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NUCLEAR-POWERED AEGIS SHIP ALTERNATIVES

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NUCLEAR-POWERED AEGIS SHIP ALTERNATIVES

EXECUTIVE SUMMARY

Background

Surface ship survival at sea in the presence of the threat posed by modern surveillance systems and anti-ship missiles requires effective defensive systems. According to the Department of Defense officials, the Navy's currently deployed fleet-defense surface-to-air missile (SAM) systems are not sufficiently effective against the new generation of Soviet missiles, and the Aegis SAM system is urgently needed to overcome this deficiency.

Because of the high cost of an Aegis-equipped nuclear-powered cruiser ($835 million for the second and subsequent ships of the new CGN-42 class), the most cost-effective way of satisfying the Navy's requirement is of interest.

This report examines three basic solutions to satisfy the Navy's requirement. One solution is to build new Aegis-equipped cruisers. A second solution is to backfit the Aegis weapon systems into existing nuclear-powered cruisers (CGNs) such as the four ships of the VIRGINIA class. And a third solution is to build new Aegis-equipped cruisers and backfit the Aegis system into existing CGNs.

An important factor in determining whether to backfit the Aegis system into the VIRGINIA class cruisers is whether the Tartar-D surface-to-air missile system (as currently installed in the VIRGINIA class) is adequate against the postulated future threat. With respect to the adequacy of the Tartar-D system, the Senate Armed Services Committee denied funding in 1975 for a fifth Tartar-D-equipped VIRGINIA-class cruiser with the following comment:

> The Committee has carefully considered this request and believes it inappropriate to build any ship, and especially a nuclear ship, with a weapon system that is clearly inadequate to meet the projected threat within a relatively short period of time after delivery of the ship.

Purpose

This report evaluates the adequacy of the Tartar system in the USS VIRGINIA (CGN-38) and her sister ships against the current threat, and the threat projected through the year 2000. The report then examines the costs of building new Aegis-equipped CGNs as compared with the cost of backfitting the Aegis system into existing nuclear-powered cruisers, and examines the cost of a combination of these options. It also assesses the impact of each option on the numerical requirement for nuclear-powered guided-missile cruisers as carrier escorts.

Findings Concerning the Capability of the Tartar-D-Equipped CGN

a. While the USS VIRGINIA (CGN-38) is considered by Navy spokesmen to be the most capable anti-air warfare (AAW) escort ship in the Navy today, its capability on a stand-alone basis against the near term future high density anti-ship missile threat is inadequate.

b. Projected improvements for the Tartar-D system, if aggressively undertaken, could significantly improve the capabilities of the system by the 1985-1990 time period. According to Navy experts, if the potential improvements are implemented, the performance of a Tartar-D-equipped ship will be effective against projected threats when operating as a team coordinated by an Aegis-equipped ship, if Aegis performs as expected.

c. The projected AAW improvements for the Tartar-D-equipped CGN (intraship and missile modifications) are evolutionary in nature, and are considered to be of low technical risk, provided adequate resources are made available. However, the development of the inter-ship AAW coordination system for Tartar-D and Aegis-equipped ships seems to lack sponsorship and financial resources. There is no identifiable integrated program to insure Tartar-D improvements are implemented on a timely schedule to meet the anticipated threat.

Shipbuilding and Conversion Alternatives

Surface Escort Tasks

The Navy recognizes that the Soviet Union since World War II has built and deployed major naval forces having, among other purposes, an anti-carrier mission. The Soviet anti-carrier capability is composed of aircraft, submarines and surface ships. Although each of these platforms operates in a different medium, and each has its individual capabilities and limitations, all three rely on the anti-ship missile as their principal weapon. Appreciating this significant threat against its carrier forces, the U.S. Navy has developed the tactical concept of defense in depth against attack. This concept calls for the destruction of the attacking platform before it can launch its weapons -- a task that is assigned to carrier-based aircraft and submarines in the escort role. However, should they fail, the next effort is to shoot down or decoy the enemy missiles before they can reach their targets. This latter task is shared by aircraft and surface escorts using air-defense missiles and guns. 1/ Surface escorts also must defend against submarines that approach near enough for a torpedo attack. In this role they may attack with short-range anti-submarine weapons, seeking to destroy or distract the attacking submarine. And in tense, edge of war, crisis management situations such as in the Mediterranean Sea during the last two Mid-East wars, when the Soviet and U.S. fleets were at times intermingled, surface escorts have a role against opposing surface ships. As U.S. surface ships are fitted with the Harpoon medium-range anti-ship missile over the next several years, their anti-ship role will increase.

1/ Surface-to-air missiles could be used against attacking aircraft that come within range, however, Soviet tactics seem to eschew this procedure in favor of stand-off tactics, employing their long-range missiles from beyond the range (less than 100 miles) of U.S. surface-to-air missiles.

Escort Requirements

In his FY 1969 Defense Posture Statement Secretary of Defense McNamara stated that six conventionally-powered or four nuclear-powered escorts were required for each carrier task group. These numbers have been frequently cited since then as the basis for various determinations of the proper number of escorts for a given number of carrier task groups. Secretary McNamara's statement was based on the Navy's Major Fleet Escort Study completed in 1967. The Navy's study was based on concepts current for those days, when the principal threat to aircraft carriers was deemed to be aircraft delivered bombs and submarine-fired torpedoes, and proposals to employ U.S. submarines in an escort role were in their infancy. In recent years this study has been challenged as no longer providing a sound basis for determining the number of escorts required in a carrier-supported task group. Admiral Holloway has testified that a carrier-supported task group should include two or three cruisers and one to three submarines. Presumably this reflects more recent study. These new planning factors have not been supported by detailed testimony before Congress.

While the use of submarines as task group escorts is an unproven concept, the concept has been examined in fleet exercises and is reported to be a good one. Surface escorts have traditionally performed many necessary assignments in carrier task groups in addition to purely defensive ones. Some of these tasks, such as shore bombardment, search and rescue, board and search, and similar assignments, could not be ordinarily assigned to submarine escorts. With several surface escorts in a task force, a short diversion of one or two of them to these collateral tasks has normally been affordable. However, whether that will be the case when only two or three surface escorts are assigned to the task group has not been shown.

In the analysis presented in this report several escort requirements statements by Admiral Holloway are synthesised as the basis for structuring alternative Aegis-equipped nuclear-powered cruiser acquisition programs for analysis. The resulting options should not be construed as representing hard and fast requirements, but only as examples of possible acquisition programs.

Ship Availability Considerations

The Navy's stated minimum requirement for nuclear-powered cruisers is based on the number of nuclear-powered aircraft carriers in the fleet. The Chief of Naval Operations (CNO), Admiral James L. Holloway, has testified that if an all-nuclear-powered aircraft carrier task group has three nuclear-powered guided-missile cruiser (CGN) escorts, only one need be an Aegis-equipped ship. If only two cruisers are assigned to the task group, they should both be Aegis equipped. Therefore, since the Navy has four nuclear-powered aircraft carriers in service or under construction, the near-term minimum requirement stated by the Navy is for eight CGNs if all are Aegis-equipped or 12 CGNs if only four have the Aegis weapon system.

When the MISSISSIPPI (CGN-40) joins the fleet in 1978, the Navy will have eight operational nuclear-powered cruisers; and with the commissioning of the ARKANSAS (CGN-41) in 1980, the total will be nine -- none of which are Aegis-equipped. It is expected that the fourth nuclear-powered aircraft carrier, the USS CARL VINSON (CVN-70), will be commissioned in 1981.

The availability of a sufficient number of escorts for the all-nuclear-powered carrier task forces depends on the composition of the individual escort force. The following surface escort force compositions for each of the four all-nuclear-powered carrier task forces have been postulated for this study:

Case 1 -- Two nuclear-powered Aegis-equipped cruisers per task group; for a force level of eight Aegis-equipped CGNs.

Case 2 -- Three nuclear-powered cruisers (one Aegis-equipped) per task group; for a force level of 12 CGNs (including four Aegis-equipped CGNs).

Case 3 -- Four nuclear-powered cruisers (one Aegis-equipped) per task group; for a force level of 16 CGNs (including four Aegis-equipped CGNs).

Table A shows the effect of three options for meeting the requirement for nuclear-powered Aegis-equipped CGNs: (1) through new construction; (2) by backfitting the Aegis system into existing nuclear-powered cruisers; and, (3) by backfitting the Aegis system into the four VIRGINIA-class cruisers and building four new cruisers.

TABLE A - NUCLEAR-POWERED CRUISERS

	Year																
	1978	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	2000
MINIMUM REQUIREMENT FOR CGNs:																	
Case One	6 Aegis	6 Aegis	6 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis
Case Two - CGNs (Aegis CGNs)	9 (3A)	9 (3A)	9 (3A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)
Case Three - CGNs (Aegis CGNs)	12 (3A)	12 (3A)	12 (3A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)
OPTION 1 - New Construction of Aegis-Equipped CGNs:																	
Operational - CGNs (Aegis CGNs)	8	8	9	9	9	9	10 (1A)	10 (1A)	11 (2A)	12 (3A)	13 (4A)	14 (5A)	15 (6A)	16 (7A)	16 (8A)	16 (8A)	15 (8A)
SCN Funding (Hull No.)		(42)		(43)	(44)	(45)	(46)	(47)	(48)	(49)							
Delivered (Hull No.)	(40)		(41)				(42)		(43)	(44)	(45)	(46)	(47)	(48)	(49)		
Retired (Hull No.)															(25)R	(35)R	
OPTION 2(a) - Aegis Backfit Into the VIRGINIA (CGN-38) Class:																	
Operational - CGNs (Aegis CGNs)	8	8	9	8	8	8 (1A)	8 (1A)	8 (2A)	8 (2A)	8 (3A)	8 (3A)	9 (4A)	9 (4A)	9 (4A)	8 (4A)	8 (4A)	7 (4A)
SCN Funding (Hull No.)		(38)		(39)		(40)		(41)									
Delivered (Hull No.)	(40)		(41)			(38)		(39)		(40)		(41)					
Retired or in Backfit (Hull No.)				(38)		(39)		(40)		(41)					(25)R	(35)R	
OPTION 2(b) - Aegis Backfit Into the VIRGINIA (CGN-38) Class, CGNs 36-37, and CGN-9:																	
Operational - CGNs (Aegis CGNs)	8	8	9	8	7	7 (1A)	7 (2A)	7 (3A)	7 (4A)	7 (5A)	8 (6A)	9 (7A)	9 (7A)	9 (7A)	8 (7A)	8 (7A)	7 (7A)
SCN Funding (Hull No.)		(38)	(36)	(39)	(37)	(40)	(9)	(41)									
Delivered (Hull No.)	(40)		(41)			(38)	(36)	(39)	(37)	(40)	(9)	(41)					
Retired or in Backfit (Hull No.)				(38)	(36)	(39)	(37)	(40)	(9)	(41)					(25)R	(35)R	
OPTION [illegible] - Aegis Backfit Into the VIRGINIA (CGN-38) Class and Construction of Four CGN-42 Class Ships:																	
Operational - CGNs (Aegis CGNs)	8	8	9	8	8	8 (1A)	9 (2A)	9 (3A)	10 (4A)	11 (6A)	12 (7A)	13 (8A)	13 (8A)	13 (8A)	12 (8A)	12 (8A)	11 (8A)
SCN Funding (Hull No.)		(42) (38)		(43) (39)	(44)	(45) (40)		(41)									
Delivered (Hull No.)	(40)		(41)			(38)	(42)	(39)	(43)	(44) (40)	(45)	(41)					
Retired or in Backfit (Hull No.)				(3P)		(39)		(40)		(41)					(25)R	(35)R	

[illegible]

Option 1(a) (new construction of four Aegis-equipped CGN-42 class ships):

Assuming the CGN-42 is authorized in the FY79 Defense budget, and allowing a one-year gap before three additional CGNs are authorized in successive years, the first nuclear-powered Aegis-equipped ship could be delivered in 1984. Thus, the Navy's minimum requirement for four Aegis-equipped nuclear-powered cruisers described in Case 2 could be met in 1988.

Option 1(b) (new construction of eight Aegis-equipped ships):

This option is an expansion of Option 1(a). It requires that the four CGN-46 class ships be authorized in successive years to the CGN-42 class ships. Under this option 16 CGNs would be available in 1992, eight of which would be Aegis configured. Therefore, under this option the alternate requirements described in Case 1 and Case 2 would be met in 1992 and 1988, respectively, and Case 3 could be achieved in 1991.

Option 2(a) (backfit of four VIRGINIA (CGN-38) class cruisers):

With the CGN-41 about 40% complete, it is considered impractical to equip her with the Aegis system while she is under construction. If an Aegis system backfit for the CGN-38 is authorized by the Congress in the FY79 Defense budget, and for the other three sister ships at two-year intervals (to minimize reduction in the total number of operational CGNs), the Navy could receive the first Aegis-equipped CGN a few months earlier than under Option 1(a). With the assumed backfit sequence, the fourth Aegis-equipped CGN would not be delivered to the Navy until 1989.

Under Option 2(a), neither the CNO's requirement of eight Aegis-equipped CGNs (Case 1) nor his requirement for four Aegis-equipped and eight other CGNs (Case 2) can be met. And the total number of CGNs available after 1997 decreases when the CGN-35 reaches the end of its service life.

Option 2(b) (Backfit of the CGN-38 class, CGNs 36-37, and CGN-9):

This option is an expansion of Option 2(a). In addition to the assumptions used for the VIRGINIA-class ships, it assumes that the backfits of the Aegis system into the CGN-36, CGN-37 and CGN-9 are authorized in the intervening years (i.e., FYs 80, 82, and 84).

Under Option 2(b), nine CGNs would be operational in 1989 (seven of which would be Aegis-equipped) and could essentially meet the CNO's requirements through a combination of Case 1 and Case 2 (i.e., three all-nuclear task forces with two Aegis-equipped cruisers each, and one task force with three nuclear-powered cruisers, one of which is Aegis-equipped). However, the availability of 16 CGNs (Case 3) would not be met.

Option 3 (Backfit of the CGN-38 class and new construction of four CGN-42 class ships):

This option is a combination of Options 1(a) and 2(a). Under Option 3, 13 CGNs would be operational in 1989 (eight of which would be Aegis-equipped) and meet the requirements of Case 1 and Case 2. However, the availability of 16 CGNs (Case 3) would not be met. Option 3 could essentially also meet the CNO's minimum requirement in 1987 through a combination of Case 1 and Case 2 requirements (i.e., two task groups with two Aegis-equipped CGNs per task group, and two task groups with one Aegis-equipped and two non-Aegis-equipped CGNs per task group).

Availability - Cost Analysis

Table B is a comparative analysis of the three options shown in Table A, using availability and cost as criteria.

TABLE B - COMPARATIVE ANALYSIS OF CGN ESCORT FORCE ALTERNATIVES
(cost figures in millions of FY78 dollars)

EVALUATION CRITERIA	OPTIONS: BUILD 1(a)	BUILD 1(b)	BACKFIT 2(a)	BACKFIT 2(b)	BUILD & BACKFIT 3
Availability:					
Maximum number of CGNs	13	16	9	9	13
Aggregate remaining CGN ship-years	328	448	208	208	328
Maximum number of Aegis-equipped CGNs	4	8	4	7	8
Aggregate remaining Aegis-equipped CGN ship-years	120	240	95	143	215
Year in which option would permit meeting the requirements of:					
Case 1 (two Aegis-equipped CGNs per task group; for a total of eight Aegis-equipped CGNs)	none	1992	none	none	1989
Case 2 (three CGNs -- one Aegis-equipped -- per task group; for a total of 12 CGNs -- including four Aegis-equipped CGNs)	1988	1988	none	1989*	1989/ 1987**
Case 3 (four CGNs -- one Aegis-equipped -- per task group; for a total of 16 CGNs -- including four Aegis-equipped CGNs)	none	1991	none	none	none
Cost:					
Program cost (including outfitting and post-delivery costs) to acquire new CGNs (if any) and/or backfit CGNs	3,884	6,974	2,266	4,156	6,150
Remaining-life cost	16,756	24,318	10,666	12,556	19,022
Average remaining annual cost per Aegis-equipped CGN	69.6	66.3	62.2	65.1	66.3
Average remaining annual cost per CGN	51.1	54.3	51.3	60.4	60

* Meets the requirements through a combination of Case 1 and Case 2 (i.e., three all-nuclear task groups with two Aegis-equipped cruisers each, and one task group with three CGNs, one of which is Aegis-equipped).

Also meets the Case 2 requirements through a combination of Case 1 and Case 2 requirements (i.e., two task groups with two Aegis-equipped CGNs per task group, and two task groups with one Aegis-equipped and two non-Aegis-equipped CGNs per task group).

Findings Concerning Escort Requirements for All-Nuclear-Powered Aircarft Carrier Task Forces:

a. The capability of a carrier task force to cope successfully with an anti-ship missile attack, of the scope and intensity postulated within the capabilities of the Soviet Navy in the near future, depends on the availability of one or more Aegis weapon systems in the task force, if Aegis performs as expected.

b. The number of escorts required should be determined considering the entire spectrum of the threat (i.e., AAW, ASW, and Surface Warfare). The analytical basis of an escort force of two or three surface escorts and one to three submarines for a carrier-supported task group has not been reported to the Congress.

c. For a Navy force level of four all-nuclear-powered aircraft carrier task forces, the number of surface escorts required depends on the number of Aegis-equipped escorts available. The minimum number of Aegis-equipped escorts stated by the CNO is four -- one for each task force. However, in this case eight or more additional non-Aegis-equipped escorts would be needed. The minimum number of escorts required results when eight Aegis-equipped escorts are available, if the CNO's stated requirements are accepted as valid.

Comparison of Alternatives for the Aegis-Equipped CGN:

Among the three alternative ways of acquiring a sufficient number of Aegis equipped nuclear-powered cruisers to meet mission requirements, the choice depends on the relative emphasis given to cost and availability criteria. Build options are, in general, more costly than backfit options, but result in more ships available, in total numbers and during the acquisition period. A suitably structured build and backfit alternative may offer an acceptable compromise.

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NUCLEAR-POWERED AEGIS SHIP ALTERNATIVES

BACKGROUND, PURPOSE AND SCOPE

Background

Surface ship survival at sea in the presence of the threat posed by modern surveillance systems and anti-ship missiles requires effective defensive systems. According to Department of Defense officials, the Navy's currently deployed fleet-defense surface-to-air missile (SAM) systems are not sufficiently effective against the new generation of Soviet missiles, and the Aegis SAM system is urgently needed to overcome this deficiency.

The Navy's stated minimum requirement for Aegis-equipped nuclear-powered cruisers is based on the number of nuclear-powered aircraft carriers in the fleet. The Chief of Naval Operations (CNO), Admiral James L. Holloway, has testified that if an all-nuclear-powered aircraft carrier task group has three nuclear-powered guided-missile cruiser (CGN) escorts, only one need be an Aegis-equipped ship. If only two cruisers are assigned to the task group, they should both be Aegis equipped.[1/] Therefore, since the Navy has four nuclear-powered aircraft carriers in service or under construction, the minimum requirement stated by the Navy is for eight CGNs if all are Aegis-equipped or 12 CGNs if only four have the Aegis weapon system.[2/] When the USS ARKANSAS is delivered in 1980 the Navy will

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1/ House Appropriations Subcommittee on the Department of Defense. FY 1978 Appropriations Hearings, Part 4, p. 738.

2/ The number of Aegis-equipped CGNs required is dependent on the number of CGNs available.

have nine nuclear-powered cruisers, none Aegis-equipped.

Because of the high cost of an Aegis-equipped nuclear-powered cruiser ($835 million for the second and subsequent ships of the proposed new CGN-42 class), the most cost-effective way of satisfying the Navy's minimum requirement is of interest.

This report examines three basic solutions to satisfy the Navy's requirement. One solution is to build new Aegis-equipped CGNs. A second solution is to backfit the Aegis weapon system into existing nuclear-powered cruisers such as the four ships of the VIRGINIA class. And a third solution is to build new Aegis-equipped CGNs and backfit the Aegis system into existing nuclear-powered cruisers.

An important factor in determining whether to backfit the Aegis system into the VIRGINIA class, is whether the Tartar-D SAM system (as currently installed in the VIRGINIA class) is adequate against the postulated future threat. Another factor, is the cost to backfit compared with new construction; while a third factor,is the number of CGNs required for the all-nuclear-powered carrier-supported task groups.

With respect to the adequacy of the Tartar-D system, the Senate Armed Services Committee denied funding in 1975 for a fifth Tartar-D-equipped VIRGINIA-class cruiser with the following comment:

> The Committee has carefully considered this request and believes it inappropriate to build any ship, and especially a nuclear ship, with a weapon system that is clearly inadequate to meet the projected threat within a relatively short period

of time after delivery of the ship. 1/

Issues Addressed in this Report: (1) Will Tartar-D-equipped cruisers of the VIRGINIA class be useful and viable against future threats? (2) What is the minimum number of CGNs required in an all-nuclear-powered carrier-supported task group? (3) Is backfitting the Aegis system into existing nuclear-powered cruisers the most cost-effective way to meet the Navy's minimum requirement for Aegis-equipped CGNs?

Purpose

This report evaluates the adequacy of the Tartar system in the USS VIRGINIA (CGN-38) and her sister ships against the current threat, and the threat projected through the year 2000. The report then examines the costs of building new Aegis-equipped CGNs as compared with the cost of backfitting the Aegis system into existing nuclear-powered cruisers, and examines the cost of a combination of these options. It also assesses the impact of each option on the numerical requirement for nuclear-powered guided-missile cruisers as carrier escorts.

Scope

This report discusses the performance of the medium-range surface-to-air Tartar-D missile system, as now installed in the USS

1/ Senate Armed Services Committee. Report to accompany S. 920, Authorizing Appropriations for the Department of Defense for FY 1976 and July-September Transition Period. Senate Report no. 94-146. p. 56.

VIRGINIA (CGN-38), against expected threats in the 1990s and beyond, and considers the expected improvements in its performance after projected modifications.

In comparing the cost of new Aegis-equipped CGNs versus the cost of backfitting the VIRGINIA class and other CGNs with the Aegis system, and versus the cost of a combination of these options, the report discusses various implications of these solutions and, in particular, the role of the CGN as an escort for the nuclear-powered aircraft carrier and the number of CGNs required for that role.

Although there is a design for a conventionally-powered class of Aegis-equipped destroyers, the first of which (DDG-47) was authorized by Congress in FY78, conventionally-powered Aegis-equipped ships will not be addressed in this report because its scope is limited to nuclear-powered cruisers.

WEAPON SYSTEM DESCRIPTION

Current Tartar-D System

For a better understanding of the current Tartar-D system it is appropriate first to provide a brief description of the guided-missile cruiser platform in which it is currently installed.

The USS VIRGINIA (CGN-38) was commissioned in September 1976. As described by her commanding officer,[1/] the VIRGINIA brings to the Navy's operating forces the latest combat systems equipment now available. She

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1/ Davis, George W., Jr., Capt., USN. USS VIRGINIA (CGN-38). U.S. Naval Institute Proceedings. Aug. 1977. p. 85.

possesses the fleet's first fully integrated command and control system. This command and control system relies on multi-purpose information exchange among its computers through the use of a commom "memory." The use of a common "memory" increases the information exchange rate.

Other innovative features of the VIRGINIA permit the manning level to be reduced from that required for other ships of similar size. In addition, her design makes allowance for space to add new equipment as the requirements evolve during the remainder of this century.

The VIRGINIA's anti-air warfare (AAW) system is built around the Tartar-D's MK-74 missile-fire-control system which fires the Standard SM-1(MR) medium-range missile. The primary air-search capability of the system is provided by the SPS-48A three-dimensional (3D) radar, which indicates height of the target as well as its direction and distance. Backing up the SPS-48A radar is the MK-86 gun-fire-control system, which, with its own air-track and surface-search radars (SPG-60 and SPQ-9, respectively) can track targets at speeds up to Mach 3.

Command and control, and target designation, are provided through the conventional Navy Tactical Data System (NTDS). Information received either from shipboard sensors (radars or sonars), or via data link from other ships, is presented as target symbols on the ship's NTDS consoles in the Combat Information Center (CIC). Targets are designated to the SPG-51D missile-guidance radar, either manually or automatically, through a computer software module of the command and control program. This current target designation[1/] system is a significant improvement

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1/ Weapons designation is the process of commanding the high-powered, narrow-beam, missile-fire-control radar where to look for a target.

over the earlier Tartar installation which required a separate manually-operated weapons-designation system.

The semi-active homing SM-1(MR) missile has a range of about 25 miles.[1/] Semi-active homing relies on the target's reflectivity to an illumination signal transmitted from the missile-firing ship. The VIRGINIA-class cruisers have three illuminator channels to provide for missile homing, one in each of the two SPG-51D missile-fire-control radars, and one channel by utilizing the MK-86's gun-fire-control system SPG-60 radar. The SM-1(MR) missiles are launched from two twin-arm MK-26 missile launchers, one at each end of the ship.

Tartar/Aegis Comparison

In assessing the Tartar system's capability, some standard of comparison is necessary. The Aegis system is the most advanced shipboard SAM system now under development and is, therefore, a logical system against which to compare the Tartar system. The performance of both systems against the postulated threats will be presented in the sections that follow.

The Tartar-D's radars have rotating antennas which can sweep through 360 degrees in about four seconds, whereas the Aegis' SPY-1 radar (with no moving parts) sweeps by means of electronically activating discrete elements of the antenna through 360 degrees at least once every second. Further, the SPY-1's electronic signal transmissions are under computer control and thus the sweep can be varied instantly and

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1/ Standard Missile. Missiles/Spacecraft. Defense Marketing Service Intelligence Report. Greenwich, Conn. p. 1.

flexibly to confirm detections, establish tracks, examine a high activity area, provide missile control, whereas the Tartar-D's radar follows a rigid pattern.

Target detection, tracking, and evaluation is essentially a manual process for the Tartar-D system as now configured, whereas in the Aegis system it is completely automatic and therefore faster as well as more certain. With the Tartar system the target must be designated to the fire-control radar, which in turn must make its own detection. The missile-fire-control system must then "lock on" the target or commence to track it automatically with the fire-control radar. In contrast, the Aegis' SPY-1 radar functions both as a search and fire-control radar. Thus the Aegis system, with no intermediate target designation process, can commence firing with significantly less delay than the Tartar system.

The Aegis system uses the Standard SM-2(MR) missile which has a range of approximately 40 miles,[1/] and a mid-course command-guidance capability. In the Aegis system radar tracks both the missile and the target, and through data link directs the missile on an intercept trajectory. The Tartar system on the other hand, with the SM-1 missile, must have one of its three guidance radars dedicated individually to each missile salvo throughout its flight. The firepower of the Aegis system is significantly greater than that of the Tartar system because the Aegis system has four computer-controlled illuminators,

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1/ Standard Missile. Missiles/Spacecraft. Defense Marketing Service Intelligence Report. Greenwich, Conn. p. 1.

and these need to illuminate their targets only during the terminal phase of the missile's flight. Thus, the Aegis system is able to guide more missiles in flight than the Tartar system, and to intercept targets at further ranges with its SM-2(MR) missiles. In addition, the Aegis' system SPY-1 radar can, through computer control, transmit on a variety of frequencies, making it difficult to jam. This and other design features permit the Aegis system to operate against heavy electronic counter-measures (ECM) with relatively small degradation in system effectiveness. In contrast, the SPS-48A radar of the Tartar-D system, lacking the adaptability of the SPY-1, has a considerable degradation of performance in a severe electronic jamming environment.

Material Performance

A development program initiated in 1951 led to the first successful firing of a missile from a Tartar-equipped ship in 1961. Subsequent to that test, after the introduction of a completely new SAM design technology into the fleet, the early version of the Tartar system was beset with material performance problems. These material problems were corrected by incremental changes during the period 1960 to 1970. The basic Tartar system, with performance up to its design potential, remains in service today on many ships of the Navy.

In the period 1964 to 1968 the digital Tartar-D system was developed as a logical evolution of the basic analog Tartar system design of the 1950's. The Tartar-D system was designed with a digital fire-control system compatible with the NTDS, and an increase in radar power. In addition to the flexibility provided by digital computers, the Tartar-D system overall maintainability and availability were upgraded through the use of improved solid-state devices, added redundancies, and simplifications of system adjustments.

The newest available operational Tartar-D system went to sea in 1974, in the USS CALIFORNIA (CGN-36). However, initial performance of the Tartar-D system in the CALIFORNIA left much to be desired in respect to full realization of the basic capabilities of the systems installed, and a major improvement program was initiated by the Navy to bring the system up to design intent capability. The lessons learned from the Tartar-D system installation in the CALIFORNIA were used in guiding the installation and integration of the Tartar-D system in the VIRGINIA. The VIRGINIA's Tartar-D system underwent at-sea operational evaluation in April 1977, and although the formal report on this evaluation will not be available until early in 1978, informal discussion with Navy officials indicates that the system's performance met their expectations. In addition to the at-sea operational evaluation of the Tartar-D system as a separate entity, an operational evaluation of the VIRGINIA's entire combat system is scheduled for 1978. This operational evaluation will provide figures on material performance. However, preliminary results show that material performance will be satisfactory.

<u>Potential Improvements to Tartar-D</u>

The threat against which a weapon system must perform changes as technological innovations are introduced in the adversary's competing forces. To remain viable even the newest weapon systems must be continuously upgraded and modernized to enable them to deal with the enemy's improving capabilities.

A number of modifications to the Tartar-D system and its associated equipment are in the planning and development stages. Each of these modifications can contribute to enhancing the performance of the Tartar-D system. The significance of the modifications are discussed later in this report.

The first major modification, an Automatic Detection and Tracking (ADT) feature for the SPS-48A search radar, will be installed in the VIRGINIA class starting in 1978. The modified SPS-48A radar will be designated as the SPS-48C.

The second major area of improvements involve shipboard fire-control equipment and SM-1(MR) missile modifications, and the installation of a more effective receiver antenna in the SM-1(MR) missile.[1/] These changes will permit mid-course command guidance of the missile during its flight.

The third major potential improvement to the Tartar-D-equipped CGNs is gained when they are in company with a ship equipped with a Task Force Anti-Air Warfare Weapons Coordination System (TFAAWCS). However, this improvement is possible to implement only in an Aegis-equipped ship. Although the TFAAWCS has been funded to

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1/ Standard Missile. Missiles/Rockets. Program Element 6.33.66.N, Fundings has been (in millions): FY76 $30.8; FY7T $4.0; FY77 $11.9; and FY78 $2.1. Defense Marketing Service Intelligence Report. Greenwich, Conn. p. IV-195.

some extent [1] and is recognized by the Navy as an important item for fleet introduction in the 1980's, [2] its development seems to be lagging with minimal funding.

There are some surface-to-air missile developments underway that also are applicable to the Tartar-D system. Significant among them is the development of a complete shipboard system for launching Standard missiles from a vertical canister. The major advantages of the vertical launch installations are higher firepower, redundancy, and simplicity. During 1978 a prototype Vertical Launch system is scheduled for installation for at-sea tests in the USS NORTON SOUND. In addition, there are projects to upgrade the performance of the Standard missile. These projects include a higher class of rocket propellant, rocket motor design changes, [3] and a nuclear warhead designed for the SM-2(MR) missile [4] -- some of which may be applicable to an improved SM-1 missile. However, no firm plan has been announced by the Navy to incorporate these changes.

1/ Tactical Programs, Navy FY 1978/FY 1979. Program Element 6.33.66.N, Task Force Anti-Air Weapons Coordination System. Industry News Service, Inc. Wilton, Conn. p. N-122.

2/ House Appropriations Subcommittee on the Department of Defense. FY 1978 Appropriations Hearings, Part 4, p. 742.

3/ Standard Missiles. Tactical Programs, Navy FY 1978/FY 1979, Program Element 6.43.66.N. Industry News Service, Inc. Wilton, Conn. p. N-226.

4/ Surface Missiles Warhead Development. Missiles/Rockets. Program Element 6.43.65.N. Defense Marketing Service Intelligence Report. Greenwich, Conn. p. IV-193.

ANTICIPATED THREATS

The Navy's functions require that its ships be able to move freely in all of the world's oceans. The primary threat that could inhibit the Navy's free movement at sea comes at present from the Soviet Naval Forces. The Soviet Union has developed a substantial capability for attacking the U.S. Navy's surface forces with missiles launched from aircraft, submarines, and surface ships. The capabilities of the Soviet Navy may be further upgraded in the future as its forces increase their ability to coordinate operations through the use of satellite surveillance and improved command, control, and communications systems (C^3).

The Soviet land-based naval aviation constitutes the greatest numerical anti-ship missile threat. Soviet Naval Aviation has consisted up to recently of about 290 BADGER land-based jet-powered aircraft fitted to carry several types of anti-ship missiles possessing "stand off" ranges of over 130 nautical miles. The capabilities of the Soviet Naval Aviation are being enhanced significantly by the replacement of the 1500-mile range BADGER with the BACKFIRE bomber, a supersonic (Mach 2.0) land-based aircraft reported to have an unrefueled high-altitude subsonic combat radius of some 2500 miles.[1/]

The next greatest anti-ship missile threat is posed by the Soviet submarine force. Approximately 67 Soviet submarines are now equipped with anti-ship missiles, among these are the CHARLIE-class and PAPA-class submarines capable of launching their 30-nautical mile range SS-N-7

1/ O'Neil, William D. Backfire: Long Shadow on the Sea-Lanes. U.S. Naval Institute Proceedings. Mar. 1977. p. 29.

anti-ship missiles while submerged. The other anti-ship missile-firing submarines must surface to launch their SS-N-3 missiles capable of ranges over 150 nautical miles.

Finally, there are about 72 Soviet surface-combatant ships, and hundreds of smaller surface craft which carry anti-ship missiles. Some of these missiles have ranges up to 300 nautical miles.

The newest Soviet anti-ship missiles are supersonic, and employ a variety of flight profiles that compound the problem of defense against them. Their survivability toward the target is improved through electronic jamming capabilities possessed by the Soviets. Most significant, most (if not all) Soviet anti-ship missiles can carry either high explosive (HE) or nuclear warheads.

Some general characteristics of Soviet naval anti-ship missiles are listed below.[1/]

	Range (nautical miles)	Speed (Mach)	Warhead Type	Initially Operational (year)
Surface-Launched				
SS-N-3 (Shaddock)	150-200	1.5	HE or nuclear	1960
SS-N-9	150	1.0+	HE or nuclear	1968-69
SS-N-12	300	?	?	
Submerged-Launched				
SS-N-7	30	1.5	?	1969-70
Air-Launched				
AS-3 (Kangaroo)	350	2.0	nuclear	1960
AS-4 (Kitchen)	250	4.0	HE or nuclear	1967
AS-5 (Kelt)	150	1.0	HE or nuclear	1965
AS-6 (Kingfish)	200	3.0	HE or nuclear	1970
AS-7	6	1.0	HE	1971

1/ Unclassified Defence Intelligence Agency sources.

The AS-6 missile is believed to arm the supersonic BACKFIRE bomber. It is possibly an improved version of the AS-4 and may be serving as an interim weapon pending introduction of a higher performance missile specially configured for the BACKFIRE.

The AS-7 missile is probably deployed with the SU-19 FENCER swing-wing multi-role strike aircraft. There are at least two more new weapons to be identified, the FENCER's alternative missile armament and the new, high-performance, stand-off missile for the BACKFIRE.

In 1970 and again in 1975, the Soviets carried out major naval exercises which showed that they could conduct anti-ship attacks on a large scale. In 1975 special emphasis seemed to be placed on attacking surface ships, especially by aircraft equipped with missiles. In the 1975 naval exercise, the Soviet Navy demonstrated convincingly that its surveillance, command and control, and attack systems could be organized to conduct coordinated massive attacks on an opposing fleet. 1/

The Defense Intelligence Agency (DIA) has stated 2/ that the largest proportion of Soviet ships and weapon systems for the year 2000 are already observable in their fleets, are under construction, or are in advanced research and development. Therefore, the DIA claims much of the information on 50 to 65 percent of this force can be projected with some confidence. Other estimates consist of forecasts and projections

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1/ Watson, B.A. and M.A. Walton. Okean-75. U.S. Naval Institute Proceedings. July 1976. pp. 93-97.

2/ The Soviet Naval Threat Circa 2000 (Secret). Defense Intelligence Agency. Aug. 1977.

based upon an assessment of Soviet perceptions of their needs. The Soviet air threat to our surface ships will probably continue to evolve slowly and probably in a direction of more sophistication. The higher speeds of the more recent Soviet anti-ship missiles, improved coordination among Soviet naval forces, and greater deployment -- trends that are now evident -- tend to confirm this projection.

The CNO, Admiral Holloway, testified to the Congress[1/] that the high-threat areas are those in which the Soviet Union can coordinate and execute "saturation attacks," attacking nearly simultaneously with more weapons than our defensive systems can engage in a short period of time. The CNO considers high-threat areas to be those which lie within a 1,000 to 1,500-mile radius of bases in the Soviet Union -- the Norwegian and North Seas, the Baltic, Eastern Mediterranean, Sea of Japan, and much of the Western Pacific. However, as a greater proportion of the Soviet submarine fleet becomes nuclear powered, and as more BACKFIRE aircraft become operational, these high-threat areas will expand.

Jane's Fighting Ships[2/] states that the Soviets now have a capability to deploy "in security" to all the major strategic maritime areas, with assured anchorages and berthing facilities in Cuba, Guinea, South Yemen,

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1/ House Appropriations Subcommittee on the Department of Defense. FY 1978 Appropriations Hearings, Part 4, p. 722.

2/ Jane's Fighting Ships 1977-1978. New York. p. 117.

and possibly Angola and Mozambique. Soviet naval aircraft regularly deploy to Cuba and Guinea.1/ Thus, the Soviets are becoming capable of posing a threat in many areas of the world if they so desire.

In summary, the Soviets have today the capability to pose a severe air threat to the U.S. Navy's surface-combatant ships in many critical areas of the world. This threat is primarily based on a large number of anti-ship missiles, and the Soviet's demonstrated capability to coordinate their naval resources for large-scale attacks within some 1,500 miles of their homeland. If present trends continue, before the end of the century the Soviet Union will be able to mount a challenge of varying intensity to U.S. Naval Forces world-wide.

PERFORMANCE ANALYSES

Navy Analyses

Data upon which this report is based includes examination of Navy analyses on the performance of the Tartar-D and Aegis weapon systems, and on a study made by the Institute for Defense Analysis.2/ One Navy analysis matched AAW systems against the expected threat for the near-term (1979-1983), mid-term (1984-1993), and far-term

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1/ The Soviets have obtained flight facilities (officially to relieve trawler crews) at Mauritius, and have sought similar facilities in Tonga and Western Samoa in return for construction of airfields. However, peacetime use of these facilities does not necessarily translate into permission to use them for wartime missions.

2/ Fleet Air Defense: Analysis of Certain Systems and Concepts for Ship-Based Area Weapon Systems (Secret). Institute for Defense Analysis. Washington. Apr. 1975.

(1994-2003).[1/] In so doing, the Navy's analysis identified deficiencies in capabilities and steps being taken to correct them. The study by the Institute for Defense Analysis dealt with performance of integrated groups of ships in escort roles against massive attacks. The analysts used computer runs based on assumed performance perameters.

A report on modernization options for the USS LONG BEACH (CGN-9) was furnished to the Senate and House Armed Services Committees in November 1975.[2/] The report compares in some detail the expected performance of a Tartar-D system with an Aegis system if either were backfitted into the LONG BEACH. Another Navy report highlighting Tartar missile system problems and performance was issued in 1975.[3/]

Because published analysis on the capabilities of the Tartar-D system against the projected threat is not available, the consultants assisting in the preparation of this report held informal discussions on this subject with Navy officials[4/] and a Tartar development consultant.[5/] Data and analyses examined and discussed were comprehensive and thorough with perhaps one exception. The possibility of having to counter nuclear

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1/ Surface Warfare Plan (Secret). Deputy Chief of Naval Operations for Surface Warfare. Navy Department. Washington. Sept. 1977.

2/ USS LONG BEACH Modernization Study. Naval Sea Systems Command (NavSea-93). Navy Department. Washington. 1975.

3/ SMS Project Manager Final Report (Secret). Surface Missile Systems Project Manager. Navy Department. Washington. Mar. 20, 1975.

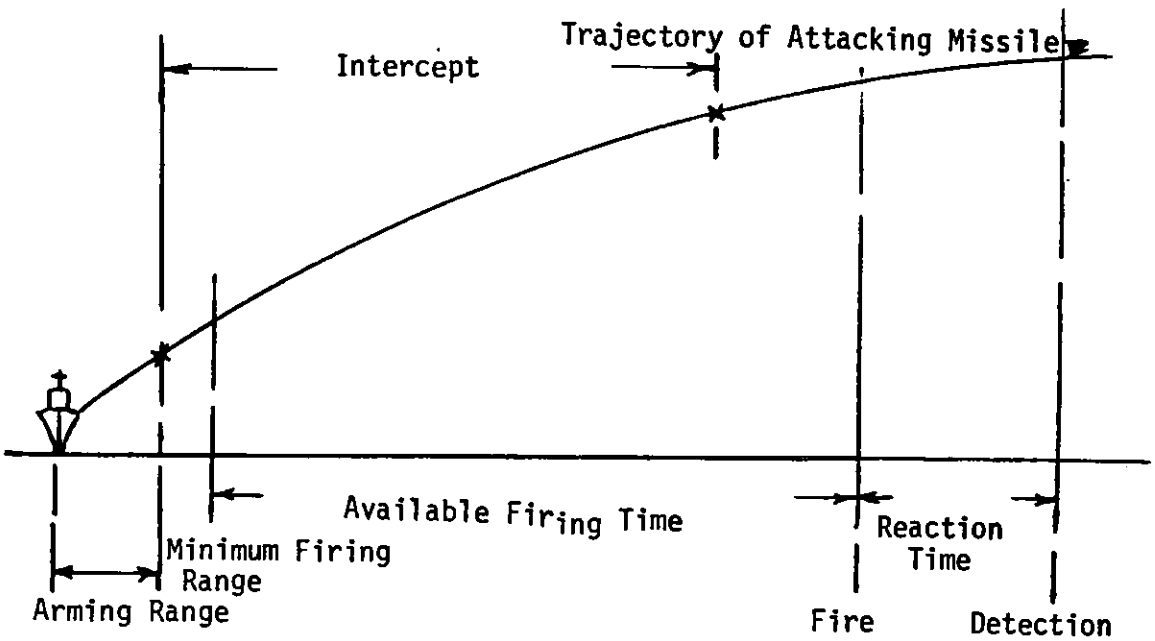
4/ Naval Sea Systems Command, Navy Department. Washington.

5/ Applied Physics Laboratory, The John Hopkins University.

weapons is not addressed in any depth in analyses made available. Yet, the Soviet nuclear warheads are certainly part of the threat the Navy's surface forces may be expected to counter.1/

Ship AAW Operational Performance

In any shipborne surface-to-air missile (SAM) weapon system, there are six key elements to AAW operational performance: (1) detection, (2) reaction time, (3) firepower, (4) area coverage, (5) susceptibility to electronics countermeasures (ECM), and (6) system availability. These elements can perhaps best be understood in connection with the diagram below.



1/ Kassing, David. Protecting the Fleet. Paper prepared for the American Enterprise Institute Conference on Problems of Sea Power as We Approach the 21st Century. Oct. 1977: p. 15. Kassing notes that the basic rationale for the Navy's tactical nuclear posture has received little attention and that literature on the subject is negligible. He speculates that the principal reason for this neglect has been the clear and distateful results of studies carried out in the 1960's.

Time is a particularly critical factor in intercepting an attacking missile. Firing time is maximized if detection takes place outside the envelope of the defensive missile's capability so that the attacking missile can be engaged as early as possible. If detection occurs inside the defensive missile's envelope, every second of reaction time decreases the time available to fire the defensive missile. Available firing time is compressed as the speed of the attacking missile increases. Maximum possible firing time for the Tartar-D system, and for the Aegis system with its longer range missile, is shown below for various attacking missile speeds.

	Approximate Maximum Available Firing Time (in seconds)		
	Attacking Missile Speed		
System	Mach 1	Mach 2	Mach 3
Tartar-D	138	69	46
Aegis	228	114	76

Detection probability is affected by conditions such as target size, altitude, presence or absence of ECM, and operability of installed radars.

Reaction time after initial detection consists of the time required to: establish a track, recognize the target as an attacker, and designate the target to the fire-control radar (which must in turn establish a track and then "lock on" the target).1/ In addition, the defensive-

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1/ Since the Aegis radar functions as both detection and fire-control radar, the second track and "lock on" functions are not part of the Aegis' system reaction time.

missile's launcher must be armed with missiles and slewed to the direction of the incoming target.[1/]

Firepower becomes critical against multiple missile attacks. In addition to the number of missiles in the magazines as a limit to firepower, the time for initial loading and the reloading of the launchers from the magazines may in many situations be vital.

Area coverage is limited to the missile's range/attitude envelope including the minimum range required for the missile to arm after it is launched.

The susceptibility of a system to ECM is a significant factor in its performance. ECM or jamming can materially reduce the detection range. It increases reaction time, and it may decrease the probability of successful terminal homing by the missile.

System "availability" is based on the probabilities that the myriad of components of the radars, computers, fire-control systems, launchers, and the missiles function properly, or have adequate redundancy to permit operations in the presence of malfunctions.

Tartar-D System Current Performance

Admiral Rickover testified to the Congress in March 1973 as follows:

> The anti-air warfare (AAW) sensors and weapons being installed in the DLGN-38 class nuclear frigates are the best available today and for the next several years. The Navy considers that the Standard missile with the sensors and Tartar-D fire control system

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1/ The Vertical Launch system will eliminate this requirement.

in this class of ships will be more capable against cruise missiles than any AAW missile system now in the fleet. 1/

From discussions with Navy officials and missile systems contractor personnel of the Applied Physics Laboratory, The Johns Hopkins University, and review of classified data reflecting current Tartar-D performance, the following general assessment has been determined on an individual ship performance basis.

-- Detection: The SPS-48A three-dimensional scanning radar installed in the VIRGINIA-class cruisers is the most modern air-search radar in current use in the fleet. It does, however, depend on manual methods for detection of targets. For this reason the full potential of the radar has not been realized in fleet operations, and the detection capability of the Tartar-D AAW system against multiple high-speed targets is marginal considering today's threat environment.

-- Reaction Time: Performance is adequate against the low-threat target (i.e., subsonic target having a relatively large radar cross-section in a clear ECM environment). Performance degrades against high-threat targets (i.e., multiple supersonic targets having small radar cross-sections, and in a high ECM environment).

-- Firepower: Performance is inadequate against high-threat targets. Simple arithmetic shows that Tartar-D in the VIRGINIA-class cruisers

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1/ Joint Committee on Atomic Energy. Naval Nuclear Propulsion Program -- 1972-73. FY 1973 Hearings, Part 1, p. 117.

(having only three radar illuminating channels) saturates under the most favorable conditions (i.e., initial detection well beyond the SM-1(MR) missile's performance envelope) when attempting to intercept nine Mach 1.5 missiles approaching simultaneously.

-- Area Coverage: The Tartar-D system is currently limited to the performance envelope of the SM-1(MR) missile, which has a range of approximately 25 nautical miles and a ceiling of at least 50,000 feet.[1/]

-- Susceptibility to ECM: On a stand-alone basis, the Tartar-D system performance will degrade significantly in a medium to high ECM environment.

-- System Availability: The Tartar-D system in the VIRGINIA seems to have met the availability specifications. A more precise assessment will be available upon completion of the operational evaluation in 1978.

Postulated Future Tartar-D System Performance

As noted earlier there are a number of modifications in planning or development which could significantly enhance the performance of the Tartar-D system. According to senior Navy technical personnel the technical feasibility of these improvements is not in doubt.[2/] However, given the present low funding support, completion of engineering development, testing, and initiation of production of many of these modifications for fleet introduction

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1/ Standard Missile. Missiles/Spacecraft. Defense Marketing Service Intelligence Report. Greenwich, Conn. p. 1.

2/ Informal conversations with Rear Admiral E.W. Carter III, Deputy Commander Weapons Systems and Engineering Directorate, Naval Sea Systems Command, and Rear Admiral W.E. Meyer, Project Manager Aegis Project, Naval Sea Systems Command. Washington.

in the near term (i.e., by 1982) is not possible. With adequate funding support, they believe these improvements could be placed in the fleet in the 1985 to 1990 period.

When the Automatic Detection and Tracking (ADT) modification is applied to the SPS-48 radar, its detection probability should approach 100% for both low and high-threat targets as is the case with the Aegis system. With the ADT feature, target parameters are set directly into the system. The ADT system computers are far faster, and more reliable (especially with heavy traffic), than a human operator in noting scattered indications and determining whether target parameters meet the threat criteria set into the system. In addition, the reaction time will also be decreased significantly by target evaluation and designation becoming automatic. The SPS-48 radar with the ADT feature should have a real capability against high-threat targets. This improvement has been funded as previously noted, and installations will begin in 1978 on some SPS-48-equipped ships.

The Standard Missile Mid-Course Guidance Modification would by the mid-1980s give the Tartar-D system increased firepower through the ability to engage more than three targets simultaneously. This improvement is necessary to permit the in-flight control of the missiles fired by a VIRGINIA-class cruiser by any Aegis-equipped ship. It would also increase the missile's capability in a jamming environment.

Other projected missile upgrading projects would provide the Standard missile with extended range, improved dynamic (maneuvering) performance, and better resistance to ECM, while providing greater capability to the Tartar-D system and the Aegis system as well.

The projected Task Force Anti-Air Warfare Coordination System (TFAAWCS) would significantly improve full coordination between ships equipped with the Aegis and Tartar-D systems. A missile with the mid-course guidance feature, compatible with both systems, is one key factor in making the TFAAWCS work. The TFAAWCS will be discussed in greater detail later in this report.

The Vertical Launch system, undergoing development, is attractive for its lighter weight, greater simplicity, higher firepower, lower manning level, and because it would allow for the quick selection of different missile types. While the Vertical Launch system once fully developed should provide better performance than the present MK-26 missile launcher, and at lower cost, the installation will probably be practical only for ships under construction.

The Nuclear Warhead option for the Standard missile is intended to to provide a defensive capability against surface-hardened warheads of conventionally-armed and nuclear-armed anti-ship missiles, particularly in a jamming environment.[1/]

Escort AAW Capabilities

Thus far, the performance of the Tartar-D system has been considered on a single ship or stand-alone basis. However, it is appropriate also to consider the capabilities of a Tartar-D-equipped

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1/ Surface Missiles Warhead Development. Missiles/Rockets. Program Element 6.43.65.N. Defense Marketing Service Intelligence Report. Greenwich, Conn. p. IV-193.

surface escort in a carrier task group. The basic elements to determine the number of carrier escorts needed to counter the air threat are: detection, control, coverage, and engagement.

Detection of the enemy is the first requirement of a ship or task group. Generally, detection can be accomplished satisfactorily by a single ship equipped with the new two-dimensional (2D) and three-dimensional (3D) search radars coupled with the integrated Automatic Detection and Tracking system. Low-flying attackers, seeking to approach below the radar horizon, may be detected by AEW (E-2) aircraft. The output data of the detection system defines the enemy's location, and predicts his future movements with respect to the task group.

Control, the threat evaluation and weapons assignment process, is one of the significant deficiencies in the ability of the force to respond successfully to the various types of detected threats. Progress in the 1960s and 1970s in implementing the Navy Tactical Data System (NTDS), and digital Weapon Direction Systems, has improved individual ship weapon control. However, until the advent of the Aegis system, AAW systems coordination control between and among the AAW ships of the escort force will be difficult, and subject to easy saturation.

Coverage, involves the capability of the SAM system to provide an AAW protective umbrella over the task group. Coverage required is dependent on the size of the task group, its dispersal, an threat environment, among other factors.

Engagement involves the launching of missiles to intercept and destroy the attacking enemy missiles or aircraft. The Navy claims that currently available and future improved Standard missiles under development, for use by both the Aegis and Tartar/Terrier-equipped ships, will give the aircraft carrier escorts a high kill probability for the present and through the projected threat of the 1990's.[1/] However, a General Accounting Office (GAO) report completed in 1977 is less optimistic.[2/]

The Institute for Defense Analysis (IDA) has conducted an extensive analysis of the AAW capabilities possessed by an aircraft-carrier-supported task force when defended by six escorts.[3/] Low and high intensity enemy attacks by anti-ship missiles (delivered under various attack profiles), countered by eight different mixes of Terrier/Tartar/Aegis-equipped escorts, are considered in the IDA analysis. Some escort forces in the IDA analysis included Aegis-equipped ships, some did not. The weapon system configurations in the individual ships of the escort forces were varied from currently operational equipment to configuration including projected modifications such as: installation of the

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1/ SMS Project Manager Final Report (Secret). Surface Missile Systems Project Manager. Department of the Navy. Washington. Mar. 20, 1975.

2/ Information on Fleet Air Defense (Secret). Report to the Congress. General Accounting Office. Washington. Apr. 25, 1977.

3/ Fleet Air Defense: Analysis of Certain Systems and Concepts for Ship-Based Area Weapon Systems (Secret). Institute for Defense Analysis. Washington. Apr. 1975.

Automatic Detection and Track (ADT) system, SM-2 missile improvements, Vertical Launch system, and task force coordination of AAW fire.

Against the several threat profiles used in the analysis, the IDA study indicates a threefold performance improvement of the projected modified Tartar-D system over the current baseline Tartar-D system. In every scenario considered, Aegis-equipped escort forces performed significantly better than non-Aegis-equipped forces. In addition, TFAAWCS coordination of the task force AAW escorts' missile-firepower improved the AAW performance in all of the scenarios analyzed.

Although the Tartar-D system alone cannot defend against high-intensity threats, when Tartar-D-equipped ships are accompanied by an Aegis-equipped ship the total AAW capability of the two systems is higher than the sum of their individual capabilities.

CARRIER TASK FORCE PROTECTION

World War II established the pre-eminence of the aircraft carrier as the principal capital ship in the Navy. Since that time all the Navy's numbered fleets have been organized around the attack aircraft carrier (conventionally-powered -- CV, or nuclear-powered -- CVN). Combat experience in the Korean and Vietnam limited wars, while confirming the offensive capabilities of the Navy's carrier task forces, did not subject the ships to any meaningful threat in a modern sense.

The Navy recognizes that the Soviet Union since World War II has built and deployed major naval forces having, among other purposes, an anti-carrier mission. The Soviet anti-carrier capability is composed of aircraft, submarines and surface ships. Although each of these platforms operates in a different medium, and each has its individual capabilities and limitations, all three rely on the anti-ship missile as their principal weapon. Appreciating this significant threat against its carrier forces, the U.S. Navy has developed the tactical concept of defense in depth against attack. This concept calls for the destruction of the attacking platform before it can launch its weapons -- a task that is assigned to carrier-based aircraft and submarines in the escort role. However, should they fail, the next effort is to shoot down or decoy the enemy missiles before they can reach their targets. This latter task is shared by aircraft and surface escorts using air-defense missiles and guns.[1/] Surface escorts also must defend against submarines that approach near enough for a torpedo attack. In this role they may attack with short-range anti-submarine weapons, seeking to destroy or distract the attacking submarine. And in tense, edge of war, crisis management situations such as in the Mediterranean Sea during the last two Mid-East wars, when the Soviet and U.S. fleets were at times intermingled, surface escorts have a role against opposing surface ships. As U.S. surface ships are fitted with the Harpoon medium-range anti-ship missile over the next several years, their anti-ship role will increase.

Escort Requirements

In his FY 1969 Defense Posture Statement Secretary of Defense McNamara stated that six conventionally-powered or four nuclear-powered escorts were required for each carrier task group. These numbers have been frequently cited since then as the basis for various determinations of the proper number of escorts for a given number of carrier task groups.[2/] Secretary McNamara's statement was based on the Navy's Major Fleet Escort Study completed just prior to that time. The Navy's study was based on concepts current for those days, when the principal threat to aircraft carriers was deemed to be aircraft-delivered bombs and submarine-fired torpedoes, and proposals to employ U.S. submarines in an escort role were in their

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1/ Surface-to-air missiles could be used against attacking aircraft that come within range, however, Soviet tactics seem to eschew this procedure in favor of stand-off tactics, employing their long-range missiles from beyond the range (less than 100 miles) of U.S. surface-to-air missiles.

2/ U.S. Naval Force Alternatives. Congressional Budget Office. Staff Working paper. Mar. 26, 1976: p. 15.

infancy. In recent years this study has been challenged as no longer providing a sound basis for determining the number of escorts required in a carrier-supported task group. Admiral Holloway's previously cited statement that a carrier-supported task group should include two or three cruisers and one to three submarines, presumably reflects more recent views. These new planning factors have not been supported by detailed testimony before Congress, and may prove to be controversial.

While the use of submarines as task group escorts is an unproven concept, the concept has been examined in fleet exercises and is reported to be a good one.[1/] Surface escorts have traditionally performed many necessary assignments carrier in task groups in addition to purely defensive ones. Some of these tasks, such as shore bombardment, search and rescue, board and search, and similar assignments, could not be ordinarily assigned to submarine escorts. With several surface escorts in a task force, a short diversion of one or two of its escorts to these collateral tasks has normally been affordable. However, whether that will be the case when only two or three escorts are assigned to the task group has not been shown.

In the analysis presented in this report several escort requirements stated by Admiral Holloway are synthesized as the basis for structuring alternative Aegis-equipped nuclear-powered cruiser acquisition programs for analysis. The resulting, options should

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1/ House Appropriations Subcommittee on the Department of Defense. FY 1978 Appropriations Hearings, Part 4, p. 746.

not be construed as representing hard and fast requirements, but only as examples of possible acquisition programs.

Aegis-Equipped Nuclear-Powered Cruisers

In responding to the inquiry as to "How many Aegis-equipped ships are planned?" Admiral Holloway testified that:

> No decision has been made yet on a precise programmed force level, because that decision will depend in large part on how effective Aegis proves to be when actually introduced into the fleet. For planning purposes, we estimate that 18-24 ships with the Aegis System would be sufficient. This number would provide two Aegis ships with each carrier operating in conditions of higher threat, one with those carriers in the open ocean, and a few additional ships to provide flexibility to our operational commanders. When CVVs enter the fleet, we would anticipate an Aegis ship would operate with them depending on the threat. 1/

In other testimony to the Congress, the CNO stated that the Navy plans to put the Aegis system on some nuclear-powered cruisers to achieve the capability of operating all-nuclear-powered task forces as units for faster response to crisis situations. Admiral Holloway also testified that:

> Our immediate requirement is for four Aegis-equipped nuclear cruisers. Future plans have established the requirement for additional, more V/STOL [Vertical/Short Take Off and Landing] capable, nuclear, Aegis cruisers which will be capable of independent operations as well as strengthening the basic multipurpose nuclear task groups. 2/

From testimony by the CNO and other Navy witnesses during the FY78 Defense budget hearings, it appears that there is a minimum requirement for at least one Aegis-equipped nuclear-powered cruiser for each all-

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1/ House Appropriations Subcommittee on the Department of Defense. FY 1978 Appropriations Hearings, Part 4, pp. 742, 744.

2/ Senate Armed Services Committee. FY 1978 Authorization Hearings, Part 5, p. 3441.

nuclear-powered aircraft carrier task group, and a less well defined requirement for additional nuclear-powered Aegis-equipped cruisers.

This report will consider three cases in determining the nuclear-powered escort requirements for nuclear-powered carrier task groups: one case using two Aegis-equipped nuclear-powered cruisers per task group; a second case using three nuclear-powered cruisers per task group, with one of these cruisers to be Aegis-equipped; and a third case, using four nuclear-powered cruisers per task group, with one of these cruisers to be Aegis-equipped.

This report does not address the issue whether the Navy's requirement for four all-nuclear-powered task groups is valid, but accepts the requirement for purposes of the analysis that follows.[1/]

For the first case (two nuclear-powered Aegis-equipped surface escorts per task group), there is a requirement for eight Aegis-equipped nuclear-powered cruisers. For the second case (three nuclear-powered surface escorts per task group), there is a requirement for 12 nuclear-powered cruisers (at least four of which are Aegis-equipped); and for the third case (four nuclear-powered cruisers per task group), there is a requirement for 16 nuclear-powered cruisers (at least four of which are Aegis-equipped).

In summary, depending on the number of nuclear-powered escorts available, the number of Aegis-equipped nuclear-powered cruisers required to form four all-nuclear-powered aircraft carrier supported task forces

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1/ In his FY 1979 Posture Statement before the House Armed Services Committee Admiral Holloway alludes to the desirability of having six all-nuclear-powered carrier task groups, and testified that he would prefer that the next aircraft carrier constructed be nuclear powered.

appears to vary from a minimum of four to a eight or more.

This report examines in some detail the impact of the minimum four Aegis-equipped CGN requirement on the U.S Naval Force in the 1978-2000 time period; a maximum eight Aegis-equipped ship requirement is also considered.

NUCLEAR-POWERED AEGIS CRUISER ACQUISITION

Ship Nominal Service Life

The nominal service life of warships is projected to some extent arbitrarily. Tactical obsolescence is reached when the weapon systems in a ship are no longer capable of meeting the threat. A ship's machinery and hull eventually wear out, but this is usually a gradual process which can be restrained by maintenance and repair procedures. However, repair costs increase progressively with the ship's age.

The Vinson-Trammell Act, as amended in 1938, recognized 20 years as the nominal service life for a cruiser. At the other end of the spectrum, Admiral Holloway testified to the Congress that nuclear-powered cruisers can be serviceable for 35 years.[2/] The Navy has estimated that the LONG BEACH (CGN-9) could be operated until about the year 2006, a total 45 years, if given a "service life extension" overhaul. However, the Congressional Budget Office and the Navy use 30 years as the nominal service life in making life-cycle cost estimates. Extended periods of inactivity by the ship, such as when the ship is out of service for modernization.

1/ The USS LONG BEACH (CGN-9) is in this status now.

2/ House Appropriations Subcommittee on the Department of Defense. FY 1978 Appropriations Hearings, Part 4, pp. 743, 749.

purposes, are not included in the "30-year life." The consideration of such inactive periods in projecting the ship's service life would bring the actual total years close to the 35 year figure given by Admiral Holloway. Accordingly, this report will consider 30 years as the nominal service life of a nuclear-powered cruiser.

Ship Availability Considerations

The Navy has the following nuclear-powered cruisers in operation or under construction:

Ship	Year of delivery	End of 30 year life
CGN-9 (LONG BEACH)	1961	1991 plus extension
CGN-25 (BAINBRIDGE)	1962	1992
CGN-35 (TRUXTUN)	1967	1997
CGN-36 (CALIFORNIA)	1974	2004
CGN-37 (SOUTH CAROLINA)	1975	2005
CGN-38 (VIRGINIA)	1976	2006
CGN-39 (TEXAS)	1977	2007
CGN-40 (MISSISSIPPI)	1978	2008
CGN-41 (ARKANSAS)	1980	2010

When the MISSISSIPPI (CGN-40) joins the fleet later this year, the Navy will have eight operational nuclear-powered cruisers; and with the commissioning of the ARKANSAS (CGN-41) in 1980, the total will be nine -- none of which are Aegis-equipped. It is expected that the fourth nuclear-powered aircraft carrier, the USS CARL VINSON (CVN-70), will be commissioned in 1981.

The availability of a sufficient number of escorts for the all-nuclear-powered carrier task forces depends on the composition of the individual escort force. As previously noted, the following escort requirements for each of the four all-nuclear-powered carrier task forces have been variously described:

Case 1 -- Two nuclear-powered Aegis-equipped cruisers per task group; for a force level of eight Aegis-equipped CGNs.

Case 2 -- Three nuclear-powered cruisers (one Aegis-equipped) per task group; for a force level of 12 CGNs (including four Aegis-equipped CGNs).

Case 3 -- Four nuclear-powered cruisers (one Aegis-equipped) per task group; for a force level of 16 CGNs (including four Aegis-equipped CGNs).

Table I shows the effect of three options for meeting the requirement for nuclear-powered Aegis-equipped CGNs: (1) through new construction; (2) by backfitting the Aegis system into existing nuclear-powered cruisers; and, (3) by backfitting the Aegis system into the four VIRGINIA-class cruisers and building four new cruisers.

Option 1(a) (new construction of four Aegis-equipped CGN-42 class ships)

Assuming the CGN-42 is authorized in the FY79 Defense budget, and allowing a one-year gap before three additional CGNs are authorized in successive years, the first nuclear-powered Aegis-equipped ship could be delivered in 1984. Thus, the Navy's minimum requirement for four Aegis-equipped nuclear-powered cruisers described in Case 2 could be met in 1988.

Option 1(b) (new construction of eight Aegis-equipped ships)

This option is an expansion of Option 1(a). It requires that the four CGN-46 class ships be authorized in successive years to the CGN-42 class ships. Under this option 16 CGNs would be available in 1992, eight

TABLE I - NUCLEAR-POWERED CRUISERS

	Year 1978	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	2000
MINIMUM REQUIREMENT FOR CGNs:																	
Case One	6 Aegis	6 Aegis	6 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis	8 Aegis
Case Two - CGNs (Aegis CGNs)	9 (3A)	9 (3A)	9 (3A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)	12 (4A)
Case Three - CGNs (Aegis CGNs)	12 (3A)	12 (3A)	12 (3A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)	16 (4A)
OPTION 1 - New Construction of Aegis-Equipped CGNs:																	
Operational - CGNs (Aegis CGNs)	8	8	9	9	9	9	10 (1A)	10 (1A)	11 (2A)	12 (3A)	13 (4A)	14 (5A)	15 (6A)	16 (7A)	16 (8A)	16 (8A)	15 (8A)
SCN Funding (Hull No.)		(42)		(43)	(44)	(45)	(46)	(47)	(48)	(49)							
Delivered (Hull No.)	(40)		(41)				(42)		(43)	(44)	(45)	(46)	(47)	(48)	(49)		
Retired (Hull No.)															(25)R	(35)R	
OPTION 2(a) - Aegis Backfit Into the VIRGINIA (CGN-38) Class:																	
Operational - CGNs (Aegis CGNs)	8	8	9	8	8	8 (1A)	8 (1A)	8 (2A)	8 (2A)	8 (3A)	8 (3A)	9 (4A)	9 (4A)	9 (4A)	8 (4A)	8 (4A)	7 (4A)
SCN Funding (Hull No.)		(38)		(39)		(40)		(41)									
Delivered (Hull No.)	(40)		(41)			(38)		(39)		(40)		(41)					
Retired or in Backfit (Hull No.)				(38)		(39)		(40)		(41)					(25)R	(35)R	
OPTION 2(b) - Aegis Backfit Into the VIRGINIA (CGN-38) Class, CGNs 36-37, and CGN-9:																	
Operational - CGNs (Aegis CGNs)	8	8	9	8	7	7 (1A)	7 (2A)	7 (3A)	7 (4A)	7 (5A)	8 (6A)	9 (7A)	9 (7A)	9 (7A)	8 (7A)	8 (7A)	7 (7A)
SCN Funding (Hull No.)		(38)	(36)	(39)	(37)	(40)	(9)	(41)									
Delivered (Hull No.)	(40)		(41)			(38)	(36)	(39)	(37)	(40)	(9)	(41)					
Retired or in Backfit (Hull No.)				(38)	(36)	(39)	(37)	(40)	(9)	(41)					(25)R	(35)R	
OPTION 3 - Aegis Backfit Into the VIRGINIA (CGN-38) Class and Construction of Four CGN-42 Class Ships:																	
Operational - CGNs (Aegis CGNs)	8	8	9	8	8	8 (1A)	9 (2A)	9 (3A)	10 (4A)	11 (6A)	12 (7A)	13 (8A)	13 (8A)	13 (8A)	12 (8A)	12 (8A)	11 (8A)
SCN Funding (Hull No.)		(42) (38)		(43) (39)	(44)	(45) (40)		(41)									
Delivered (Hull No.)	(40)		(41)			(38)	(42)	(39)	(43)	(44) (40)	(45)	(41)					
Retired or in Backfit (Hull No.)				(38)		(39)		(40)		(41)					(25)R	(35)R	

Key - R Denotes retired.

of which would be Aegis configured. Therefore, under this option the alternate requirements described in Case 1 and Case 2 would be met in 1992 and 1988, respectively, and Case 3 could be achieved in 1991.

Option 2(a) (backfit of four VIRGINIA (CGN-38) class cruisers)

With the CGN-41 about 40% complete, it is considered impractical to equip her with the Aegis system while she is under construction.[1/] If an Aegis system backfit for the CGN-38 is authorized by the Congress in the FY79 Defense budget, and for the other three sister ships at two-year intervals (to minimize reduction in the total number of operational CGNs), the Navy could receive the first Aegis-equipped CGN a few months earlier than under Option 1(a). With the assumed backfit sequence, the fourth Aegis-equipped CGN would not be delivered to the Navy until 1989.

Under Option 2(a), neither the CNO's requirement of eight Aegis-equipped CGNs (Case 1) nor his requirement for four Aegis-equipped and eight other CGNs (Case 2) can be met. And the total number of CGNs available after 1997 decreases when the CGN-35 reaches the end of its service life.

Option 2(b) (Backfit of the CGN-38 class, CGNs 36-37, and CGN-9)

This option is an expansion of Option 2(a). In addition to the assumptions used for the VIRGINIA-class ships, it assumes that the

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1/ Joint Committee on Atomic Energy. Naval Nuclear Propulsion Program -- 1972-73. FY 1973 Hearings, Part 1, p. 207.

backfits of the Aegis system into the CGN-36, CGN-37, and CGN-9 are authorized in the intervening years (i.e., FYs 80, 82, and 84).[1/]

Under Option 2(b), nine CGNs would be operational in 1989 (seven of which would be Aegis-equipped) and could essentially meet the CNO's minimum requirements through a combination of Case 1 and Case 2 (i.e., three all-nuclear task forces with two Aegis-equipped cruisers each, and one task force with three nuclear-powered cruisers, one of which is Aegis-equipped). However, the availability of 16 CGNs (Case 3) would not be met.

Option 3 (Backfit of the CGN-38 class and new construction of four CGN-42 class ships)

This option is a combination of Options 1(a) and 2(a). Under Option 3, 13 CGNs would be operational in 1989 (eight of which would be Aegis-equipped) and meet the requirements of Case 1 and Case 2. However, the availability of 16 CGNs (Case 3) would not be met.

Option 3 could essentially also meet the CNO's minimum requirement in 1987 through a combination of Case 1 and Case 2 requirements (i.e., two task groups with two Aegis-equipped CGNs per task group, and two task groups with one Aegis-equipped and two non-Aegis-equipped CGNs per task group).

1/ Backfitting the CGNs and 37 with the Aegis system is believed to be feasible since their hulls and propulsion closely resemble the VIRGINIA-class cruisers. However, it is probable that additional design work would be required and the overall cost of backfitting could be somewhat greater than for the VIRGINIA class. Backfitting the BAINBRIDGE and TRUXTUN (CGNs 25 and 35) with the Aegis system is probably not feasible.

The VIRGINIA (CGN-38) class ships is chosen for backfit over the CGNs 36, 37, and 9, because: (1) They have more years of life remaining than the other existing CGNs; (2) The four CGN-38 class ships already have many of the essential components required for a conversion to an Aegis-equipped ship (i.e., launcher, computers, fire-control elements, etc.).

Program Cost Considerations

Table II compares the life-cycle costs of the CGN-38 (if backfitted with the Aegis system) to the costs of the CGN-42 (built from the keel up with the Aegis system).

TABLE II - PER SHIP LIFE-CYCLE COSTS OF AEGIS CGNs 1/

CGN-38 Backfit w/Aegis vs CGN-42 New Construction 2/
(in millions of FY78 dollars)

Class	Backfit or New Construction Cost	Outfitting and Post Delivery Costs 3/	Mid-Life Modern-ization Cost 4/	Mid-Life Recoring Cost	Annual Oper-ating Cost	30-Year Life-Cycle Cost
CGN-38	550 5/	17	250	64	26.8	1,685 6/
CGN-42	835	25	250	64	26.8	1,978

1/ Provided by the Office of the Chief of Naval Operations.

2/ The cost for the CGN-42 is based on the cost estimated for a follow ship to the CGN-42 (excluding special costs of the CGN-42).

3/ The outfitting and post-delivery costs shown are estimated to be three percent of the backfit or new construction cost.

4/ The mid-life modernization cost for the CGN-38 is assumed to be equivalent to that for the CGN-42.

5/ Does not include initial acquisition cost.

6/ Ibid.

It should be noted that the CGN-42 would have several significant features which would not be installed in a CGN-38 class Aegis conversion. These features would include a towed-array sonar system, two LAMPS III helicopters instead of one, greater magazine capacity, and possibly a Vertical Launch system for the SM-2 missiles.

Remaining-Life Costs of Options

The estimated remaining-life costs of CGN force options are shown in Table III. These costs are derived from ship availability shown in Table I, CGN cost data presented in Table II, and the following ship acquisition and backfit cost data and assumptions:

1. The acquisition cost for the four CGN-42 class ships is estimated to be $3,771 million ($1,251 million for the CGN-42, $916 million for the CGN-43, $817 million for the CGN-44, and $787 million for the CGN-45); [1/] and, the acquisition costs for the second group of four new ships (CGNs 46 through 49) are estimated to be about $750 million each. [2/]

2. The costs to backfit the CGN-36 and the CGN-37 are assumed to be the same as the cost to backfit each of the CGN-38 class ships (see Table II).

1/ Department of the Navy Supporting Data for Fiscal Year 1979 Budget Estimate Submitted to Congress. Shipbuilding and Conversion, Navy. P-1 Line Item: CGN-42 class. Jan. 1978. p. I-9.

2/ The estimated acquisition cost per ship is obtained by extrapolating the cost estimate of the CGN-42 class.

TABLE III - ESTIMATED REMAINING-LIFE COSTS OF ALTERNATIVE CGN ESCORT FORCES
(in millions of FY78 dollars)

Ship Designation	Aggregate* Remaining Life (years)	Acquisition Cost	Backfit Cost	Outfitting and Post-Delivery Cost	Mid-Life Moderni-zation Cost	Mid-Life Recoring Cost	Remaining-Life Operating Cost	Remaining-Life Cost
OPTION 1(a): New construction of four Aegis-equipped CGNs.								
CGNs 42-45	120	3,771	---	113	1,000	256	3,216	8,356
CGNs 38-41	114	Excluded	---	Excluded	1,000	256	3,055	4,311
CGNs 36-37	51	Excluded	---	Excluded	500	128	1,367	1,995
CGN-9	12	Excluded	---	Excluded	250	64	322	636
CGN-35	18	Excluded	---	Excluded	250	64	482	796
CGN-25	13	Excluded	---	Excluded	250	64	348	662
Totals	328	(13 CGNs, of which four are Aegis equipped)						16,756
OPTION 1(b): New construction of eight Aegis-equipped CGNs.								
CGNs 42-45	120	3,771	---	113	1,000	256	3,216	8,356
CGNs 46-49	120	3,000	---	90	1,000	256	3,216	7,562
CGNs 38-41	114	Excluded	---	Excluded	1,000	256	3,055	4,311
CGNs 36-37	51	Excluded	---	Excluded	500	128	1,367	1,995
CGN-9	12	Excluded	---	Excluded	250	64	322	636
CGN-35	18	Excluded	---	Excluded	250	64	482	796
CGN-25	13	Excluded	---	Excluded	250	64	348	662
Totals	448	(17** CGNs, of which eight are Aegis equipped)						24,318
OPTION 2(a): Aegis backfit into the VIRGINIA(CGN-38) class.								
CGNs 38-41	114	Excluded	2,200	66	1,000	256	3,055	6,577
CGNs 36-37	51	Excluded	---	Excluded	500	128	1,367	1,995
CGN-9	12	Excluded	---	Excluded	250	64	322	636
CGN-35	18	Excluded	---	Excluded	250	64	482	796
CGN-25	13	Excluded	---	Excluded	250	64	348	662
Totals	208	(9 CGNs, of which four are Aegis equipped)						10,666
OPTION 2(b): Aegis backfit into the VIRGINIA (CGN-38) class, CGNs 36-37, and CGN-9.								
CGNs 38-41	114	Excluded	2,200	66	1,000	256	3,065	6,577
CGNs 36-37	51	Excluded	1,100	33	500	128	1,367	3,128
CGN-9	12	Excluded	735	22	250	64	322	1,393
CGN-35	18	Excluded	---	Excluded	250	64	482	796
CGN-25	13	Excluded	---	Excluded	250	64	348	662
Totals	208	(9 CGNs of which seven are Aegis equipped)						12,556

* Remaining life is computed starting FY 1979 or when the ship is delivered, whichever is the latter, and is based on a 30-year operational life.

** As shown in Table .. the highest number of CGNs (16) would be operational only from 1991 through 1997. A total of 17 CGNs is used in Table III for the purpose of computing the aggregate remaining-life costs of the option.

TABLE III (Continued) - ESTIMATED REMAINING-LIFE OF ALTERNATIVE CGN ESCORT FORCES
(in millions of FY78 dollars)

Ship Designation	Aggregate* Remaining Life (years)	Acquisition Cost	Backfit Cost	Outfitting and Post-Delivery Cost	Mid-Life Moderni-zation Cost	Mid-Life Recoring Cost	Remaining-Life Operating Cost	Remaining-Life Cost
OPTION 3: Aegis backfit into the VIRGINIA (CGN-38) class and construction of four CGN-42 class ships.								
CGNs 42-45	120	3,771	---	113	1,000	256	3,216	8,356
CGNs 38-41	114	Excluded	2,200	66	1,000	256	3,055	6,577
CGNs 36-37	51	Excluded	---	Excluded	500	128	1,367	1,995
CGN-9	12	Excluded	---	Excluded	250	64	322	636
CGN-35	18	Excluded	---	Excluded	250	64	482	796
CGN-25	13	Excluded	---	Excluded	250	64	348	662
Totals	328	(13 CGNs, of which eight are Aegis equipped)						19,022

* Remaining life is computed starting FY 1979 or when the ship is delivered, whichever is the latter, and is based on a 30-year operational life.

3. The cost to backfit the LONG BEACH (CGN-9) is obtained from the NavSea study of 1975.[1/]

4. The outfitting and post-delivery costs are assumed to be three percent of the acquisition and backfit costs (if any).

The estimated remaining-life costs presented in Table III exclude the acquisition cost of CGNs that have already been funded, and therefore represent new funding required to exercise the options.

Estimated Average Remaining Annual Cost Per Aegis-Equipped CGN

The remaining-life cost of the Aegis-equipped CGNs offered by each option shown in Table III when divided by the remaining life of these ships, after backfit or completion of new construction, yields the average remaining annual cost per Aegis-equipped CGN under each of the options considered.

Option	Average Remaining Annual Cost Per Aegis-Equipped CGN[2/] (in millions of FY78 dollars)
1(a)	\$8,356/120 ship-years = \$69.6
1(b)	(\$8,356 + \$7,562)/240 ship-years = \$66.3
2(a)	\$5,907/95 ship-years = \$62.2
2(b)	(\$5,907 + \$2,672 + \$723)/143 ship-years = \$65.1
3	(\$8,356 + \$5,907)/215 ship-years = \$66.3

1/ USS LONG BEACH Modernization Study. Naval Sea Systems Command (NavSea-93). Navy Department. Washington.

2/ Remaining-life costs of backfitted CGNs have been adjusted for operating costs during the period which the ships are not Aegis configured. Consequently, the remaining-life costs shown do not match the remaining-life costs shown in Table III.

Estimated Average Remaining Annual Cost Per CGN

The remaining-life cost of the CGN force options presented in Table III when divided by the remaining life of these ships, after backfit or completion of new construction, yields the average cost per ship-year under each option.

Option	Average Remaining Annual Cost Per CGN (in millions of FY78 dollars)
1(a)	\$16,756/328 ship-years = \$51.1
1(b)	\$24,318/448 ship-years = \$54.3
2(a)	\$10,666/208 ship-years = \$51.3
2(b)	\$12,556/208 ship-years = \$60.4
3	\$19,022/328 ship-years = \$60

Evaluation Criteria of CGN Escort Force Alternatives

Shown in Table IV is a comparative analysis of the various CGN force options considered using availability and cost as criteria.

Among the three alternative ways of acquiring a sufficient number of Aegis-equipped nuclear-powered cruisers to meet mission requirements, the choice depends on the relative emphasis given to cost and availability criteria. Build options are in general more costly than backfit options, but result in more ships available (in total numbers and during the acquisition period). A suitably structured build and backfit alternative may offer an acceptable compromise. The individual average remaining annual cost

TABLE IV - COMPARATIVE ANALYSIS OF CGN ESCORT FORCE ALTERNATIVES
(cost figures in millions of FY78 dollars)

EVALUATION CRITERIA	OPTIONS: BUILD 1(a)	BUILD 1(b)	BACKFIT 2(a)	BACKFIT 2(b)	BUILD & BACKFIT 3
Availability:					
Maximum number of CGNs	13	16	9	9	13
Aggregate remaining CGN ship-years	328	448	208	208	328
Maximum number of Aegis-equipped CGNs	4	8	4	7	8
Aggregate remaining Aegis-equipped CGN ship-years	120	240	95	143	215
Year in which option would permit meeting the requirements of:					
Case 1 (two Aegis-equipped CGNs per task group; for a total of eight Aegis-equipped CGNs)	none	1992	none	none	1989
Case 2 (three CGNs -- one Aegis-equipped -- per task group; for a total of 12 CGNs -- including four Aegis-equipped CGNs)	1988	1988	none	1989*	1989/ 1987**
Case 3 (four CGNs -- one Aegis-equipped -- per task group; for a total of 16 CGNs -- including four Aegis-equipped CGNs)	none	1991	none	none	none
Cost:					
Program cost (including outfitting and post-delivery costs) to acquire new CGNs (if any) and/or backfit CGNs	3,884	6,974	2,266	4,156	6,150
Remaining-life cost	16,756	24,318	10,666	12,556	19,022
Average remaining annual cost per Aegis-equipped CGN	69.6	66.3	62.2	65.1	66.3
Average remaining annual cost per CGN	51.1	54.3	51.3	60.4	60

* Meets the requirements through a combination of Case 1 and Case 2 (i.e., three all-nuclear task groups with two Aegis-equipped cruisers each, and one task group with three CGNs, one of which is Aegis-equipped).

** Also meets the Case 2 requirements through a combination of Case 1 and Case 2 requirements (i.e., two task groups with two Aegis-equipped CGNs per task group, and two task groups with one Aegis-equipped and two non-Aegis-equipped CGNs per task group).

per ship varies within plus or minus 10% for the options examined in this analysis, which is within the tolerance of the basic cost data on which the analysis is based. Therefore, average annual cost per ship should be regarded with caution.

CONCLUSIONS

Capability of the Tartar-D-Equipped CGN:

a. While the USS VIRGINIA (CGN-38) is considered to be the most capable AAW ship in the Navy today its capability, on a stand-alone basis against the near term and future high-density anti-ship missile threat, is inadequate.

b. Projected improvements for the Tartar-D system are technically feasible and, if aggressively undertaken, can significantly improve the capabilities of the system by the 1985-1990 time period. According to Navy experts, if the potential improvements are implemented, the performance of a Tartar-D-equipped ship will be effective against projected threats when operating in a team coordinated by a Aegis-equipped ship, if Aegis performs as expected.

c. The projected AAW improvements for the Tartar-D-equipped CGN (intraship and missile modifications) are evolutionary in nature, and are considered to be of low technical risk, provided adequate resources are made available. However, the development of the inter-ship AAW coordination system for Tartar-D and Aegis-equipped ships seems to lack sponsorship and financial resources. There is no identifiable integrated program to insure Tartar-D improvements are implemented on a timely schedule to meet the anticipated threat.

Escort Requirements for All-Nuclear-Powered Aircraft Carrier Task Forces

a. The capability of a carrier task force to cope successfully with an anti-ship missile attack, of the scope and intensity postulated within the capabilities of the Soviet Navy in the near future depends on the availability of one or more Aegis weapon systems in the task force, if Aegis performs as expected.

b. The number of escorts required should be determined considering the entire spectrum of the threat (i.e., AAW, ASW, and Surface Warfare). The analytical basis of an escort force of two or three surface escorts and one to three submarines for a carrier-supported task group has not been reported to the Congress.

c. For a Navy force level of four all-nuclear-powered aircraft carrier task forces, the number of surface escorts required depends on the number of Aegis-equipped escorts available. The minimum number of Aegis-equipped escorts stated by the CNO is four -- one for each task force. However, in this case eight or more additional non-Aegis-equipped escorts would be needed. The minimum number of escorts required results when eight Aegis-equipped escorts are available, if the CNO's stated requirements are accepted as valid.

Alternatives for the Aegis-Equipped CGN

Among the three alternative ways of acquiring a sufficient number of Aegis-equipped nuclear-powered cruisers to meet mission requirements, the choice depends on the relative emphasis given to cost and availability criteria. Build options are in general more costly than backfit options, but result in more ships available, both in total numbers and during the acquisition period. A suitably structured build and backfit alternative may offer an acceptable compromise.

APPENDIX 1

GLOSSARY

AAW - ANTI-AIR WARFARE: Techniques and technology used to counter threats by airborne vehicles (manned or unmanned aircraft, or missiles) except ICMB reentry vehicles.

ANTI-SHIP MISSILE: (Sometimes also referred to as "anti-shipping missile") A guided missile specially designed to penetrate shipboard defensive systems and sink or damage surface vessels.

AREA AIR DEFENSE SYSTEM: An AAW system for use in defending other ships, in addition to own ship, against attacking airborne vehicles. Area Air Defense systems are characterized by relatively long range and the ability to counter targets that fly directly toward own ship.

ASW-ANTI-SUBMARINE WARFARE: Techniques and technology used to counter threats by submarines. If the submarine succeeds in firing a missile, the problem becomes an AAW problem as well.

COMBAT SYSTEM: All of the various components associated with a ship's weapons including sensors, computers, fire control systems, guns, missile launchers, magazines, and the communications networks linking them.

COMBAT INFORMATION CENTER: The section of a ship manned and equipped to collect, display, evaluate, and disseminate tactical information.

COMMAND AND CONTROL SYSTEM: The information processing, communication and display equipments that function together to correlate available information to aid in tactical decision making and in implementing tactical decisions after they are made.

CGN: Navy designation for a Cruiser armed with an area air defense Guided missile system (N denotes nuclear propelled).

CSGN: Navy designation for a Cruiser armed with area air defense Guided missile system and a surface-to-surface missile system (N denotes nuclear propelled).

CROSSING TARGETS: Targets that do not pass over the firing platform, but pass within range of its weapons. Characteristically, they are attacking another unit within the group, such as the high value unit. Because of the relatively high component of target motion normal to the line of sight between the weapon and the target at time of firing, Crossing Targets present a difficult challenge to a fire control system.

CV/CVN: Navy designation for an Aircraft Carrier (N denotes nuclear propelled).

DLGN: Obsolete Navy designation for a Large destroyer with an area air defense Guided missile system installed. (N denotes nuclear propelled). DLGNs have been redesignated CGN.

FIRE CONTROL SYSTEM: The apparatus that functions to locate a target precisely, to compute its direction and speed of motion and an intercept point for its own weapons, to position the launcher, and, on order, to launch own weapons. Depending on the design of the system, the various tasks of the fire control system may be performed manually or by automation.

FIRE DISTRIBUTION: The process of evaluating threats and assigning weapons so that all threats are take under fire, with the most menacing given priority.

FIRE-POWER: A measure of the number of targets that can be effectively engaged, by a particular weapon system or the combination of weapon systems in a ship or group of ships, in a specified period.

INTEGRATED COMBAT SYSTEM: A system in which two or more weapon systems are designed to function simultaneously without interfering with one another, and, when possible, to complement each other. For example, an ASW weapon system might receive alerting information from an AAW or surface-to-surface weapon system. The most prevalent means of integrating combat systems today is by use of digital computers. Integration is most often effected through the command and control system.

MISSILE CONTROL SYSTEM: The apparatus that provides flight control, navigation, targeting data and commands to a guided missile in flight.

NTDS - NAVY TACTICAL DATA SYSTEM: Computerized system for assembly and evaluation of all available tactical information, including friendly and enemy ships and aircraft, which offers this information for study by tactical commander and also offers possible solutions.

PHASED ARRAY RADAR SYSTEM: A radar system in which the shape, intensity and direction of the radar beam is varied by changing the sequence and timing of the transmissions from each of several transmitting elements that make up its antenna. Phased array radar antennae may be either fixed or rotating. In a fixed array system more than one antenna face is required to achieve hemispheric coverage.

POINT DEFENSE: Close-in defense (often synonymous with self-defense).

REACTION TIME: The elapsed time between the moment a hostile target first reaches a position where it could be detected by visual or electronic means, and complete readiness to launch the first intercept weapon against it. Detection, recognition of its hostile character, decision to engage, designation as a target to a particular weapon system and the fire control process all occur during this elasped time.

SSN: Navy designation for an anti-ship Submarine (N denotes nuclear propelled).

SURFACE COMBATANT (SHIP): The U.S. Navy categorizes battleships, cruisers, destroyers and frigates as surface combatants.

TASK FORCE (GROUP): An aircraft carrier and its escorts may be designated as a task force or task group, depending upon a particular mission and the way it is organized. The terms are used interchangeably in this report.

WEAPON CONTROL SYSTEM: The apparatus that accepts engagement orders from the command and control system and implements them by selecting weapon systems, designating targets to individual fire control system, controlling the launch of the weapons, evaluating weapon effects, and re-engaging with the same or a different weapon system as indicated until targets are defeated.

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