Executive Summary

The Phase III Accreditation Support Package (ASP III) is intended to provide the model user with a high confidence statement of model credibility backed by detailed verification and validation assessments. The format of information in this package is tailored to identify clearly those areas where the model can be used to support analysis, testing, and acquisition decisions.

The Phase III package includes an assessment of the accuracy of the code implementation as well as data that bear out how well this model reflects reality. This information is presented in two main components, a verification report and a validation report.

ALARM FE Verification and Validation Summary

Five of the 22 FEs modeled in ALARM have verification results documented in this report; validation results are included for three FEs. The FEs for which V&V findings are included in this document are shown in table 1 below.

Table 1 ALARM FE Verification and Validation Summary

Functional Element	Verification Section	Validation Section
Fluctuations	2.4	
Multipath / Diffraction	2.13	3.13
Antenna Gain		3.20
Threshold	2.22	
MTI	2.23	3.23
Integration	2.25	

Significant Verification Results

Signature Fluctuations: Errors in checking theoretical limits on probability of false alarm (P_{fa}) and probability of detect (P_d) were found in subroutine RDRERR, a minor error was found in subroutine RCSPRT, and overflow errors can occur in subroutine THRESH. In addition, the developer should consider changing the calculation of "loss" for a non-fluctuating target.

Code quality is generally good; however, the design makes tracing fluctuation effects into the radar range equation somewhat difficult. Additional comments are recommended.

Internal documentation is fairly adequate, but could be improved. Headers for the subroutines GETRCS, RCSINP, and RCSINT omit some standard information. Additional comments are recommended to emphasize or explain fluctuations aspects of several subroutines. The most serious deficiency is the misinformation about the log-normal distribution.

The external documentation for ALARM 3.0 is inadequate. The most serious problem is in the User's Manual, which gives incorrect directions for the fluctuation table inputs and gives incorrect bounds on the variables PSUBD and PSUBFA. According to Blake [A.1-4], they should be $0.1 \le \text{PSUBD} \le 0.9$ and $10^{-12} \le \text{PSUBFA} \le 10^{-4}$. In addition, the User's Manual should clearly explain bounds on the fluctuations table. It also should emphasize that the azimuth bound is for the total number of azimuth segments, not just half when the symmetry flag is true.

The descriptions of subroutines THRESH and RCSINT in the Programmer's Manual do not mention the fluctuations portion of these routines; descriptions of these portions should be added. The Analyst's Manual gives a good description of fluctuations in the section on detection theory; a reference to this in the section on target RCS might be helpful.

Multipath/Diffraction: The broadest discrepancy is that ALARM 3.0 does not exactly match the MIT Lincoln Laboratory SEKE code; the following three items differ: (1) the constants in the logic to determine which propagation effects will be calculated, (2) the definition of the terrain profile, and (3) the extent of the tangent plane used in the calculation of the multipath effect. Apart from the differences from SEKE, several minor discrepancies were found in subroutines MLTPTH, VISBLE and SEKINT. The ALARM external documentation for this FE is inadequate, because the analyst's manual gives an unacceptably incomplete description of the relevant algorithms.

Threshold: One code discrepancy was found in the preliminary comparisons of S/I to threshold (T) in subroutines PULSED and PULDOP. The error occurs when the preliminary S/I equals T, so the comparison test is not passed and additional sources of interference are (generally) not computed.

A second discrepancy is the error in checking the theoretical limits on P_{fa} and P_d in RDRERR; this error is due to using referenced algorithms (from Blake, [A.1-4]) without maintaining the limits specified by the reference.

A third possible problem is not a discrepancy, since the code implements the design as described in section 3.3.7 of the User's Manual, and as mentioned in the Programmer's Manual (pages 22-23 and 25-26) and the Analyst's Manual (section 4.2.6). However, it seems inconsistent that no distinction is made between target detection and deceptive jammer detection in contour plot mode, but this distinction is made in flight path mode. A re-examination of this design issue is recommended to the model developer.

Code quality is generally very good in ALARM proper, but not in the post-processing program BINPRO. The major problem in BINPRO is that it seems to have been written for a UNIX system and then modified to run on VMS. This can lead to confusion for VMS users.

Internal documentation in ALARM is adequate, but should be improved to provide a consistent set of information in the subroutine headers.

Some discrepancies were found in the ALARM manuals.

The User's Manual contains several errors in the section describing the binary plot file (page B-3). In addition, the Input Guide in the User's Manual gives incorrect bounds on PSUBD and PSUBFA. Appendix F of the User's Manual describes the support programs for ALARM. BINPRO is discussed on pages F-14 through F-18. The inputs are not described in the same detail as for the ALARM model proper.

The Programmer's Manual states that program DETECT is described in appendix F of the SUM, but DETECT is no longer described there. Descriptions of BINPRO, PREPGP, and GNUPLOT should be added to the Programmer's Manual.

The Analyst's Manual gives a very good description of the calculation of the threshold value in section 4.4.6, but the last paragraph on page 61 could be mistakenly interpreted as implying that ALARM provides default values of P_d and P_{fa}. This manual also provides a very good description of the calculation of S/I in section 4.2.6, but it should note (as a unique pulse doppler aspect) that the S/I over all PRFs is selected as the overall S/I for the radar.

MTI: No major problems or anomalies were found with the ALARM MTI references or the code implementation. The minor problems found in RDRERR could be eliminated by replacing lines 522 and 560 with the following:

Line 522: 'IF (RMTIMX(IGATE) .LT. RMTIMN(IGATE)) THEN '

Line 560: 'IF (AMTIMX(IGATE) .LT. AMTIMN(IGATE)) THEN'

Code quality is generally good. Internal documentation is adequate, but should be improved to provide a consistent set of information in the subroutine headers and to correct spelling errors.

External documentation for MTI in ALARM 3.0 is generally good. The manuals have been updated to match the new code in this version. The minor error in the User's Manual could be corrected by replacing "NDELAY > 0" with "NDELAY≥ 0".

Integration: No major errors were found. Errors in checking theoretical limits on P_{fa} and P_d were found in RDRERR; these errors are due to using referenced algorithms without maintaining the limits specified by the reference.

Code quality is generally good, although there are some unused input variables with minor discrepancies between the printed output from RDRPRT and the ALARM input guide. Internal documentation is adequate, but should be improved to provide a consistent set of information in the subroutine headers.

The external documentation is somewhat inadequate. The Input Guide in the User's Manual gives incorrect bounds on PSUBD and PSUBFA. In addition, the Input Guide should warn users that the value entered for NPULSE should be the equivalent number of pulses integrated and refer to table 2.2 in Blake [A.1-4]. (The Analyst's Manual warns users to carefully define the number of pulses integrated, but it does not give specifics or mention equivalent number of pulses integrated.) Also, the Input Guide should refer to parameter names (not specific values) for array dimensions.

Significant Validation Results

Multipath/Diffraction: Results for test case 1, ATCOM/AATD SPAR model data, are inconclusive. Further testing is required to validate this FE. Such testing must include extremely accurate target altitude measurements in order to assess the ALARM implementation of multipath.

The second validation test, a comparison of measured and modeled one-way pattern-propagation factors, indicates significant differences, particularly as a function of the method chosen by ALARM to determine the one-way pattern-propagation factors. The overall impact of these differences on the prediction of maximum target detection is significant if a clear line-of-sight exists between the radar and the target. If the target is masked from the radar, the impact is insignificant.

Several Model Deficiency Reports (MDRs) were generated during testing that report known or suspected problems with the ALARM implementation of this FE. These MDRs are summarized in table 2; ALARM ASP I, Appendix C, contains a complete list of MDRs.

Table 2 Model Deficiency Reports of Multipath/Diffraction Errors

MDR	Date	Description	Disposition
9	9 Nov 92	Negative round earth diffraction factors	ALARM92
21	21 Oct 93	Incorrect SEKE antenna gain calculation	New
22	11 Jan 94	Incorrect clutter processing for coastal sites	New
24	26 Jan 94	Incorrect SEKE processing (per Lincoln Laboratory)	New
27	31 Jan 94	Add SEKE1 algorithm	New
33	2 Jun 94	Incorrect sea-state definitions in the analyst's manual	New
34A	21 Sep 94	Incorrect SEKE diffraction affects threshold	New

Disposition:
ALARM 92 - Implemented in ALARM92 (ALARM 3.0 beta version).
New- Not yet reviewed by the ALARM Users Group and CCB

Implications of these errors for model users include:

1. All MDRs identified by a status indicating an implementation version have been fixed in the specified version.

2. Errors found during the SMART verification process are not listed here unless the developer (SAIC), in agreement with the independent verifying agent (ENTEK), has opened an MDR for the alleged anomaly.

3. MDRs 21, 24, 27, and 34A represent identified differences between the ALARM implementation of the Lincoln Laboratory (LL) SEKE propagation algorithms, and the LL version. On several occasions LL has briefed differences in the propagation factor generated in ALARM/SEKE vice that generated by their in-house SEKE code. To date, LL has specifically observed that the majority of these differences seem to be caused by the multipath calculations. Both LL and SAIC are committed to reviewing the SEKE code during FY95. Corrections to the ALARM implementation are anticipated pending the results of those investigations.

4. MDR 22, *Incorrect Clutter Processing for Coastal Sites*, will only cause problems in the modeling of radar performance of coastal sites where the target appears both over land and over water. This problem can be dealt with by making two separate model runs with different propagation/clutter parameters, then manually merging the results. Code has been developed by SAIC to provide the data to the model to more accurately represent the problem, but it is not yet known whether the CCB will approve the proposed change.

5. MDR 33, *Change Sea State Definition in Documentation*, suggests clarification of the actual definitions of the sea states used in the model. There is no impact on the informed user.

Antenna Gain: Antenna gain can have a significant impact on detection range in a clutter environment. There are also some differences, although small, noted in the stand-off jamming environment. It is recommended that a 3-D measured antenna gain pattern, rather than a pattern built by ALARM from a 2-D pattern, be used in studies involving high clutter and/or stand-off jamming environments.

Four errors have been uncovered for the Antenna Gain FE as a result of the SMART Project V&V efforts. These are summarized in the table below; implications for model use are discussed after the table.

Table 3 Model Deficiency Reports of Antenna Gain Errors

MDR	Date	Description	Disposition
3	10 Jul 92	Gain for square apertures only considered by ALARM	ALARM92
19	15 Mar 93	Incorrect interpolation of transmit and receive antenna gain	ALARM92
63	26 Apr 95	Slight differences in calculation of transmit and receive antenna gain	New
65	2 May 95	In some cases, ALARM is not detecting when the transmit and receive antenna gain patterns differ	New

Disposition:
ALARM 92 - Implemented in ALARM92 (ALARM 3.0 beta version).
New- Not yet reviewed by the ALARM Users Group and CCB

1. MDR 3, *ALARM Calculates Gain for Square Apertures Only*, was corrected in ALARM 92. This error could cause incorrect estimates of clutter and jamming signals when modeling radar antennae having other than square apertures.

2. MDR 19, *Incorrect Interpolation of Transmit and Receive Antenna Gain*, was also corrected in ALARM 92. This error could lead to erroneous model results.

3. MDR 63, *Differences in Subroutines TGAIN and RGAIN*, points out a slight discrepancy in the way transmit and receive antenna gain are calculated. This can lead to small differences between the transmit and receive gain for the same antenna pattern.

4. MDR 65, *ALARM Not Always Detecting When Transmit and Receive Antenna Gain Patterns Differ*, prevents the user from specifying different transmit and receive antenna gain patterns when input using the in-line method.

MTI: One validation test for this functional element is included in this document. The comparison of measured MTI response relative to the ALARM modeled MTI response indicates significant differences in the gain/attenuation at target blind speeds which occur when the relative velocity of the target creates doppler frequencies that are integer multiples of the radar PRF. However, the overall impact of these differences on the prediction of maximum target detection is insignificant.

One error has been uncovered in the ALARM implementation of MTI, documented in MDR 1. The problem, fixed in ALARM 92, concerned invalid algorithms for staggered-pair MTI. It caused ALARM to incorrectly estimate both clutter and target signal power.