE & DEPLOY	NO
RECONSTITUTION	NONE	ACCELERATE DEPLOYMENT	YES
PROLIFERATION	ECONOMICAL PROLIFERATION	ACQUIRE & DEPLOY	NO
ONBOARD COUNTERMEASURES	COUNTERMEASURES VS THREAT MATRIX	IMPLEMENT & DEPLOY	YES
STEALTH	LOW OBSERVABLE OPERATIONS	IMPLEMENT & DEPLOY	PROBABLY NOT