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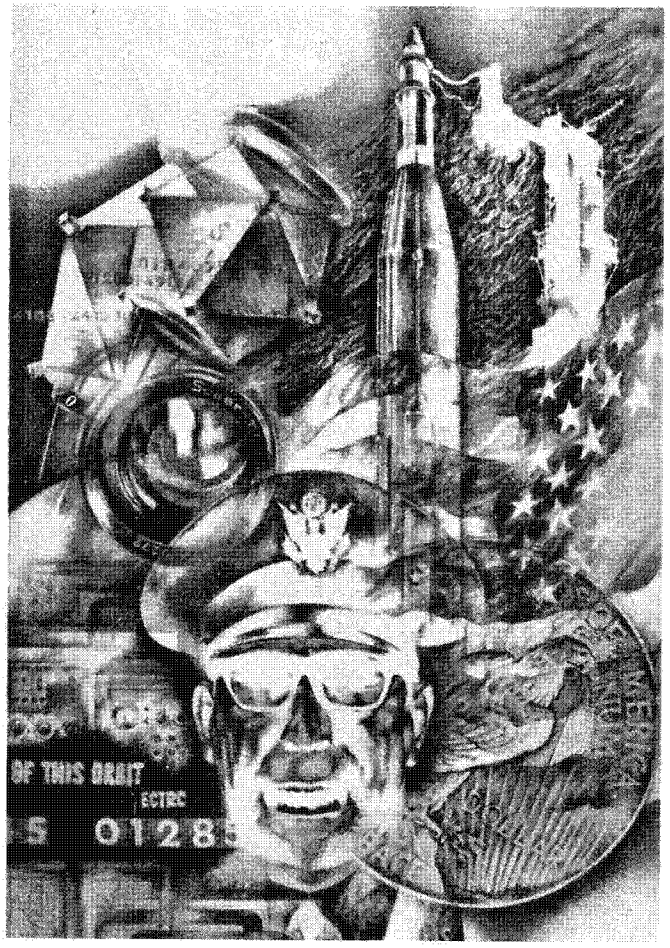
National Reconnaissance Office

Survivability Enhancement Action Plan

in Response to National Security Decision Memorandum 333



VOLUME I

Executive Summary

October 1976

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GAMBIT/HEXAGON/KENNEN/EARPOP
[redacted]/10170

SURVIVABILITY ENHANCEMENT ACTION PLAN

A report to the

NSDM 333

WORKING GROUP

VOLUME I

EXECUTIVE SUMMARY

OCTOBER 1976

NATIONAL RECONNAISSANCE OFFICE

GAMBIT/HEXAGON/KENNEN/EARPOP
10170

COVER ILLUSTRATION

The illustration on the cover is from an article titled "The Space Networks of Espionage" by Maj Gen Avn B. Aleksandrov and Col A. Yur'yev (of the PVO Strany). It was published in the Soviet general circulation magazine SMENA, no 13, on July 1970.

INTRODUCTION

The vulnerability of current U.S. reconnaissance satellite systems to an ever increasing range of operational Soviet threats has long been a source of considerable concern to the NRO. Such vulnerabilities derive from a history of system acquisition guidance which asserts that the overhead mission is primarily one of S&T and National Technical Means of Verification collection, that reconnaissance satellites are stabilizing in times of crisis, and that reconnaissance spacecraft are therefore sanctioned. A meaningful reversal of this situtation requires a new national policy, stating a need for space systems survivability which is commensurate with the missions and levels of conflict being supported. The NRO perceives the enunciation of such a policy, causing an appropriate rebalancing of resource allocation between survivability and other system performance parameters, as the most salient potential contribution of the NSDM 333 study. This NRO response has been structured specifically to support this most important objective.

In the belief that the programmatic goal at this point is to define a general survivability objective and level of effort, the NRO has developed several alternative programs of graduated cost and effectiveness against the foreign threat. To assure confidence in the resulting cost estimates, these alternatives have been constructed from specific projects identified for each system. It must be recognized, however, that the entire study was accomplished in essentially two months, and that the cost figures must be regarded as only rough estimates. Once a decision is made upon the appropriate level for NRP survivability, a detailed follow-on study will be conducted to structure a specific, more optimum program and to identify more carefully the attendant costs.

To raise the level of NRP survivability as soon as practical, the focus of this effort has been on the period of the next five-to-ten years; i.e., developing remedies for systems already in acquisition. Such remedies are typically only partially effective, since they basically require retrofitting systems not initially designed for survivability. The far-term offers greater opportunity. New reconnaissance system concepts can be developed from the beginning with survivability as a major system performance criteria. Systems specifically emphasizing survivability can be conceived, taking advantage of such recent introductions as the Space Shuttle. Such an emphasis could,

in the long-run, lead to a different system mix for the NRP, incorporating systems with fundamentally different characteristics than seen today. Although outside the scope of this immediate report, the NRO is pursuing such concepts, starting with the investigation of quick-reaction systems, both Imaging and SIGINT. To conclude by re-emphasizing the fundamental issue, this report is intended to serve as a tool in the reassessing and enunciating of national policy and for establishing broad survivability guidelines. The NRO believes that this objective should be kept clearly in mind and that, unlike the many studies which have preceded it, the NSDM 333 effort will become a prime instrument for restructuring our space survivability program.

Options

(Levels-of-Conflict)

A range of Options has been defined by the NSDM 333 Working Group to isolate subsets of critical satellite missions and levels of conflict.

The prioritization of system Survivability Enhancement Options requires an appreciation of the relative criticality of the various NRP systems for each option. Consequently the Information Needs implied by each option were identified and prioritized. As will be seen in later sections, the exact prioritization was not a major factor in determining the Recommended Program. Nonetheless, this process was accomplished by the NRO study group and subsequent validation by competent authority would be useful.

As seen in Table 1, nine of the options deal with varying levels of territorial conflict or crisis/confrontation. One is concerned with the capability of space systems to continue to perform during interference in peacetime. In the other nine options, the purpose of satellite derived information is to either (a) support the conduct of or manage and control crises/confrontations/conflicts or (b) maximize military support in conflicts. In the Space/Peacetime Option, the emphasis is the requirement to maintain space operations during the interference.

Criticality of NRP Systems to Option Support

The Operational Options emphasize crisis/conflict scenarios which in turn places primary emphasis upon time-critical functions. Consequently, these criticality-ranking results differ from the traditional NRP peacetime roles. The information needs of each option and their relative priorities were estimated. The ability of each NRP system to meet these needs and the utilization of the systems were next determined. This analysis was used to determine only broad grouping of system criticalness. The detailed ranking of systems within the general groups was not a factor.

Table 2 indicates a bunching of the satellites into three groups of decreasing criticality; most critical: [redacted] KENNEN; critical: [redacted] least critical: P-989, HEXAGON, GAMBIT.

TABLE 1

OPERATIONAL OPTIONS

1. Maintain space operations in peacetime (but during interference)
2. Manage and control escalation or deescalation of U.S./ Soviet crisis/confrontation
3. Manage and control escalation of a conventional conflict involving the U.S. but not involving the Soviet Union or vital Soviet interests (e.g., Vietnam)
4. Maximize military support of a conventional conflict involving the U.S. but not involving the Soviet Union or vital Soviet interests (e.g., Vietnam)
5. Manage and control escalation of a U.S./Soviet conventional conflict
6. Maximize military support during a U.S./Soviet conventional conflict
7. Manage and control escalation of a NATO/Pact conflict
8. Maximize military support during a NATO/Pact conflict
9. Support the conduct of limited strategic nuclear options
10. Support the conduct of strategic nuclear conflict

This is the Option list provided by the DoD/IC NSDM 333 Response Working Group. It is used as the basis for the analysis that follows on subsequent pages.

TABLE 2

OPTIONS INFORMATION NEEDS FULFILLED BY NRP SYSTEMS

(i.e. CRITICALITY)

OPTION	GAMBIT	HEXAGON	KENNEN	[redacted]	P-989
1	43	66	126		57
2	28	50	118		61
3	15	40	92		58
4	14	35	80		55
5	19	38	111		57
6	19	38	109		60
7	19	38	109		57
8	19	38	112		61
9	23	35	93		38
10	18	33	86		32
		411	1036		

High numeric value indicates high relative informiation need fulfillment.

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Threat

The Soviet ASAT threat to U.S. satellites consists of a variety of systems and capabilities; this threat is summarized in Figure 1. The Soviets have a coorbital intercept system that uses a fragmentation warhead. It uses a modified SS-9 ICBM booster and can intercept targets at up to 2500NM altitude. Using a larger space booster, it could intercept targets in semisynchronous and synchronous (19,3000NM) orbits. A probable high power ground-based laser, possibly already in operation, may be an ASAT system under development. It is likely the Soviets will undertake development of a very high power ground-based laser ASAT system. The Soviets intend to conduct electronic warfare against satellites during wartime and are believed to have such a capability. The Soviets are reportedly developing a space-based laser weapon for use against satellites which could be demonstrated in the early 1980's. In addition the nuclear-armed Galosh ABM interceptors would undoubtedly be used in an ASAT role against satellites thought to threaten Moscow. The Soviets could develop nuclear intercept systems for attack of very high altitude satellites. There is no evidence of such development. The Soviets also have the capability for covert attacks on space systems ground facilities in the U.S. and overseas. It is highly likely that the Soviets will develop radio-frequency damage weapons, in spite of the uncertainty in achieving kill inherent in such weapons.

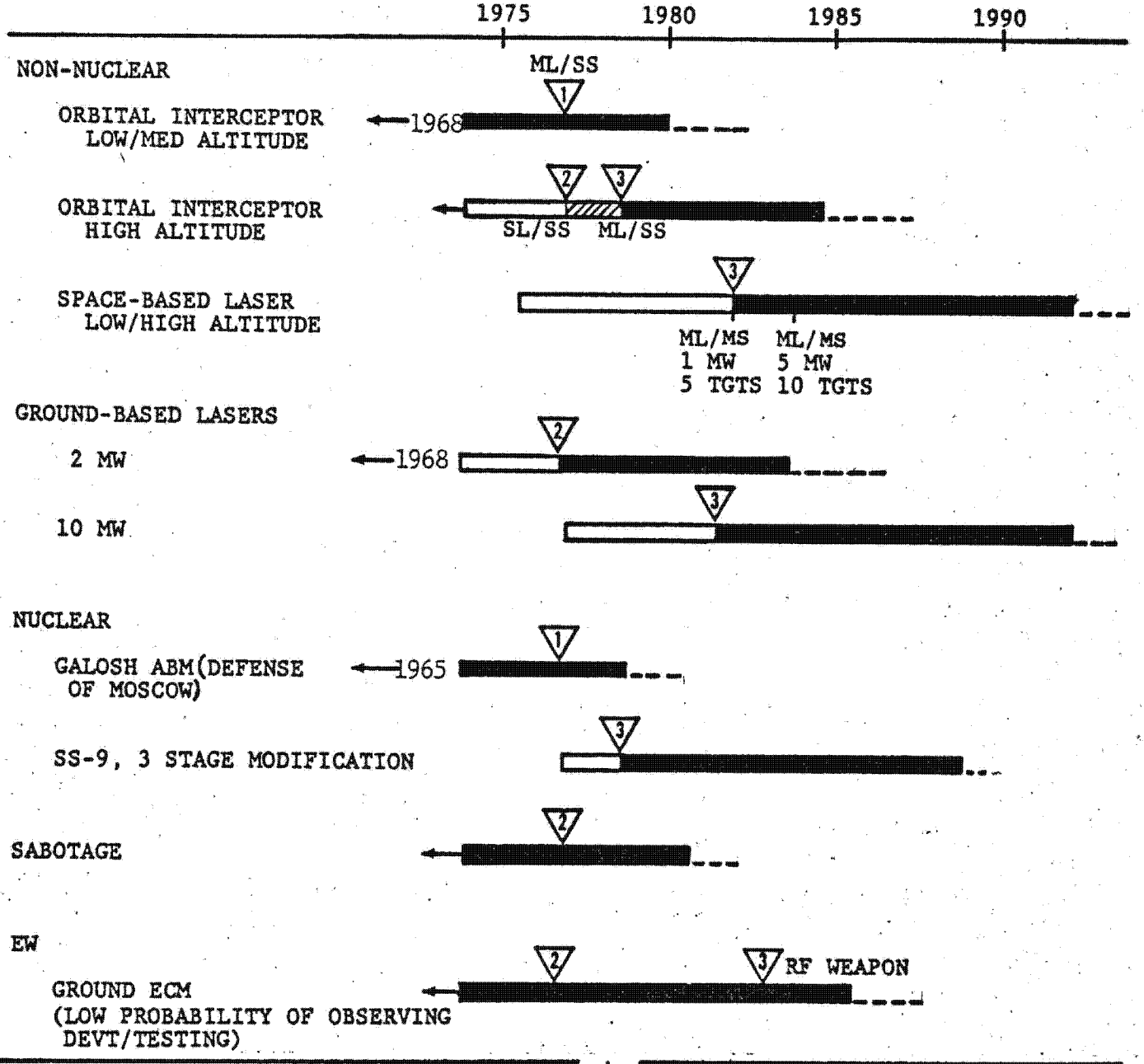
Survival Enhancement Options

The Soviets are assessed to currently have the capability to interfere with or destroy any NRP space systems they choose. They are believed to be developing advanced capabilities that will be even more effective. NRP systems are also vulnerable to inadvertent destruction from non-targeted nuclear weapons and sabotage of ground facilities.

The development of very high value NRP collection systems has placed a premium on survival techniques to allow mission completion by existing or replacement systems. The application of sophisticated U.S. space technology in the survival enhancement area is expected to provide a high payoff in mission completion and in increasing the difficulties encountered by the Soviet ASAT forces--in some cases by

FIGURE 1

THREAT MODEL SUMMARY



LEGEND

- DEVELOPMENT
- OPERATIONAL LIMITED LAUNCH RATE
- OPERATIONAL

SS ∿ SINGLE SHOT
MS ∿ MULTI-SHOT
SL ∿ SINGLE LAUNCH
ML ∿ MULTI-LAUNCH

BASIS FOR THREAT MODEL

1. DEMONSTRATED MILITARY CAPABILITY.
2. PROBABLE MILITARY CAPABILITY.
3. PREDICTED MILITARY CAPABILITY. CONSTRUCTION OR TESTING WILL BE OBSERVED.

enforcing a higher technological requirement than they can achieve. The major survival techniques are summarized in Table 3. The measures presented are expected to have a high probability of being effective. Maneuver countermeasures against the current orbital intercept system can hold off intercept for some time only, but will allow further collection and increase Soviet intercept costs.

TABLE III-11

MAJOR SURVIVAL ENHANCEMENT OPTIONS

THREAT	COUNTERMEASURE	APPLICABLE SATELLITE
ORBITAL INTERCEPTOR		
CURRENT (FRAGMENTATION WARHEAD)	EVASIVE MANEUVER, WELL IN ADVANCE, LOW ΔV	IMAGING
	HOMING SENSOR DECEPTION/JAMMING	ALL
	PROLIFERATION AND/OR RAPID LAUNCH/DEORBIT	ERRS
ADVANCED (LASER WARHEAD)	ACQUISITION/POINTING SENSOR DECEPTION/JAMMING	ALL
	(NEGATION BY U.S. ASAT SYSTEMS)	ALL
GROUND-BASED LASER		
CURRENT (MEDIUM POWER)	TARGET DEFENSIVE REORIENTATION	IMAGING
	TARGET ACCELERATION TO DEGRADE LASER POINTING	IMAGING
	LASER SITE AVOIDANCE MANEUVER	IMAGING
	HARDENING	MED. ALTITUDE (989)
ADVANCED (HIGH POWER)	LASER SITE AVOIDANCE MANEUVER	IMAGING
	HARDENING	MED. ALTITUDE
ELECTRONIC WARFARE		
C&C TAKEOVER/DISRUPTION	COMMAND SYSTEM LOCKOUT, SCRAMBLE, ENCRYPTION	ALL
JAMMING	ANTI-JAM (SPREAD SPECTRUM, FREQ. HOPPING)	ALL
HIGH POWER DAMAGE	RECEIVER PROTECTION (ATTENUATORS, CURRENT LIMITERS)	LOW/MED ALTITUDE
GROUND STATION SABOTAGE		
PHYSICAL ATTACK	INCREASED PHYSICAL SECURITY	ALL
ELECTRONIC WARFARE	SOURCE DETECTION, ELECTRONIC AND/OR PHYSICAL NULLIFICATION	ALL
LAUNCH VEHICLE SABOTAGE		
PHYSICAL ATTACK	INCREASED PHYSICAL SECURITY	ALL
ELECTRONIC WARFARE	COMMAND DESTRUCT SYSTEM SECURITY, RADIO GUIDANCE SECURITY, ANTI-JAM DESIGN	ALL
NON-TARGETED NUCLEAR		

CONCLUSIONS AND RECOMMENDATIONS

This section summarizes, with minimum explanation, the conclusions and recommendations developed throughout the study. These results derive from the NRO perception of; (1) the community coordinated threat, (2) the present and potential utilization of NRO systems, (3) trends in dependence upon NRP systems, (4) the technical feasibility of implementing survivability enhancement options, and (5) the associated cost and schedule impacts.

General Comments

This study concentrates upon specific hardware solutions to threats to systems which are now approved for acquisition. There also exists a range of less specific actions which should also be highlighted.

National Policy - A directive statement of national policy is required for survivability to become a meaningful element of basic programmatic decisions. The following statement of policy is offered:

> "U.S military space systems will possess a level of survivability commensurate with the missions and levels of conflict they support."

Recommendation

Enunciate a directive national policy.

Political Action - Hardware oriented solutions are but a subset of all initiatives available to the U.S. It is apparent that a political solution should also be vigorously pursued. In addition to the general subject of interference with foreign spacecraft, topics which could be considered are weapons in space (the co-orbital ASAT and the Spacebased Laser) and "keep-out" regions.

Recommendation

The U.S. should vigorously pursue political responses in parallel with the system oriented efforts.

Survivability as a system performance evaluation criteria - Much of the program proposed in this report is concerned with retrofitting systems which were not initially designed with survivability as a major system element. For survivability to become an integral element of the U.S. space reconnaissance capability, it will have to be perceived as a critical performance criteria to be balanced with other system constraints throughout the system life cycle. This emphasis should be an element of higher level review processes, including funding decisions.

Long-range opportunities - The far-term offers opportunities for achieving much more effective and efficient survivability because the issue can be addressed in the system concept definition stage. On-going NRO examples are; (1) a joint effort with NSA investigating techniques for anti-jam protection through a mixture of system architecture measures such as narrow steerable antenna beams, processing, and encoding (rather than sole reliance on brute-force "black box" add-ons), and (2) studies to exploit the unique capabilities of the Space Shuttle. Although not a major thrust of this report, the NRO will vigorously pursue such long-range opportunities.

Effectiveness of defensive measures - Although the measures proposed in this study have the potential for improving survivability, they have not generally been subjected to an exhaustive effectiveness study. To the extent practical, the NRO will conduct such studies before implementing any projects, but true effectiveness will often not be known until the measures are exercised.

Short-Term Action Plan

The Short-Term Action Plan provides for better use of existing resources within the currently approved NRP program. These remedies are (1) typically only partially effective but can be implemented rapidly, (2) do not require additional NRP funding, and (3) are needed independent of which long-term strategy, if any, is eventually approved. The elements of the plan are outlined below.

1. Timely warning will be implemented by coordination with ADCOM and DEFSMAC to achieve an integrated warning capability.

2. Minimal on-board verification sensors for laser attack are now carried on HEXAGON and KENNEN. A more complete survivable verification package, including an expanded sensor complement to respond to other threats and reduce ambiguities will be developed in the short-term vulnerability R&D program (for implementation in the Long-Term Action Plan).

3. The NRO Contingency Plan is being revised to respond better to the evolving Soviet threat and includes recognition of the NSDM 333 requirement for providing the maximum feasible executive reaction time.

4. Encryption is now fully implemented on several systems and will be included on new systems in accordance with DCI policy. Provisions for retrofitting existing unprotected systems are included in the Long-Term Action Plan.

5. Exploitation of U.S. reconnaissance systems, consisting of reading uplinks and downlinks, would provide the Soviets with knowledge of intelligence sources and methods, collection strategies and targets, system technical characteristics, and opportunities for effective interference. Denying such exploitation is key to all aspects of survivability. To counter this threat, increased voice communication security provisions for state-side management communications will be pursued in the Short-Term Action Plan.

6. Physical security of ground segments is a major concern, due to the ease of attack. An initiative was started in this area about 18 months ago and will continue to receive emphasis.

7. R&D projects are required to support a number of future improvements. The NRO will implement projects as appropriate. Those projects which are not inherently BYEMAN and which are more properly the responsibility of other agencies are identified for implementation by other DOD organizations.

Recommendation

Implement the proposed Short-Term Action Plan. Cost: Within NRP program.

Long-Term Action Plan

Basic NRP Survivability - It appears the survivability and contingency reaction capability of the NRP systems as a whole could be raised to an acceptable base level. The Minimum Responsible Survivability Program would provide a high confidence of support through lower level scenarios which are historically the most common situations. While individual satellites would still be vulnerable to a dedicated Soviet attack in higher level scenarios, the galaxy of all NRP satellites on orbit at any moment which is only a subset of all critical U.S. satellites, would exhibit considerably improved survivability. This is the minimum program necessary to control exploitation, to provide attack warning and verification, and to protect existing NRP assets to the extent it is cost-effective to do so. The program, however, stops short of the high costs necessary to protect assets against continued physical attacks. Within this program, funds are being balanced between systems and across the various aspects of survivability: Namely; exploitation, attack warning and verification, and defensive measures. These are measures which are generally needed across the entire range of operational options. Residual vulnerabilities following implementation of this plan are as shown in Figure 2.

Recommendation

If it is decided to provide an acceptable level of survivability against hostile action, the Minimum Responsible Survivability Program should be approved. Cost: ≈$235M for six years (≈$57M peak, ref Fig 3). Funds not currently available within NRP budget.

Replacement Schemes - While the Minimum Responsible Survivability Program, if implemented, would decrease the probability of a successful attack, it would not typically provide a backup capability if an act of interference were successful. This situation would exist at all levels of conflict and suggests the investigation of replacement schemes. In this era of sophisticated, high value, long-life vehicles, the maintenance of ready replacement vehicles is generally very expensive -- typically only permits a 40-45 day response time. If the negated system segment is the ground station, pipeline vehicles may be to no avail. These conditions argue strongly for investiation of quick reaction system concepts which can be truly responsive, independent of conventional system segments, quite survivable, and flexible in deployment.

FIGURE 2

RESIDUAL VULNERABILITIES

(IF MINIMUM RESPONSIVE SURVIVABILITY ALTERNATIVE IS IMPLEMENTED)

OPTION / VULNERABILITY	2 CRISIS	3 NON-SOVIET CONFLICT NCA	4 NON-SOVIET CONFLICT MIL	5 SOVIET NON-NATO CONFLICT NCA	6 SOVIET NON-NATO CONFLICT MIL	7 NATO/PAC CONFLICT NCA	8 NATO/PAC CONFLICT MIL	9 LNO/RNO	10 MAO/SAO	1 PEACE/ OPPOSED SPACE
GROUND STATION										
NUC U.S. SITE								----	———	
FOREIGN SITE						----	----	———	———	
NON-NUC	----	----	----	———	———	———	———	———	———	----
VEHICLES (S/C & L/V)										
FULL ECM				———	———	———	———	———	———	———
FULL RF PULSE				———	———	———	———	———	———	———
FULL LASER/ASAT				———	———	———	———	———	———	———

LEGEND: ---------Limited, but finite, vulnerability

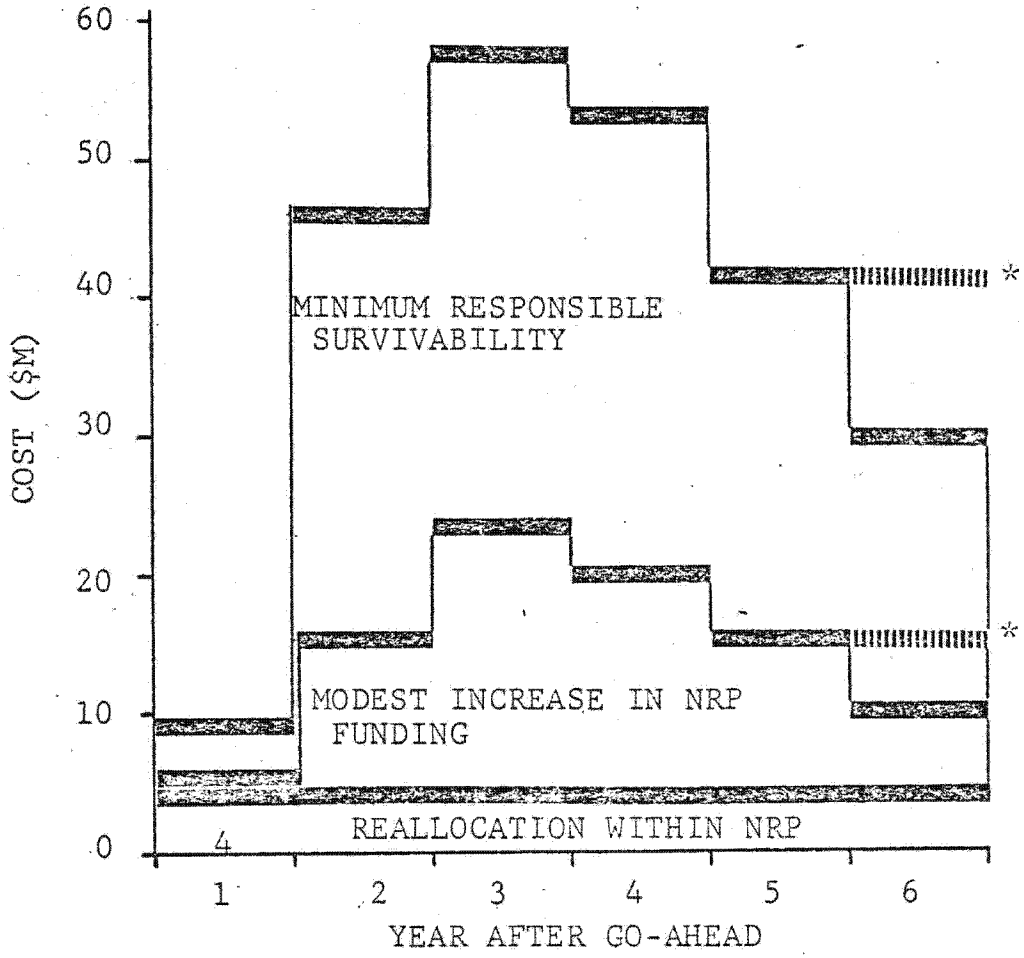
———————Significant vulnerability

FIGURE 3

LONG-TERM ACTION PLAN

COST PROFILE

(TOTAL COST/YEAR FOR EACH OPTION,
IN MILLIONS OF DOLLARS)



*FUNDS IN OUTYEARS APPEARS TO DECLINE BECAUSE ESTIMATES ARE BASED UPON ACTUAL NEAR-YEAR PROJECTS, MORE REALISTICALLY THE PROGRAM WOULD LEVEL OUT AS SUGGESTED BY DASHED LINES.

Recommendation

Endorse NRP investigations of Quick Reaction Systems as potential responsive backups to approved systems.

Balanced Survivability - It is apparent that proposals to truly "harden" the approved systems, which were not initially designed for survivability, suffer from rapidly increasing cost and slowly increasing effectiveness as operations at higher levels of conflict are considered. Individual hardening projects, including backup ground stations and replacement vehicles, tend to be individually very expensive. Conducting a meaningful cost/survivability tradeoff analysis is very scenario dependent and could not be performed in the abstract. If specific high-interest operational options and critical missions can be defined, specific approaches can be studied by the NRO as a follow-on effort.

Recommendation

Higher authority should structure specific high-interest goals for higher level conflicts as a basis for follow-on definitive studies.

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