Proceedings of the Annual General Donald R. Keith Memorial Conference
West Point, New York, USA
April 29, 2021
*A Regional Conference of the Society for Industrial and Systems Engineering*

# Improvement of the U.S. Army's At-Platform Automatic Test Systems (APATS)

**Eldon Davis-Picou, Juliana Galvan, Matthew Gray, Matthew Martin, and Jace Taliaferro**

United States Military Academy
Department of Systems Engineering
West Point, NY

Corresponding Author's Email: jace.taliaferro@westpoint.edu

**Author Note:** This USMA research study was advised by the Department of Systems Engineering's Major John Case. This project was made possible by the support of the Product Director for Test, Measurement, And Diagnostic Equipment (PD-TMDE), who provided data collection and expertise in the subject matter.

**Abstract:** Equipment maintenance is critical to the success of the U.S. Army because it directly supports combat readiness. This research supports PD-TMDE's efforts to improve how electronic maintenance is conducted on military vehicles and weapon systems. This study's objective is to improve the at-platform automatic test system (APATS), which will decrease the time vehicles are inoperable, therefore increasing combat readiness. Using a Systems Engineering approach, solution strategies were identified through stakeholder analysis and system decomposition. The main findings of this study are that system users are not well trained to use APATS components for their intended purposes. Secondly, the unit maintainers are not authorized to sustain the MSD at the unit level. Finally, the APATS suffers from configuration complexity. The impact of this study is that PD-TMDE has an improved understanding of the problem and potential solution strategies, enabling electronic maintenance improvement across the Army.

**Keywords**: Testing, Diagnostics, Maintenance

## 1. Introduction and Background

The At-Platform Automatic Test System (APATS) is the Army's standard automatic test kit for vehicles. APATS is managed by the Product Director for Test, Measurement, and Diagnostic Equipment (PD TMDE), who is also in charge of all the Army's automatic test systems and the proper test, measurement and diagnostics that are conducted by these devices. The APATS main purpose is to identify failures in vehicle systems at the vehicle's location, rather than having to bring the vehicle to a maintenance facility. When the vehicle Built in Test (BIT) warns of a fault, a soldier maintainer can diagnose and fix the fault using the APATS capabilities. The Maintenance Support Device (MSD) was created to test vehicle systems, including the engine, transmission, brakes, onboard computer, and tire inflation systems. Figure 1 depicts how the MSD interacts with other system components to aid maintainers.

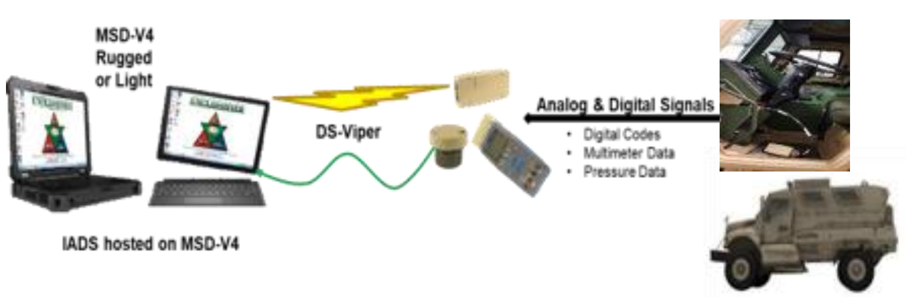


Figure 1. MSD and Connection Kits Graphic (PD-TMDE, 2020).

The critical system stakeholders were identified in accordance with systems engineering standards (Parnell et al., 2011). The overall decision authority is Tom Lettis as the head of PD-TMDE. The clients are Steve Butcher and Collin Clark, who also serve as project advisors. The system owners are the PD-TMDE APATS Project Office, including Kent Van, Nick Vivian, and Bob Russel. Users of the systems are Army mechanics and maintenance supervisors. System consumers include Army unit members who benefit from timely and effective vehicle maintenance.

## 2. Methodology

The methodology portion of the paper is meant to analyze the methods used to identify, evaluate, and conduct stakeholder analysis as well as the methods used to analyze the APATS. Stakeholders comprise the set of individuals and organizations that have a vested interest in the problem and its solution to include the system operators, system maintainers, regulatory agencies, and senior technical advisors (Parnell et al., 2011). In general, there are three techniques that are commonly used for stakeholder analysis: interviews, focus groups and surveys. Due to COVID restrictions, interviews were conducted virtually, while focus groups and demonstrations were conducted by PD-TMDE team members who had the ability to travel to Army units. Interviews consisted of 30–60-minute conversations with key stakeholders. A main source of stakeholder analysis occurred through surveys, which targeted MSD maintainers, users, and maintenance supervisors within Army units. In particular, a PD-TMDE team member conducted the surveys designed by the USMA study team in-person at Fort Hood and relayed the data to the USMA capstone team for analysis. The remainder of the surveys were distributed online to Army units, consisting of two types. The first survey type was directed at MSD users and maintainers at the Company and Battalion level. The second survey type was directed at maintenance supervisors at all levels within an Army Brigade Combat Team (BCT). The intent of these surveys was to collect information from a large and diverse group of stakeholders to understand user perspectives and enable data collection for system analysis.

The method used to analyze the APATS was through system decomposition and functional analysis with IDEFØ models, which are a structured representation of the functions, activities or processes within the modeled system or subject area (Integration Definition for Function Modeling, 1993). The viewpoint of the IDEFØ method is derived from the stakeholder analysis gathered through the stakeholder interviews and surveys as well as individual research that was conducted to understand the system. The IDEFØ method is more fully illuminated in the findings and conclusions section.

## 3. Stakeholder and System Analysis

Interviews were conducted with critical APATS stakeholders, in which we asked a myriad of questions about the APATS components and how it is used operationally. Survey feedback was received from 26 Army users and maintenance supervisors across 12 different units within the 1st Cavalry Division at Fort Hood (Butcher, 2021). We interviewed maintenance supervisors CW3 Raymond Clayton (Automotive Maintenance Officer for 1-2 SBCT at Fort Base Louis-McCord) and CW2 Chris Neilson (Electronic Maintenance Officer for 3CR at Fort Hood). The APATS Project Office Logistician, Nick Vivian, was also interviewed and is a critical stakeholder within PD-TMDE. This analysis primarily served to identify the difference between intended use and actual use of the system, a critical step in formulating clear alternative generation for PD-TMDE.

Table 1. FCR Matrix from Stakeholder Interviews

| | Findings | Conclusions | Recommendations |
|---|---|---|---|
| Users | Users are **not aware** of the MSD Help Line | **Users have a lack of understanding** about how the system is supported ouside of their respective unit. | A soldier needs to be trained and authorized in MSD maintainence at the unit level. The unit communications sepcialist (25U or 25B) could fill this role. Said soldier would act as a bridge between users and the assistance they need for the system. |
| Users | Users are **not aware** of the MSD library on Milsuite | | |
| Users | Users are **not aware** of who repairs the MSD | | |
| Supervisor | No technical expert on the unit level | Units don't have **expertise readily avaible** on the system. | |
| Users | **33-50% of MSDs were FMC** | **Operational avaiablility is very low** for the MSD. | To reduce complexity between PD-TMDE, units, and PMs, PMs coul dbe required to fund PD-TMDE to support the PM complexity. PD-TMDE would source the MSD and develop risk management base packages for the PM's vehicles. This would require and increase in PM funding and manpower in order to support cyber securty verification and MSD configuration management in accordance with the PM's respective software. |
| Supervisor | Electronic maintence shops are having to borrow MSDs to conduct maintenance | | |
| Users | **Too few MSDs** to work on multiple vehicles simultaneously | | |
| APATS | Significant **lack of diagnostic equiptment training** | After initial training at AIT or NET training, there is **no additional touch points on MSD usage** throughout a maintainers career. | To assure successful usage of the MSD, Commanders must be encouraged to send their maintainers to NET training. PD-TMDE should also conisder sending a mobile rotating team of trainers to major units for refreshers on MSD usage, connection kits, and hardware trouble shooting. Additionally, NET training should also conist of a IETM training session. |
| Supervisor | **Lack of training** for maintainters on the system | | |
| Users | **No follow-on-training** for the MSD or SWICE kit | | |
| Users | IETMs often crash | The MSD has hardware or software reliabilty issues or **issues with knowledge about the system.** | |
| Users | SWICE usually does not communicate with the vehicle **as intended** | | |
| Users | **Data is not collected** from vehicles under test | Acual system usage is **not in line with intended usage.** | |

ISBN: 97819384962-0-2

These interviews allowed us to generate a Findings, Conclusions and Recommendations (FCR) Matrix for the client as depicted in Table 1. The emboldened text indicates a link to equipment availability, a key driver of readiness. Availability is where the system can improve the most and have the largest impact on the Army. APATS operational availability (Ao), user training, and system support were clearly identified as areas needing improvement, indicating a gap between intended use and actual use of the system. The findings and recommendations in Table 1 are more fully developed in the following sections.

## 4. Findings and Conclusions

The IDEFØ model shown in Figure 2 is a detailed system model showing the critical elements of the "as-is" APATS. An IDEFØ model consists of five components, which include the activity or subsystem, the inputs, the controls, the mechanisms, and the outputs (Parnell et al., 2011). Figure 2 shows the flow of information and actions that take place between the components of the system. The five APATS subsystems include the mechanic, the vehicle tested, the connection kits, the MSD and the IETM/Diagnostic software. The connections between the boxes represent the flow of information between the components. From the stakeholder analysis section, the capstone team color coded the diagram to emphasize where the system could be improved or maintained according to stakeholder feedback. Red signifies that the APATS requires major improvements, amber signifies partial improvements, and green signifies well-functioning system components. In the following subsections, we illuminate the IDEFØ model and state the conclusions gathered from these findings.

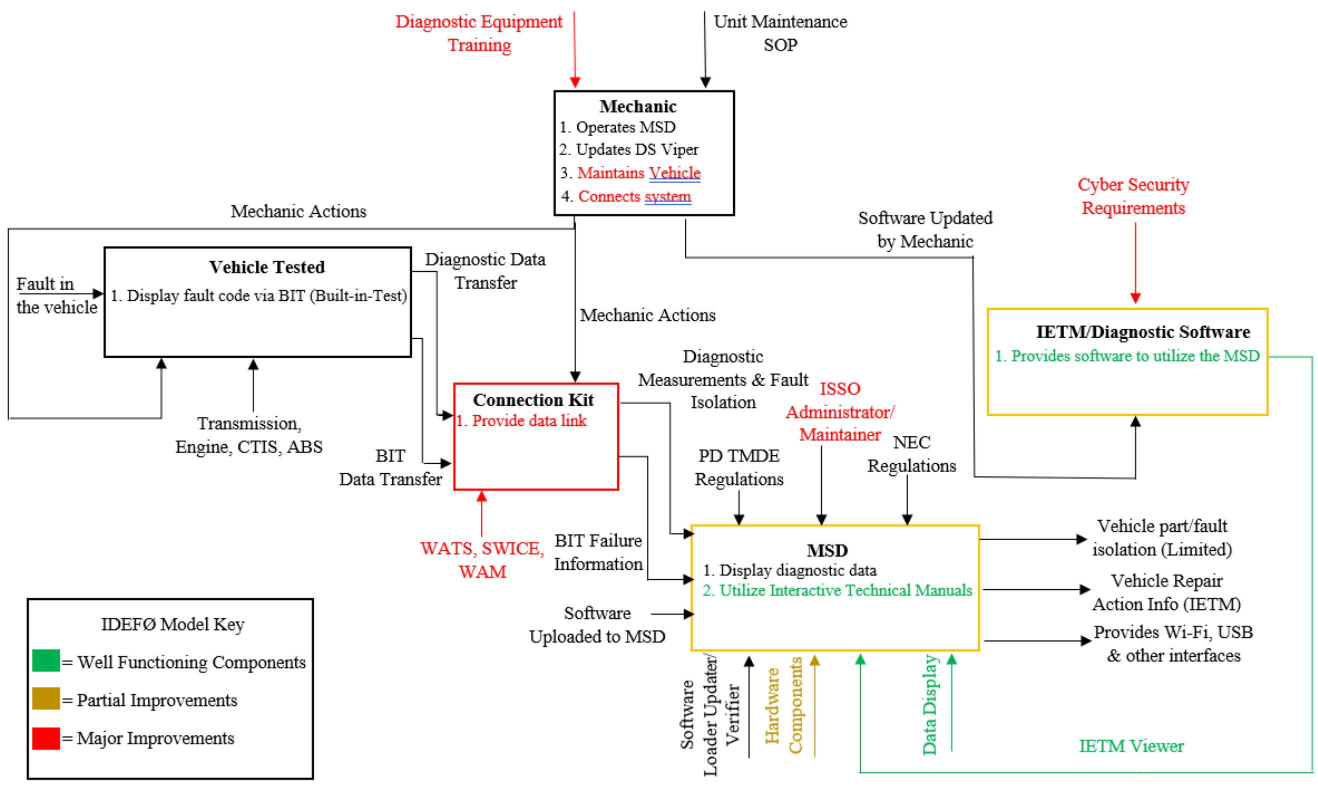


Figure 2. "As-Is" IDEFØ Model at the Subsystem Level

### 4.1 User Training

Training on the MSD starts during a mechanic's Advanced Individual Training (AIT) at Fort Lee, VA. Even though the MSD is used continuously as a technical manual (TM) viewer, soldiers are only trained for six hours on how to operate the software and connect the MSD to a vehicle to read diagnostic codes (Vivian, 2021). As a result, in Army units the MSDs are primarily used as PDF readers to view TMs, rather than diagnose faults. From the surveys conducted at 2nd and 3rd ABCT, each unit expressed that they would like more formal training on the MSD and with the connection kits. In figure 2, it is evident that the "diagnostic equipment training" control, "connects vehicle" function, "maintains vehicle" function, "provide data link" function and the "WATS, SWICE, and WAM" kit mechanism are interconnected, affecting the system as a whole and limiting system performance. The mechanics that operate the WATS, SWICE and WAM kit are not provided with sufficient diagnostic equipment training, which results in these kits not being utilized by the maintainers. Therefore, the maintainer is not able to connect the vehicle to the MSD, resulting in no vehicle data being transferred and displayed on the MSD. Proper training with the diagnostic software and connection kits will allow the MSD to operate at the level intended by PD TMDE.

### 4.2 Maintenance and Sustainability

Soldiers are not currently able to conduct maintenance on the MSD at the unit level. In fact, some units seek off-post computer repair stores to fix issues that arise on the MSD (Butcher, 2021). Units that are authorized the MSD are required to appoint an Information Systems Security Officer (ISSO) who is delegated by the commander to possess administrative privileges to maintain the MSD for the unit. However, the ISSO is rarely properly appointed and trained. The ISSO must get an A+ Security Certification to manage passwords and accounts. Currently, the ISSOs typically are not properly appointed and do not possess an A+ Certification. The IDEFØ diagram, in figure 3, highlights the "ISSO administrator/maintainer" control and the "cyber security requirements" control as a major improve because the ISSOs do not possess the means at the unit level to administer or sustain the MSD. This forces units to utilize the APATS help desk, a phone-in support service. The lack of unit-internal MSD sustainment leads to issues during deployments or training when the APATS help desk is not a feasible solution to repair or troubleshoot an MSD.

### 4.3 System Configuration Complexity

The MSD is used by over 30 Military Occupation Specialties (MOS) on over 50 vehicles, each of which requires maintenance practices determined independently by the vehicle's Program Manager (PM). An example is the Bradley Fighting Vehicle, which has software on-board, developed by the PM's vehicle manufacturer, that is uploaded via the MSD. PM Bradley produces the software and updates but must rely on TMDE to support their system's configuration, as well as cyber and network compliance. In terms of manpower and funding, the APATS office is not resourced to provide support for the many PM offices and their complexity.

## 5. Recommendations and Alternative Generation

The IDEFØ functional decomposition diagram depicted in figure 3 is a solution-agnostic system design model that also serves to identify the responsibilities of PMs and TDME. The intent of the diagram is to provide a recommendation on how APATS should function based upon the defined roles and responsibilities of the PM and TDME. In this model, the perspective is focused on system processes, rather than physical subsystems. As seen in Figure 3, TMDE responsibilities, highlighted in blue, are high-level responsibilities that focus on defining, providing, and validating system components. The responsibilities highlighted in orange are those that must be completed by the PM to ensure the actual use of the devices meets the intended use. Three broad categories of recommendations are provided in the following sections, which are based upon this system design decision tool.

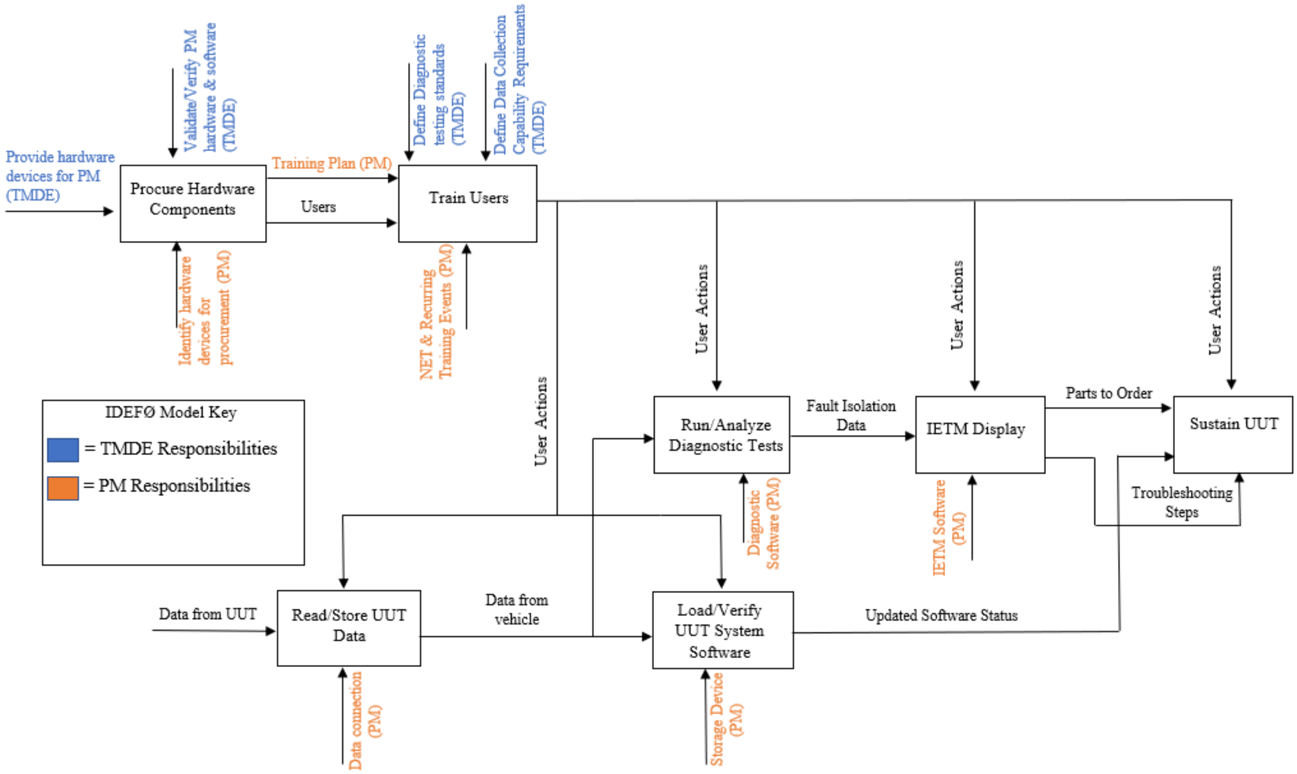


Figure 3. The Solution-Agnostic "To-Be" IDEFØ Model

## 5.1 System Configuration Complexity

The complexity of the many individual PM vehicle requirements and the MSD usage is problematic. While this is, in part, a training issue, we recommend the PM takes on greater ownership of their system requirements. As shown in figure 3, the PM will identify the MSD hardware that is best for their system and users. PD-TMDE would then procure this hardware, as well as develop the MSD system configuration for network and cyber compliance. The PM then manages the platform-specific software, user training, and fielding of the device to Army units. This arrangement is a deviation from current practice and will require reallocation of funding within PMs and TMDE. The result is that PMs will have soldiers and units who are specifically trained on their hardware, software, and maintenance practices. Additionally, maintainers will know how to use the MSDs and PD-TMDE will have more flexibility to support APATS for all Army units.

## 5.2 User Training

User training was the most pervasive issue recognized throughout stakeholder analysis. If the maintainers are not more extensively trained on the product, they will continue to misuse the MSD and negatively affect system performance. For the MSD to be used as designed, user training must be improved. PD-TMDE has already acknowledged a desire to implement the below recommendations, which include:

1. Commanders must be encouraged to send all MSD users to New Equipment Training (NET).
2. PD-TMDE should consider integrating IETM training with MSD v4 NET.
3. PD-TMDE should consider utilizing a periodic Mobile Training Team (MTT) to major units for routine refresher training of the MSD, connection kits, and hardware troubleshooting.
4. Communication with units must increase to improve knowledge of the help desk and online resources to regularly push out updates, information, and maintenance tips.

5. A direct line should be created from the help desk to PM offices to support unit needs, including IETM and connection kit troubleshooting.

### 5.3 Maintenance and Sustainability

The second most important issue found during stakeholder analysis was system sustainment. Empowering soldiers with the knowledge and skills to maintain their own equipment increases ownership of a system. PD-TMDE has acknowledged a desire to implement the below recommendations, which include:

1. Soldiers should be trained and authorized to maintain the MSD within brigades, rather than this authority being withheld at PD-TMDE, as is currently done. The unit communications specialist, the 25U/B, could fulfil this role. This would require a CASCOM soldier-hour analysis to ensure that this is a feasible unit capability.
2. NET, AIT, and MTT should also focus on troubleshooting current software issues and supply the parts and labor to fix hardware failures such as screens, batteries, ports, and drives. This would have immediate impact on readiness in a unit while also improve the skills and abilities of soldier sustainment.

## 6. Future Research

Future research should include completing the Decision Making and Solution Implementation stages of the systems decision process for APATS. Furthermore, an analysis of APATS' introduction and training of soldiers during AIT should be analyzed for improvement opportunities. This would begin to provide a baseline proficiency for Army maintenance of vehicle electronic systems. Further research should also focus on analysis and measurement of the time and cost that new maintenance procedures and training provides. If the advantages in time, cost, and effectiveness can be numerically measured, increased funding and attention for at-platform maintenance could be acquired. This would allow for the new development of technologies, processes, and personnel resulting in a better product for Army users and ultimately improve vehicle Ao across the Army.

## 7. Conclusion

Many elements of the APATS can be improved for a simpler, modernized, and more effective electronic maintenance capability. This study used a Systems Engineering approach to identify solutions through collection and analysis of surveys and interviews of maintenance supervisors, maintainers, and APATS experts to identify areas in which APATS can improve the way it provides maintenance. The impact of this study is that PD-TMDE has an improved understanding of the problem and potential solution strategies to enable improvement of electronic maintenance across the Army. These recommendations aim to improve APATS to provide the U.S. Army with a more effective maintenance system, increasing the mobility and combat readiness of our warfighters.

## 8. References

Butcher, S. (2020). *FT Hood Report, MSD Effectiveness in Line Units in the 1st Cavalry Division*. Unpublished Report.
Clayton, R. (2021, February). Personnel Interview [Virtual Meeting].
Integration Definition for Function Modeling (IDEF0). (1993, December 21). *Draft Federal Information Processing Standards Publication 183,* 1-116.
Neilson, C. (2020, September) Personal Interview [Virtual Meeting].
Parnell, G. S., Driscoll, P. J., & Henderson, D. L. (2011). *Decision Making in Systems Engineering and Management*. Hoboken, NJ: Wiley.
Product Director, Test, Measurement, and Diagnostic Equipment (2020). *At-Platform Automatic Test Systems (APATS) Overview*. [PowerPoint Presentation].
Vivian, N. (2021, February) Personal Interview [Virtual Meeting].