Abstract - Current Navy Air Launched Missile (ALM) maintenance includes Automatic Test Equipment (ATE) with varying levels of technology, training, software, and test requirements. These factors, along with excessive and redundant testing, have greatly increased maintenance costs. Subsequent ATE inefficiencies and obsolescence influenced the Naval Air Systems Command (NAVAIR) and Naval Sea Systems Command (NAVSEA) to form a Quality Management Board (QMB) to address these problems. The QMB established thirteen (13) Process Action Teams (PAT's) to evaluate the Navy's ALM testing philosophies. This paper outlines the current PAT efforts and accomplishments with emphasis on Army and Air Force practices such as mobile and proximity testing.

I. INTRODUCTION.

The Process Action Team (PAT) is evaluating current Air Launched Missile (ALM) maintenance practices such as proximity testing, mobile testing, process evaluation testing, calibration, and certification. Fig. 1 represents the organization of the PAT. Of these, mobile testing has taken top priority, based on its potential impact and cost savings to the Department of the Navy (DoN). As a prerequisite to mobile testing, each ALM planned for transitioning to an Organizational Level (O) to Depot Level (D) maintenance concept has to first be approved for proximity testing by the Weapon Safety Explosive Review Board (WSERB).

Both proximity testing and mobile testing strategies have circulated throughout the DoN ALM community for years, but without the proper technical or management support. The PAT, empowered by its Quality Management Board (QMB), has prepared recommendations based on a technical collaboration of field activities. As the PAT progresses, it becomes essential that communication takes place among the ATE and TPS developers, weapon maintainers, and logistic planners. With the QMB's support, the PAT utilizes the techniques of Total Quality Management (TQM) to improve the ALM maintenance structure and reduce out-year support costs for maintaining ALM's.

Fig. 1 PAT Organization.

This paper provides the evolution of the PAT, a description of current ALM maintenance, and a status of PAT objectives and accomplishments.

II. BACKGROUND.

In response to DoN TQM policy and an increased awareness of a declining budget, the Naval Air Systems Command (NAVAIR) and Naval Air Sea Command (NAVSEA) jointly formed a Quality Management Board (QMB). The QMB subsequently established thirteen PAT's to evaluate DoN ALM testing philosophies. Of the thirteen original PAT's, eleven accomplished their objectives. The other two PAT's, Proximity Testing and ALM Maintenance, merged to form the last remaining PAT.

Current DoN ALM maintenance produces ATE inefficiencies, obsolescence, and varying levels of technology, training, software, and test requirements. Subsequently, maintenance costs have increased as a
result of excessive and redundant testing and an increased logistics pipeline, where good ALM's are frequently failed.

In order to properly assess maintenance problems and make credible recommendations, the PAT obtained technical representation from such field activities as the Naval Air Warfare Center (NAWC) Weapons Division, Naval Weapons Stations (NWS's) Yorktown and Fallbrook, Naval Aviation Depots (NADEP's) Alameda and Norfolk, Naval Warfare Assessment Center (NWAC) Corona, Weapons Quality Engineering Center (WQEC) Concord, and Systems Engineering Division (SED) Yorktown.

Initiated with TQM guidelines and facilitators, the PAT adopted the Process of Innovation and Consensus (PIC) shown in Table I [1]. After defining its mission statement, teaming, and process examination, objectives and scope were clarified.

TABLE I
PROCESS OF INNOVATION AND CONSENSUS

| DIVergence/Divergence (DIC) | 1.1 Divergence | 1.1.1 Nominal Group Technique (NGT) |
| 1.1.2 Brainstorming | 1.1.2.1 Random |
| 1.1.2.2 Structured |
| 1.1.3 Pinpointing |
| 1.2 Convergence |
| 1.2.1 Numbering |
| 1.2.2 Clarifying |
| 1.2.3 Stream Analysis |
| 1.2.4 CDAM |
| 1.2.4.1 Combining |
| 1.2.4.2 Deleting |
| 1.2.4.3 Adding |
| 1.2.4.4 Modifying |
| 1.2.5 Lobbying |
| 1.2.6 Voting |
| 1.2.6.1 Multivoting |
| 1.2.6.2 NGT |
| 1.2.6.3 Discrete Summation |

2 Cause/Effect (CE) Diagramming (Fishbone/Fishkra)

| 2.1 Factors Type |
| 2.2 Process Type |

3 Why-Because Pursuit

4 Process Internalization

4.1 Informal Process Internalization

4.2 Formal Process Internalization

5 Data/Information Accumulation

5.1 Information and Data

5.2 Formal Process Internalization

8 How-By Pursuit

7 Force Field Analysis

Psychic Instinct

III. CURRENT ALM MAINTENANCE PROCESS.

The ALM testing process is not initiated with testing to confirm or repair a bad missile. If an ALM fails during a mission, there is a great potential for danger and it does not return for testing. The testing of a missile is a prediction that it will operate properly when launched. There is no opportunity to test a failed ALM beyond the ATE environment and no chance verify a good ALM in a mission environment [2].

Fig. 2 illustrates the current ALM Maintenance cycle. ALM's for the DoN are received from the manufacturer, checked-out, and issued to the fleet via the Naval Weapons Stations (NWS's). When an ALM fails aboard ship or requires modification, it is returned to the NWS, also referred to as the Intermediate-Level Maintenance Activity (IMA). After ALM Built-In-Test (BIT), a Missile On Aircraft Test (MOAT) is performed. The scope of the MOAT is generally limited to visual inspection and seeker test. Also, ALM's are periodically cycled back through the cycle based on its Serviceable-In-Service-Time (SIST).

At the IMA, ALM's are first tested in their All-Up-Round (AUR) configuration. If they fail, they are retested to confirm the failure. Depending on the system, after a specified number of consecutive failures, diagnostics lead to the failed section. The section is then tested to fault isolate the failure to a Weapon Replaceable Assembly (WRA). The ALM is then disassembled and its failed section is sent either to the WQEC for reject verification or the NADEP, also referred to as the D-Level.

The reject verification process was implemented to provide a step where an evaluation would take place to determine why failures and false failures were
occurring. This process has since been eliminated from DoN budget.

The NADEP's fault isolate a failure to its replaceable card or component. After the appropriate repair action, the ALM assembly is placed into storage until it is needed to be assembled, sent to the IMA, and returned to the fleet.

This process has led to a significant overtesting of ALM's. While it is critical that bad ALM's aren't passed, it is very common for a good ALM to be falsely failed and sent through the lengthy pipeline. The pipeline for a missile, once it has been declared bad by a NWS, can be as high as 18 months [3]. The cost of this pipeline continues to increase as making 'business as usual' unexecutable. The logistics tail is extremely long because of the diagnostics to confidently and rapidly isolate to a single element [4].

Test redundancy is also increasing between the IMA and NADEP's. The level of test at both level is becoming significantly extensive, resulting in over testing with ATE that is most often very old and very peculiar, increasing spares costs.

IV. PAT INITIATIVES.

After evaluating the Air Force's approach in performing proximity testing, the PAT has developed recommendations to the QMB that have been received with success. Currently, the Advanced Medium Range Air-to-Air Missile (AMRAAM), High Speed Anti-Radiation Missile (HARM), and Walleye Missile have all been approved for proximity testing by the WSERB. Under development are proposals for Maverick and Hellfire, scheduled for this summer.

The WSERB is specifically concerned with the potential of accidental rocket motor ignition or detonation of the warhead. Additionally, the PAT is involved with the design of a device that is attached to the ALM during test that effectively prohibits the signal from reaching the rocket motor.

Proximity testing eliminates military constructions, providing adequate insulation against a warhead blast and distance between the test cell and the ATE operator. It reduces maintenance facility operating costs and offers flexibility in selecting test areas, specifically enabling the mobile testing concept of an O to D Level of maintenance.

Mobile testing, as employed by the Army, will radically change the current Navy ALM maintenance cycle by replacing the IMA with a mobile Organizational-Level (O-Level). The ALM will now be serviced directly from the O to D-Level.

Proposed mobile sites are NWS Seal Beach Detachment Port Hadloc, Washington, NWS Concord, CA, and NWS Earle, New Jersey. Specific test functions to be performed are as follows:

- Visual Inspection.
- BIT.
- Software Loading/Reprogramming.

Proposed benefits of mobile testing are as follows:

- Rapid deployment of test capability to forward areas.
- Reduced overhead cost by using vans rather than fixed sites.
- Reduced transportation costs due to testing at port of entry.
- Reduced Receipt, Storage, and Issue (RSI) costs due to shorter pipeline.
- Increased asset readiness due to shorter pipeline.
- Increased safety by reducing the movement of high explosives over congested highways and through densely populated communities.

Potential disadvantages of utilizing mobile testing are summarized as follows:

- Inadequate work load.
- Excessive costs: (one time and re-occurring cost) at some locations.

The PAT also supports the elimination of reject verification, but has proposed another step called Process Evaluation Testing. This process would take place, on a sample basis, before an ALM reaches the NADEP. Failures would be verified, results documented, and an analysis performed on why the failure(s) occurred. This evaluation would lead to further recommendations on test processing improvements.

V. CONCLUSIONS.

Proximity testing and mobile testing are not new terms to the ATE or DoN communities. For years, there has been a strong influence recommending an O to D Level of maintenance. The QMB offers the vehicle and the support to implement both strategies.

While the proposals for ALM proximity testing continue to be presented to and approved by the WSERB, mobile testing efforts are much more involved.
Detailed research, analysis, and planning is now taking place to validate previous proposals.

Technically, there are many advantages to transitioning to two levels of maintenance. It will offer management information systems, artificial intelligence, integrated diagnostics, and expert systems to achieve higher levels of performance [5]. It will only work, however, if designs are highly reliable, modular, relatively inexpensive, are isolated by a dependable and accurate BIT, and do not impact overall aircraft performance and readiness [6].

With technical representation from many field activities and management support form the QMB, the PAT is proposing dramatic improvements of operational capability and significant acquisition and support cost avoidance [7].

REFERENCES