

DCIEM TECHNICAL MEMORANDUM NO. 826

PROPOSED PROGRAM TO MAINTAIN  
SONAR OPERATION ALERTNESS

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## ABSTRACT

This memorandum describes the operation of a computer program designed to assist an operator at the AN/SQS-505 *Sonar Primary Indicator* (SPI) console to perform his visual detection task and to monitor his performance at that task. This *Alertness Program* (AP) does not assist the operator in his tracking task.



## PROPOSED PROGRAM TO MAINTAIN SONAR OPERATOR ALERTNESS

### General

1. This memorandum describes the operation of a computer program designed to assist an operator at the AN/SQS-505 *Sonar Primary Indicator* (SPI) console to perform his visual detection task and to monitor his performance at that task. This *Alertness Program* (AP) does not assist the operator in his tracking task.
2. Under the general control of the Operations Room, the sonar operator is presented with AP requested synthetic sonar targets. AP monitors the operator's performance in the detection of these targets and presents him with feedback as to his success or failure in the detection task. AP keeps a record of an operator's performance. This is summarized on the sonar teletype at the end of each operator's spell of observation.
3. AP is required to run within the Standard 505 Sonar configuration. Only minor modifications may be made to the standard operating software; no modifications may be made to the system hardware. A detailed knowledge of the operating software will be required before AP can be implemented since it will use many of the standard operating software routines and will operate on standard software data tables.
4. AP will run as an overlay program within the standard operating software system. This means that its loading will be independent of the standard system and it may be overwritten at any time by some other overlay program. It cannot be loaded automatically but will have to be requested by command from the *Number Entry Panel* (NEP) on the *Sonar Remote Indicator* (SRI) located in the Operations Room.
5. AP operates on the following data which will be discussed in detail in para 21-29.
  - (a) Distribution of times of occurrence of sonar targets
  - (b) Distribution of ranges of sonar targets
  - (c) Distribution of bearings of sonar targets
  - (d) Distribution of courses of sonar targets
  - (e) Distribution of speeds of sonar targets
  - (f) Criterion for non-detection of a target
  - (g) Signal strength of the target
  - (h) Past performance data.

All items are assumed to have standard characteristics (for the distributions) or values unless changed by external control. Only items (a) and (h) may be changed in this way. Changes are entered using the NEP on the SRI.

6. AP causes the *Sonar Signal Injector (SSI)* to produce synthetic sonar targets according to parameters (a) – (e), (g). The SSI will have been initialized by external hand switch to accept its reference signals from either the Variable Depth Sonar (VDS) or the Hull Mounted Sonar (HMS) but not from both. The synthetic targets so generated will only appear on the SPI and/or SRI displaying the appropriate type of sonar returns. This means that only one sonar set in the Sonar room may use AP during an extended period. Only if the SRI is switched to receive the appropriate type of sonar target will the synthetic targets appear there as well.

7. AP produces certain alphanumeric characters for display to the sonar operator. Although the SRI may not hold the synthetic targets generated, these characters will appear on the SRI screen in a special AP message area unless a control function has been entered by the NEP on the SRI inhibiting such messages appearing on the SRI.

8. After the SSI has generated the appropriate synthetic target, AP notes the number of sonar pings of the correct type which occur between the time the signal is first generated and the time the signal is detected. Detection takes place when the sonar operator ball-tabs over the target on the circular display of the SPI and pushes the "contact" Quick Entry Button on his console.

9. When a AP requested synthetic target is detected, the characters "D n" are shown on the circular display near the target detected. "n" is an integer giving the number of sonar pings taken to detect the target. Unless inhibited, the same characters will appear in the special AP message area on the SRI even if the SRI is not switched to the correct type of sonar. The characters and the target are dropped from both displays. The "contact" symbol, which was automatically generated when the "contact" QEB was pushed on the SPI console, is dropped by use of the "Drop" QEB. If in future the QEBs can be associated directly with AP, then the contact symbol will be dropped automatically along with the characters and the target.

10. If an AP requested synthetic target is not detected within the ping count specified as the criterion for a missed target, AP checks that the target generated was actually within range of the sonar beam (see para. 23). If it was not within range, the target and all references to it are dropped. However, if the target was within range, the letter "M" is flashed on the circular display of the SPI and also in the special message area of the SRI. The target is brought up to full strength (i.e., maximum brightness on the displays) then put back to its original strength. The target and the "M" are both dropped by the operator hitting the "contact" Quick Entry Button after ball-tapping over the target on his circular display.

11. If the SPI circular display does not present the area required and the operator has missed detecting a target, then the letter "M" followed by range and bearing is flashed on the screen. On the SRI only the letter "M" is flashed in the special message area. When the operator brings the target area into the screen, the conditions of para 10 apply.

12. Messages in the special AP message area on the SRI may be removed by pushing the "contact" Quick Entry Button on the console of the SRI. They will be deleted automatically by the removal of the corresponding message on the SPI.

If a contact is made which is of a target not requested by AP and which is not deleted by the operator within two pings of detection (i.e., it is considered a real contact not just a bad bit of ball-tapping), and if a synthetic target is already presented for detection, then the letter "S" is flashed on the SPI display near the synthetic target and also in the SRI special AP message

area. The target and both messages are then dropped. Any ping count which was being kept for synthetic target is ignored.

13. For each synthetic target requested, AP records whether or not it was detected as well as the number of pings required for detection.

14. If a real contact is made, AP will not generate a new synthetic target until after the contact has been identified. If the contact is identified as "Underwater Hostile" then AP will not generate a new synthetic target until after that contact has either been dropped or reclassified. This conditional target generation feature of AP is described in para 30.

15. The signal strength of an AP generated target is a function of the operators' detection performances during the current run of AP. This function may take integer values from 1 to 15 with 1 representing the weakest and 15 representing the strongest signal generated. The description of this function is outlined in para 28.

16. A target may be entered manually into AP using the NEP on the SRI. If this occurs AP considers the target as one of its own except that the signal strength function is not responsive to the detection performance on such a target.

17. Each time an operation is made on a synthetic target, e.g., a detection, a miss or a deletion due to the detection of a real target, a printout takes place on the sonar room teletype. This printout should take one line and should contain the following information.

- (a) Time at which operation took place
- (b) Range of target
- (c) Bearing of target
- (d) Target signal strength
- (e) Ping count
- (f) Type of operation.

The "Ping Count" is the number of sonar pings of the correct type which occurred between the generation of the target and its detection. If a target is not detected, then ">n" would be put as the ping count where "n" is the criterion for detection.

The "Type of Operation" would be one of

- D - Detected target
- M - Missed target
- S - Synthetic target dropped due to a real contact.

If the target was manually inserted, the letter "I" would be appended to the type of operation (e.g., DI for Detected Inserted Target).

18. When a sonar operator starts his observation period at the SPI he identifies himself to the system by use of his NEP. He enters a fixed two-digit number followed by a second number which causes the Operations Summary for the previous observation period to be printed out on the teletype. All summation registers within AP which are local to the observation period are

initialized at this stage. The second number entered causes a heading to be printed out on the teletype. This heading is used for the individual operations printout outlined in para 17. It includes the current time of day and the Operator Identification Number along with alphabetic titles for the columns associated with the items (a)-(f) of para 17.

19. It is important that the standard operational sonar program should understand the requirements of para 18 so that the operator follows a standard logging in procedure regardless of whether AP is running or not. This is not to disguise the possible existence of AP but to ensure that the operator introduces himself to the system in the same way each time he starts a period of observation.

20. The NEP on the SRI may be used at any time during the running of AP to produce a summary of past performance.

This summary should take the following form.

(Previous)	Targets Detected	Targets Missed	Ave. Ping Count	Target Detected
(Current)	" "	" "	" " "	" "
(Total)	" "	" "	" " "	" "

#### Details of AP Data

21. AP operates on the data outlined in para 5. In addition, own ship's course and speed is entered directly into the operational program from external sensors. AP has access to a computer controlled clock so that time of day information is available.

22. The time between the generation of successive synthetic sonar targets will follow a standard negative exponential (Poisson) distribution with a mean generation rate which is a parameter for AP. Although this parameter is assigned a standard value (as yet unspecified) when AP is initially loaded, it may be changed at any time during the running of AP by way of the Number Entry Panel on the SRI. This mean generation rate may not be entered before the past performance data outlined in para 29 have been entered.

23. The distribution of ranges at which the synthetic sonar targets are generated is uniform with a maximum range determined by the sonar range setting and a minimum range of 500 yards. At the time a sonar target is to be generated, according to the distribution of para 22, AP will use the approximate speed of sound in water along with the time interval between the previous two sonar pings to determine the maximum range for the sonar. The maximum range for a synthetic target will be defined as 95% of the maximum sonar range thus determined. Note that AP must keep available the time difference between successive sonar pings. If a synthetic target is missed by the observer, the range of the target will be compared with the range of the sonar beam as determined by the last sonar ping interval. If the target range is greater than the sonar beam range then the operator must have shortened the sonar range after the decision to generate the target was made. Under these circumstances all references to that target are dropped. (See para 10.)

24. The distribution of bearings at which the synthetic sonar targets are generated is uniform with a minimum value of 0 and a maximum value of 359.

25. The distribution of courses for the targets is uniform with the same characteristics as in 24.

26. The distribution of speeds for the targets is also uniform with a minimum value of 0 and a maximum value as yet unspecified (underwater speed of a nuclear submarine?). For a speed of 0, the distribution in 25 has no meaning. The distributions 25 and 26 give true course and speed rather than speed relative to own ship.

27. The criterion for non-detection of a target is a function generated by AP and defined as follows

$$C_j = \frac{(j-1)C_{j-1} + 2D_{j-1}}{j}; \quad C_1 = \alpha$$

where  $C_j$  = criterion for non-detection of the  $j^{\text{th}}$  target presented,  $j-1$  target having been detected during this run of AP

$D_{j-1}$  = number of sonar pings taken to detect the  $j-1$ st target detected

$C_1$  = criterion for non-detection of the 1st target presented during this AP run

$j$  = number of targets detected during this run of AP (+1)

$\alpha$  = constant of the system

This function gives the criterion for non-detection of a target as approximately twice the average ping count taken to detect target during the current run of AP. The initial value of this criterion ( $C_1$ ) is a constant of the system ( $\alpha$ ) as yet unspecified but probably around 10. A target which is not detected does not change the criterion function. Since many other criterion functions could be tried, this section of AP should be strictly self-contained so that it can be replaced by sections which calculate different criterion functions.

28. The ability of an operator to detect a target is a function of the total system noise. This itself is a function of the current sea conditions and of the environment. It is assumed that these will change slowly compared with the rate of generation of synthetic targets. Since there is no practical way with the current hardware and operational software to determine the noise in the system, it appears sensible to gain some potential measure of the conditions by using the operator's own responses. For this reason the signal strength of the AP generated targets is based on the operator's past detection performance during the current AP run.

The signal strength may have integer values from 1 (weakest) to 15 (strongest). The following algorithm based on the PEST techniques described by Taylor and Creelman (JASA vol. 41 #4, April 1967), may be used by AP to determine a reasonable signal strength.

- (a) The initial strength at the start of an AP run is a constant of the system (e.g., 7).
- (b) If two synthetic targets in a row escape detection then the signal strength is raised.
- (c) If three synthetic targets in a row are detected then the signal strength is reduced.

Note: A synthetic target which is dropped before detection and which is not "missed" does not count in (b) or (c) above.



This guiding rules for determining the amount by which the strength is raised or lowered (the step size) is given in this quote from the Taylor-Creelman paper.

1. On every reversal of step direction, halve the step size
2. The second step in a given direction, if called for, is the same size as the first.
3. The fourth and subsequent steps in a given direction are each double their predecessor.....
4. Whether a third successive step in a given direction is the same as or double the second depends on the sequence of steps leading to the most recent reversal. If the step immediately preceding that reversal resulted from doubling, then the third step is not doubled, while if the step leading to the most recent reversal was not the result of doubling, then this third step is double the second."

The initial step size (also the maximum) for an AP run will be 4 units.

29. As outlined in paragraph 20 the AP may be directed to display total summary statistics on the circular display of the SPI. These statistics are based on performance during the current run of AP as well as on past performances. Input of these past performances is done immediately following the loading of AP at which time the following three numbers must be entered using the NEP of the SRI.

- (1) Total number of targets previously detected
- (2) Total number of targets previously missed
- (3) Average ping count/target previously detected.

Entry of the third number causes AP to start running. If the first number entered is zero, then AP assumes that there have been no past performances and that no other past performance numbers will be entered. AP assumes zero for the 2nd and 3rd numbers and then starts running.

30. AP has two methods of target generation. In the standard method, a target will not be generated while a real contact is awaiting identification, or has been classified as "Underwater Hostile." Generation will not take place until after such a target has been reclassified or has been dropped. In the optional method of target generation, a target will be generated regardless of the contacts currently being displayed. The NEP on the SRI may be used at any stage during the running of AP to define the method of target generation to be used. When AP is loaded, the standard method of target generation will be in effect.

**Implementation of AP**

31. The specification of AP must be satisfactory on three counts.
  1. AP will assist the sonar operator in his detection task.
  2. AP will not interfere with the operational environment.
  3. AP can be implemented with no hardware changes to the AN/SQS-505 Sonar Systems and with minimal software changes to the operational programs.
  
32. If AP as specified satisfies the points in para 31, then implementation of AP will be done by DMCS-3, which directorate has control of the operational software for the Sonar System. Following implementation DCIEM should assist in the operational evaluation of AP.