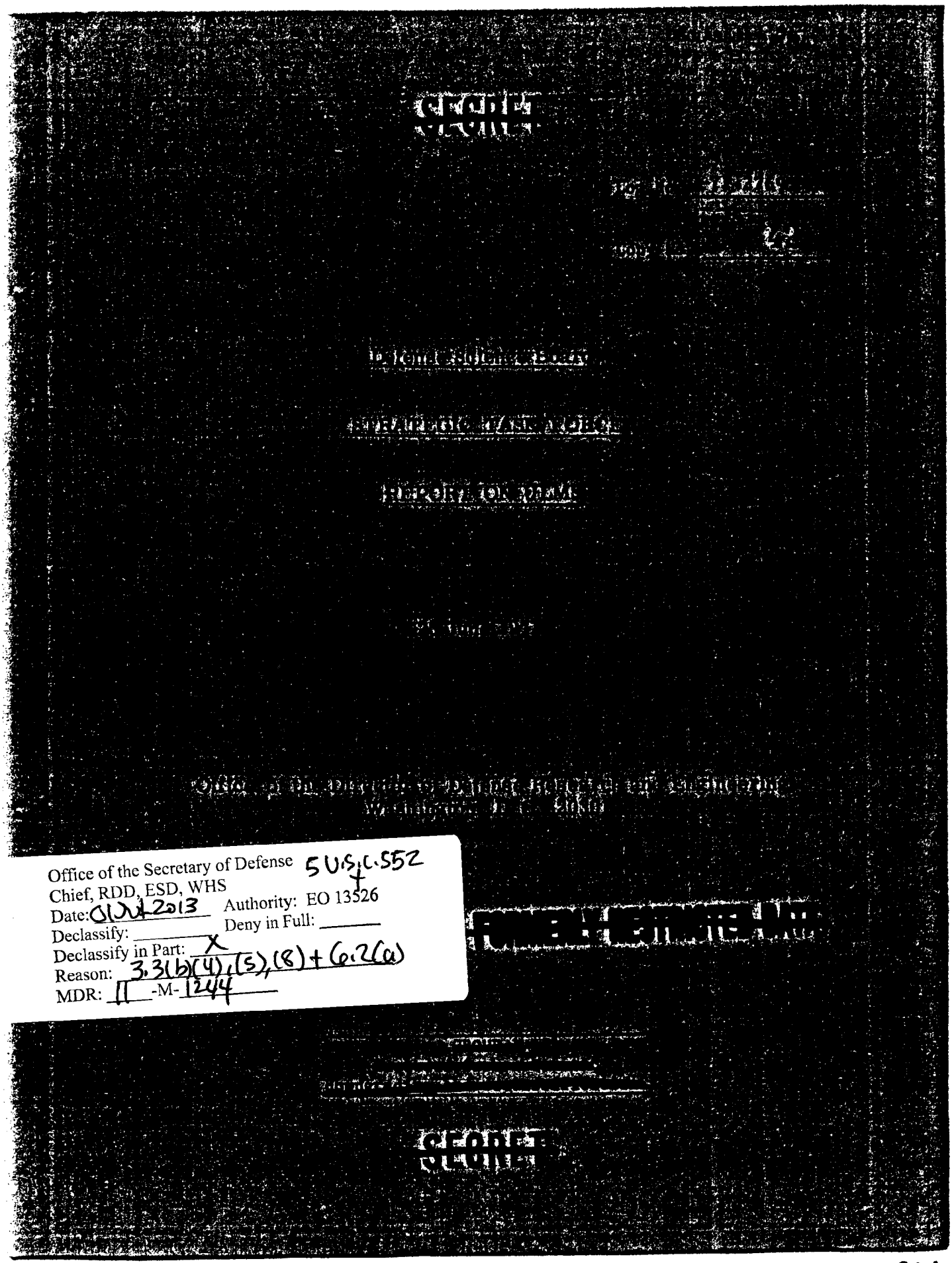

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Defense Science Board

STRATEGIC TASK FORCE

REPORT ON ULMS

25 June 1971

Office of the Director of Defense Research and Engineering
Washington, D. C. 20301

MEMBERSHIP

DSB Strategic Task Force

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(Strategic and Space Systems)
Cdr. Donald A. Miller, USN, Staff Liaison

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

20 July 1971

TO: THE SECRETARY OF DEFENSE

THROUGH: THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

The Defense Science Board's Strategic Task Force has reviewed the Navy ULMS program, and its report is hereby submitted. I would particularly call your attention to the forwarding memorandum of the Task Force Chairman, Dr. Albert L. Latter, and the recommendations underlined in the body of the report.

Gerald F. Tape
Chairman
Defense Science Board

SECRET

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

25 June 1971

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: DSB Strategic Task Force Report on ULMS

(U) I am enclosing the Strategic Task Force report resulting from our review of the Navy ULMS program.

(S) To guard against possible future developments in Soviet sensor capabilities, the Task Force believes that the SSBN fleet should be altered so as to increase the ocean area over which the submarines can operate, and so as to reduce the submarine radiated noise. In our view it is possible to make these alterations without developing a new boat--by providing POSEIDON with a new long-range missile and by expanding the ongoing noise suppression program.

(S) However, in view of the long lead time associated with the development of a new submarine and the uncertainty of the future--for instance, the possibility that it may someday be necessary to increase missile payload at sea substantially--the Task Force feels impelled to recommend R&D on a new boat--ULMS--in addition to improving the POSEIDON system. The Task Force also considered design philosophy for a new boat and concluded that the Navy-recommended ULMS configuration is not an optimum. We believe that, for a fixed cost, a different design could provide greater survivability and/or more payload at sea.

(S) Finally, the Task Force notes that to take full advantage of a long-range missile system like ULMS or long-range POSEIDON, [redacted]

OSD 3.3(b)(4),(5)

(U) This report recommends a number of studies for Navy action. The results of the studies should be reviewed by the Task Force upon completion.

A. L. Latter
Chairman
DSB Strategic Task Force

SECRET

(S) Beginning in the summer of 1970 and continuing until February 1971, the Navy conducted parametric design studies of the ULMS--a long-range ballistic missile submarine. The studies were made at the request of the CNO (Chief of Naval Operations), with the object of establishing a Navy preferred configuration. At the request of the DDR&E (Director of Defense Research and Engineering), the DSB Strategic Task Force undertook to review these studies at two meetings, the first in December 1970 and the second in February 1971 when the studies were completed.

(S) At the first meeting the Navy studies emphasized large submarines. As an example:

Submerged displacement	27,900 tons
Shaft horsepower	[redacted]
Speed	
Number of missiles	24
Missile length/diameter	49'/100"
Follow ship cost	$477 million
Estimated fleet size for $20 billion (10-year cost)	17 boats

OSD Section 6.2 (a)
NAVY 1.4(a)(h)

(S) At the February meeting of the Task Force the Navy presented its recommend ULMS configuration:

Submerged displacement	14,200 tons
Shaft horsepower	[redacted]
Speed	
Number of missiles	24
Missile length/diameter	37-1/2'/74"
Follow ship cost	$309 million
Estimated fleet size for $20 billion (10-year cost)	25 boats

OSD Section 6.2 (a)

(S) For comparison, the ULMS conceptualized in the STRAT-X study has the following characteristics:

Submerged displacement	8,240 tons (boats) 2,400 tons (capsules)
Shaft horsepower	[redacted]
Speed	
Number of missiles	24
Missile length/diameter	58'/80"
Follow ship cost	$192 million (1971 Navy) $109 million (1966 STRAT-X)

OSD Section 6.2 (a)

To evaluate the Navy recommendation, it is necessary to ask: Why is ULMS needed? According to the presentation made by the Navy, the objectives are to:

1. Increase ocean operating area,
2. Reduce submarine noise and other observables,
3. Increase maximum speed and power,
4. Replace aging POSEIDON submarines,
5. Provide additional sea-based payload.

(U) Of these five objectives, the Task Force strongly endorses the first two. However, the Task Force does not believe that a convincing case has been made for the last three objectives.

With respect to objective (3), two reasons were presented by the Navy to support their desire for a larger power plant: high speed for trailbreaking, and high power for recovery under emergency conditions. Despite these reasons, the Task Force leans toward the view adopted in the STRAT-X study that great speed and power are not of primary importance.

We feel that ULMS, like POLARIS/POSEIDON, must depend upon concealed mobility for its safety. Concealed mobility depends upon an initial state of concealment followed by quiet--that is, low-speed--operation. It is possible that high speed could be used during port egress to supplement masking and delousing efforts that can be provided by support vessels and aircraft. However, no arguments to this point were presented by the Navy, and the Task Force feels that increasing speed would aid port egress only slightly compared to the other possible actions.

OSD 3.3(b)(8)

With regard to emergency control of the boat, so far as the Task Force can determine, extra power plays only a marginal role. In fact, a high tank blowing rate--requiring no additional power--appears to be a much more significant factor. In summary, no strong arguments were presented by the Navy to convince us that the STRAT-X [redacted] would not be adequate for all purposes.[1] We believe it would be informative to pursue a thorough study of the requirements for high speed and power, including the POLARIS/POSEIDON experience of the use of maximum or near-maximum speeds or the surge use of maximum power for controllability. We recommend that the Navy undertake such a study.

(U) [1] An SSBN that carries a modest-range missile can use a high transit speed to increase its on-station availability. However, the long range of the ULMS missile should make this tactic unnecessary.

OSD
Section 6.2 (a)

[redacted] With respect to aging of the POSEIDON submarines--objective (4)--it is, of course, true that eventually the boats will age to a point of uselessness. However, the Navy did not present evidence for believing that this situation would develop in the eighties, or even the nineties. Although the boats age due to fatigue from diving, and from corrosion that occurs generally over the hull and in inaccessible places that are difficult to inspect, specific limits have not been set. Furthermore, lifetime can be extended by restricting the maximum allowed operating depth. Since the POSEIDON hulls were designed to withstand [redacted] the Navy-recommended ULMS--it appears possible to extend the operational lifetime of the POSEIDON boats without compromising the Navy goals. The Task Force recommends that the Navy be asked to review the available data on submarine aging to establish an estimate of the SSBN operational lifetime and means for extending it. NAVY 1.4(a),(h)

[redacted] The fifth objective--to increase sea-based payload--is motivated by the fear that the U. S. land-based ICBMs may become vulnerable to a Soviet first-strike and/or the Soviets may greatly increase their ABM capability. However, the Task Force believes that the land-based forces can be made survivable at a reasonable cost by employing the shelter-based concept, and it is better to have a mixture of land- and sea-based missiles rather than place reliance on the sea-based missiles alone. Furthermore, as long as the POSEIDON boats remain secure, it is not clear that more payload is needed even if MINUTEMAN were compromised. [redacted] is adequate to fulfill the principal mission of the strategic forces--deterrence --unless the Soviets deploy a heavy, effective ABM.

OSD
OSD 3.3(b)(4),(5) Section 6.2 (a)

[redacted] Supporting the first two of the five objectives, but doubting the validity of the last three, the Task Force finds itself asking the obvious question: whether operating area can be increased and observables reduced without developing a new submarine. In other words, can the first two objectives be satisfied with the POSEIDON boats themselves?

[redacted] With respect to noise and other observables--objective (2)--the major design feature of ULMS that is a clear-cut improvement over POSEIDON is the natural circulation reactor, which eliminates the main coolant pump noise. However, the Task Force understands that considerable suppression of noise and other observables can be achieved in the POSEIDON boats by expanding the ongoing noise suppression program and applying new technology. For instance, pump noise might be reduced with multiple vane impellers. The Task Force recommends that the Navy be requested to make a

study of this kind to establish the degree of quieting that can be achieved in the POSEIDON boats by using new technology.

(S) We must now turn to the question: Can POSEIDON be modified to satisfy the objective of increasing the operating area? To begin with, the Task Force fully agrees with the Navy on the desirability of achieving this objective. Technological advances suggest that the Soviets might someday be able to deploy sensors densely enough over the present POSEIDON operating area to make simultaneous detection of almost all the submarines probable. Under these circumstances, the boats could be targeted by a variety of Soviet forces. [redacted]

OSD 3.3(b)(4),(5)

(S) The most obvious way of increasing operating area with POSEIDON would be to off-load R/Vs from the POSEIDON missile. [redacted] price for a small gain. Based on map studies, the Task Force feels that a range of about 4500 nm should be the objective. This range implies an idealized operating area of as much [redacted] subject to some conditions discussed later. [redacted]

OSD 3.3(b)(4),(5),(8)

(S) Another way of increasing operating area, without great cost, would be to keep the boats on patrol in waters outside the operating range. It can be argued that submarines [redacted] and that the capability to commence launching missiles immediately is not important. However, even if this mission objective is granted, the withdrawal tactic seems worrisome for two reasons. To increase the area significantly, a very long delay would be required--perhaps

OSD 3.3(b)(4),(5)

[redacted]

OSD 3.3(b)(4),(5)

weeks.[3] More importantly, Soviet ASW could be much more effective against POSEIDON boats forced to travel a long distance to get within operating range. For example, barrier defenses might be established. The Task Force concludes that the best way to achieve the goal of greatly increasing operating area is with a new missile--one with a much longer range than that of POSEIDON. The question becomes: Can such a mission be accommodated in the POSEIDON boats? The answer appears to be yes.

(S) It is estimated that a three-stage missile having the same envelope as POSEIDON and employing new technology, [redacted] The missile recommended by the Navy for ULMS has a length/diameter of 37-1/2'/74" compared to 34'/74" for POSEIDON. With new technology and a third stage, this missile could [redacted] The Task Force sees no reason why this same missile--or perhaps an even longer one--could not be accommodated in the POSEIDON boat with a relatively straightforward extension of the launch tubes. The Task Force recommends that the Navy be asked to examine the feasibility and cost of such a boat modification. The possibility of making this modification simultaneously with the remaining POLARIS/POSEIDON conversions should also be considered.

OSD 3.3(b)(4),(5),(8)

(S) Intuitively, it is clear that upgrading the existing POSEIDON fleet with a long-range missile would be much less expensive than buying a fleet of new submarines. However, the Task Force notes that a cost comparison between conversion of POSEIDON boats and the proposed Navy ULMS must be made carefully. The Navy system carries 24 missiles per boat, instead of 16, and probably has a slightly greater availability. For the same payload on patrol the Navy system requires a fleet of perhaps 17 boats--instead of 31. As a result, fleet operating costs would be less for the ULMS.

(S) The foregoing discussion raises a question concerning the survivability of submarines. For a fixed payload in a given area of deployment, how important is the number of boats? Clearly the number--whether 17 or 31--is too small to make attacking each boat a difficult problem, once

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(S) [3]After receiving the execute message, the POSEIDON boats would have to proceed to an operational range at low speed to minimize acoustic detectability.

(S) [redacted]

OSD 3.3(b)(4),(5)

the boats are located. On the other hand, it seems clear that it would not be wise to put all the missiles in only a few boats, even if there were a substantial cost saving. Without being able to quantify the value of increasing the number of boats, the Task Force believes the number should be maximized, consistent with other factors. This criterion tends to favor the extended-range POSEIDON relative to the proposed ULMS.

(S) In recommending that POSEIDON be equipped with a new long-range missile, we have argued that the Navy did not present a convincing case for speed, POSEIDON aging, or the need for more sea-based payload. Actually, there is another important reason for considering a long-range version of POSEIDON. The IOC for the Navy ULMS is estimated as 1981; hence the POSEIDON boats will have to be a major element of the strategic forces at least until the mid eighties. The IOC for a long-range missile version of POSEIDON is estimated as 1976 or 1977. Thus, even if a strong case could be made for a new submarine, the Task Force would strongly recommend that POSEIDON be retrofitted with a long-range missile.

(S) So far, we have argued that POSEIDON should be retrofitted with a long-range missile, and we have stated that a cogent case for a new submarine has not been made. However, considering the long lead time required to develop a new submarine, and recognizing that the future is uncertain--the POSEIDON boats may be costly to maintain as they age or the Soviets may deploy a heavy ABM--the Task Force is inclined to support R&D effort on the ULMS program in addition to the development of a long-range missile for POSEIDON.[5] We are thus led to the question: If a new submarine is to be developed, is the Navy-recommended ULMS an optimum? The Task Force thinks not.

(S) For survivability, there must be a reasonable number of boats moving slowly (quietly) in a large ocean area. But survivability is not the only important consideration. There must be enough payload deployed in this survivable mode to accomplish the strategic mission assigned to the sea-based force. To achieve this goal--sufficient survivable payload at sea --with limited resources, we are forced to focus on the economic efficiency of the submarine. Economic efficiency may be conveniently defined as the volume of missiles on station per unit ten-year operating cost. (We assume that for the same missile range and technology, missile payload is simply

(S) [5]Note that although the Navy justification for ULMS includes concern about the survivability of the Minuteman force, the Task Force support (for ULMS) does not involve this consideration.

[redacted]

proportional to missile volume.) With this definition we find that the Navy-recommended system has an efficiency of 25 $ft^3/M\$$, whereas the large boat discussed during the first meeting of the Task Force has an efficiency of 41 $ft^3/M\$$.[6] For comparison, the present 640 class boat has an efficiency of 16 $ft^3/M\$$ and STRAT-X 51 $ft^3/M\$$. The Navy-recommended boat is an improvement in efficiency over the 640 but it is inferior to both the STRAT-X and the large Navy design.

[redacted] Although the large boat is more efficient than the Navy-recommended smaller boat, the Task Force does not conclude that the large boat is to be preferred. For a given level of expenditure (say $20 B), although the deployed payload is about 65 percent greater with the big boat, the number of boats is about 30 percent smaller (17, as compared to 25). More payload is desirable; a reduced number of boats is undesirable. We are led to the question: Is it possible to design a submarine as efficient as the big boat but less costly so that the fleet size will not be reduced appreciably? Since we are not apt to get something for nothing, we remind the reader that the Task Force has judged that a reduction in maximum speed and power is an acceptable price to pay.

[redacted] To see how such an efficient, low-cost submarine might be designed, it is convenient to visualize the submarine as consisting of two main parts: The weapon system and the remainder of the boat. The latter will be referred to as the Zero Stage. We observe that the Zero Stage of the large boat is larger and more expensive than the Zero Stage of the Navy-recommended boat. The Zero Stage of the Navy-recommended boat is larger and more expensive than the Zero Stage of the SSBN 640.

[redacted] Now the point is, there does not seem to be any reason why the weapon system of the large boat could not be coupled with the Zero Stage of the Navy-recommended boat or with the Zero Stage of the SSBN 640, or, for that matter, with a Zero Stage that is even smaller and less costly. To be sure, the maximum speed and acceleration of such hybrid systems would be degraded. But offsetting this loss would be increased efficiency and decreased cost. The Task Force thinks that an efficiency of perhaps 80 $ft^3/M\$$ might be achieved. The proposed design philosophy could well lead to the same number of boats as the Navy-recommended system, at the same cost, but with a payload capacity several-fold greater. Such a goal is certainly worth exploring.

[redacted] [6]So that efficiency is not a function of the fleet size, the fixed costs for R&D, facilities, etc. are not included. The availability is assumed to be 0.55 for POSEIDON and 0.65 for the other boats.

[redacted]

[redacted]

[redacted] What missile is employed with the proposed design philosophy remains to be carefully studies. It would be desirable if the long-range missile retrofitted into POSEIDON and the ULMS missile were the same. However, the Navy cost estimates for the 37-1/2'/74" and the 49'/100" missiles seem to indicate that the latter is more efficient--in payload per unit cost--by about twenty five percent. This result is not unexpected since the cost of a missile increases at a slower rate than its size--for two reasons. First, a missile system requires certain fixed items such as a guidance package. Second, missile maintenance costs do not increase appreciably with missile size. Since the missile efficiency has a strong effect on the boat efficiency, it is an important factor.

[redacted] The Task Force recommends that the Navy be requested to explore the design philosophy of coupling low-cost Zero Stages with weapon systems consisting of missiles varying in size from 37-1/2'/74" to 49'/100". The total expenditure, the payload at sea and the number of boats should be treated parametrically. Speed and power should be allowed to degrade as they will. To recoup some of the speed/power capability which could be lost in this design approach, the Task Force recommends consideration of innovative design features such as high-power-density reactors, three-abreast tube arrangements to allow a better hydrodynamic shape, and other drag-reducing measures.

(U) Finally, the Task Force would like to make a few observations concerning operating area. To achieve a large operating area, it is necessary that the submarine be equipped with a long-range missile. But a long-range missile is not sufficient. The submarine must also be able to reach the full operating area. In addition, considering the possible political vulnerability of overseas bases, it would be desirable if the full operating area could be reached from the CONUS. Unfortunately CONUS basing, by itself, does not suffice. [redacted] This otherwise unreachable area could be reached at higher patrol speed, but a high patrol speed implies an increased radiated noise and is undesirable. Since no other CONUS base can provide the desired access, it is necessary to consider overseas bases.

[redacted]

[redacted]

[redacted]

OSD 3.3(b)(4),(5),(6)

(U) Since any non-CONUS base is subject to future loss due to political problems, the Task Force feels that it is also appropriate to consider a mode of operation that avoids overseas bases entirely but does not sacrifice usable operating area. For instance, some combination of CONUS basing, at-sea crew exchange, and boat reprovisioning might be feasible. The Task Force recommends that studies be made considering the use of new bases and at-sea operations for ULMS and long-range POSEIDON.