NAVCOM # 32
1 Dec. 1976

ANTI-TORPEDO DEFENSE SYSTEM (ATDS)

-PROBLEM STATEMENT-

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A customer has requested weapon effectiveness analysis for an anti-torpedo torpedo defense system. The analysis is to provide a mathematical model which computes the probability of threat kill as a function of threat and defense system performance parameters.

The threat is a single straight running torpedo launched at a ship from a random relative bearing. The ship detects the threat using either passive or active sonar (or possibly both) and fires the anti-torpedo. The anti-torpedo is wire guided through a pattern search until lock-on is achieved at which time it is released to home on the threat.

Several performance variables must be parameterized. These are:

1. Threat Speed
2. Sonar Detection Capability (Detection range vs. bearing)
3. Sonar Detection Accuracy
4. Ship Speed
5. Anti-Torpedo Detection Capability
6. Anti-Torpedo Detection Accuracy
7. Anti-Torpedo Speed

The last three are defense system requirements.

ATDS ANALYSIS PLAN

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1. The most promising application for an Anti-Torpedo Defense System is to be investigated thoroughly first; if time and effort permits the analysis will be extended to other applications as well.

2. The most promising application is assumed to be on a freighter engaged in war-time re-supply to Europe. This requires an assumption that such seaborne re-supply will be required[1] (TASK 1).

3. If freighters are used for re-supply of Europe, they can be assumed very valuable. Actually the value is not much in the ship itself, which is likely to make only one trip in a short war, but in the successful delivery of supplies to European ports. Assuming a high 150 lb/man/day resupply requirement, one can assign 13 man-days per ton of cargo. Delivery of a typical cargo would be worth on the order of 100,000 man-days to the Army in the field.[2]

4. The utility of the ATDS should be measured by the extent to which it contributes to that delivery of the cargo - obviously if it can improve delivery chances by even a few percent it will pay for itself. However, the improvement must be measured for the whole voyage, not for a single encounter, and thus we must consider the matter at LEVEL III and below.

5. Since this is a "Requirements For" study, it is assumed at this point that an effective ATDS can be designed, and that it has a probability p_T of "killing" an incoming torpedo (i.e., preventing it from "killing" the ship). This assumption should be confirmed, and p_T established, by LEVEL V

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[1] This should not be too difficult. The U.S. is quite dependent on maritime traffic for basic existence. We shall probably have to protect our import traffic in any case.

[2] This figure would have to be refined in TASK 2; it is furnished merely to indicate that re-supply ships will be very valuable.

(Duel) calculations made at some later time. However, a part of the current task is to indicate the nature of the LEVEL V and VI calculations to be made.

It will be necessary (TASK 3) to postulate the performance and configuration variables of the "threat" torpedoes - *range, speed, accuracy, lethality,* and *signature*. These figures must be established realistically; the task of ATDS is technically very demanding and may be made literally impossible by exaggeration of the threat. Two very critical variables are *lethality* and *signature*.

Lethality is the probability that the torpedo will "kill" the target vessel given that it passes within a miss distance x. If x equals 0 a hit is required, other values of x contemplate the use of some influence fuse. One can either define p_T as a function of x or define some lethal radius R_L within which p_T has some value L. In either case one must define what is meant by "kill" - clearly that should be damage sufficient to prevent completion of the voyage.

If R_L is assumed very large the ATDS must "kill" the torpedo at considerable distance from the target ship. If signature is low and speed is high there will be insufficient reaction time to accomplish this.

Signature is the susceptibility to acquisition by various types of sensor - in this case probably sonar.

6. It is also necessary to specify (TASK 4) the characteristics and capabilities of the launch platform(s) which may deliver the torpedoes. These are not necessarily limited to submarines; aircraft and surface vessels should be included. It is not to be assumed that the torpedoes are always delivered at maximum range. if an effective defense is devised, but it is ineffective for short response times, the delivery vehicle may close to shorter range (at some additional risk).

Another key variable would be the capability for firing salvoes or spreads of torpedoes. Whether this capability is used would be a subject for LEVEL IV.

7. The LEVEL V duel model to be developed (TASK 5) must be capable of establishing the probability of survival of the target ship in a variety of encounters, with and without the use of various candidate ATDS. The encounters should vary as to:

a) Number of torpedoes
b) Type of torpedoes
c) Range at which fired
d) Bearing(s) (May include more than one launch platform)

The model will be used to map the p_s (survival probability) for a range of encounters up to and including those which make p_s very low (~ 20%). no assumptions should be made as to what the enemy will do - the consequences of various p_s's are examined at LEVEL IV and LEVEL III.

8. Paragraphs 5 - 7 have been concerned with analysis at LEVELS V and VI. As previously indicated, we plan initially to assume that an ATDS with some useful p_T can be devised and examine the consequences at LEVELS III and IV. LEVEL III (Theater) studies would establish the overall probability that a freighter would reach port after a war-time trans-Atlantic crossing. This crossing might be unescorted if ATDS is highly effective. In such case Naval forces could concentrate on an "area" type ASW to hunt and kill submarines. The other pertinent Theater strategy would employ escorted convoys - these require a LEVEL IV (Engagement) analysis. The Theater strategy may also be mixed, with convoy protection through certain areas only.

9. An ATDS, even if effective, will be useful only if torpedo attacks are a major component of the enemy's anti-ship campaign. This will be true if they are more productive (in terms of results for input effort) than other means available. The other means would include air attack, missiles delivered by surface vessel or submarine, and mines or other barriers at the terminus of the voyage.

Most scenarios for European war seem to at least tacitly assume that NATO will have air superiority and effective surface sea control over the North Atlantic shipping lanes. This is not necessarily a safe assumption, early seizure of Iceland and or the Faeroes may be a Red capability. Such a development would make sea re-supply by freighter impossible. For the purpose of our problem we shall assume that Red air over the Atlantic sea lanes is limited to long-range bombers, and that Red surface ships can make at most brief raids.

The possibility that ports can be effectively denied by mine-fields sown by submarine or air should be briefly investigated (TASK 6). This would also negate the whole re-supply operation.

Missiles launched from submarines or bombers (probably the former) are then the chief threat other than torpedoes. Another set of LEVEL V studies (TASK 7) is needed to establish p_s against this type of attack. Unless the missile is established as very clearly superior, however, it should not be assumed that Red will abandon the use of torpedoes. It is sound doctrine to have more than one means available, in case pre-war analysis proves to have been faulty.

10. The LEVEL IV analysis (TASK 8) should be a comparative study of Convoy Operations with and without ATDS protection for the escorted ships. Even an ATDS which is effective only for certain types of attack can be of benefit in convoy operations. It will permit altered tactics by the escorting vessels. The ATDS, for instance, might give good protection against torpedo attacks from the front; in this case the escorts might emphasize flank protection.

Any advantage of ATDS can be taken either in increased survivability, or in escort assets diverted to other missions.

The LEVEL IV analyses should be designed to determine what Red force is required to "defeat " to various levels of kill two or three different postulated Blue convoys. This information can be used at LEVEL III.

11. The LEVEL III (TASK 9) analysis should consider various strategies (two or more) for getting re-supply freighters safely across the Atlantic. It can be assumed that land-based air will suffice for some distance away from each shore. Between the limits of such protection, the chief decision is whether or not to convoy.

If the ATDS can provide some adequate degree of self-protection to the freighters, it might be well to discard the convoy principle. Convoying ties ASW-capable ships to a formation of slow freighters with two undesirable results:

a) The group of ships is a tempting target, and escorts are more vulnerable when they must defend the freighters.

b) Escorts on convoy duty cannot actively hunt and kill submarines - following contacts no matter how far from convoy station.

If available ASW forces can be used to cover a prescribed danger area without being tied to slow-moving convoys, they may be able more rapidly to reduce the number of active hostile submarines. Such a result may be the strongest argument for an ATDS.

12. In summary we propose to examine the credibility of the following rationale:

a) Sea borne re-supply and reinforcement is essential to the defense of Europe

b) The situation will be such that the chief threat to accomplishment of re-supply will be submarines either firing missiles or launching torpedoes.

c) An ATDS of specified kill capability can render re-supply feasible.

There has been no discussion of cost in the above; it is first necessary to link the ATDS development to some high priority national objective. It is considered highly unlikely that a system which gives only some realistically modest chance of saving a freighter can be shown to be "cost-effective".

13. The foregoing work establishes the need and the rationale for an ATDS. If the answer to the need is YES, then a reasonably specific statement of *Requirements On* can be made predicated on the results obtained above.

14. The following Tasks have been identified:

TASK 1. Discuss necessity for seaborne re-supply of Europe

TASK 2. Establish value of delivery to Europe of typical freighter cargo

TASK 3. Identify "threat" torpedo performance variables

TASK 4. Identify "threat" launch platform variables

TASK 5. Develop or adapt a Duel Model

TASK 6. Investigate feasibility of mining European ports by Red

TASK 7. Establish freighter p_s (survival probability) against surface- and air-delivered missiles.

TASK 8. Conduct LEVEL IV analysis of Convoy Operations.

TASK 9. Conduct LEVEL III analysis of alternate strategies for trans-Atlantic surface re-supply.

TASK 10. Statement of Requirements On ATDS System.

The details of conceptual solutions and capability are analyzed at LEVELS VI and V, respectively. Detailed designs and performance characteristics must be provided by Project technologists.

Appendix D