



STRYKER SUITABILITY CHALLENGES IN A COMPLEX THREAT ENVIRONMENT

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The cost of operating and maintaining weapon systems is a large expense to the Department of Defense, and suitability performance is a major factor affecting these costs. Systems with poor suitability performance (such as low reliability, high failure rates, high spare parts usage, and low availability) are extremely difficult to support in a constrained resource environment. For many DoD acquisition programs, suitability lags effectiveness during program development. Suitability determinants (such as reliability and maintainability) are generally not addressed early enough during program development (prior to fielding) and are not prioritized with the same vigor and discipline as performance parameters like speed, accuracy, and lethality. The JROC, DOT&E, and USD(AT&L) have each called for increased attention to suitability improvement.

The primary purpose of this article was to investigate the suitability performance challenges of the recently deployed Stryker system, which was accelerated into combat in 2003. Suitability drivers were identified and possible causal factors were investigated. Several specific suitability issues for the Stryker system were revealed during this study. Stryker is performing well in the field with an Operational Readiness Rate (ORR) consistently above the required contractual value. However, a harsh combat scenario, dynamic threat environment, and extremely high tempo of operations have created unique challenges to operators and maintainers.

BACKGROUND

During his first annual report to Congress, the newly confirmed Director of Operational Test and Evaluation (DOT&E) Dr. Charles E. McQueary made three

initial observations. His first observation was that Operational Test & Evaluation (OT&E) is too often the place where performance deficiencies are discovered. Finding performance problems early in the Department of Defense (DoD) acquisition process is important—either in government Developmental Test & Evaluation (DT&E) or contractor testing. Detecting and correcting design issues early in the development process will mitigate program cost overruns and schedule delays. McQueary's second observation was that the DoD acquisition system is inherently slow, and must improve to accommodate rapid fielding of new weapons systems and new technologies. The need for rapid fielding of new technology is evident in the extended hostilities in Iraq and Afghanistan (e.g., armor upgrades for the High Mobility Multipurpose Wheeled Vehicle [HMMWV] and the new Mine Resistant Ambush Protected [MRAP] vehicle). His third observation was that operational suitability of DoD systems is too low and needs to improve. The definition of operational suitability, which can be found in the *Defense Acquisition Guidebook*, Chapter 9 (Operational Test and Evaluation), Section 9.4.5 (Evaluation of Operational Suitability), is as follows:

Operational Suitability is the degree to which a system can be satisfactorily placed in field use, with consideration given to reliability, availability, compatibility, transportability, interoperability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, documentation, training requirements, and natural environmental effects and impacts. (Defense Acquisition Guidebook, 2005)

THE COST OF LOW SUITABILITY

Low suitability is a direct contributor to higher life-cycle support costs. Data for the previous three years (2004–2006) showed that 35 percent of Initial Operational Test & Evaluation (IOT&E) phases resulted in unfavorable suitability evaluations as reported to Congress in each system's Beyond Low Rate Initial Production (BLRIP) Report (Director, Operational Test and Evaluation, 2007).

While the technical performance of weapon systems (such as speed, accuracy, and firepower) has improved significantly over the last several decades, suitability parameters (such as reliability, availability, and maintainability) have not improved. Figures 1, 2, and 3 show that this problem has been a trend for more than 20 years. All data in Figures 1–3 are based on Army Test and Evaluation Command (ATEC) programs evaluated during the years shown. Figure 1 (Duma, 2005) shows that from 1985 through 1990, only 41 percent of programs evaluated by ATEC successfully demonstrated reliability requirements during operational testing. Figure 2 (Duma, 2005) shows that between 1996 and 2000, only 20 percent of programs met reliability requirements; and Figure 3 (U.S. Army Test and Evaluation Command, 2007) shows that from 1996–2005, only 34 percent of programs met reliability requirements.

FIGURE 1. RELIABILITY DURING OPERATIONAL TESTS (1985–1990)

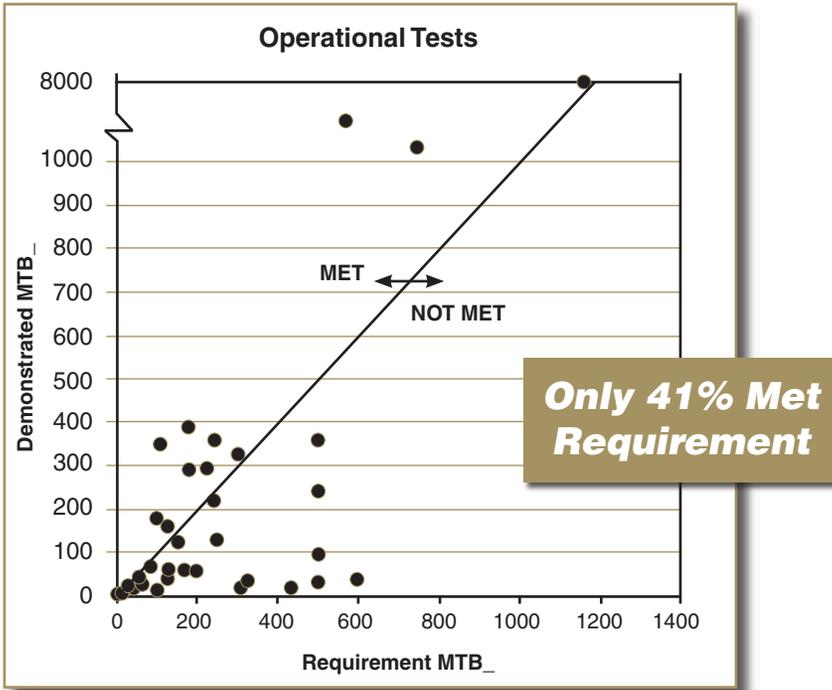


FIGURE 2. RELIABILITY DURING OPERATIONAL TESTS (1996–2000)

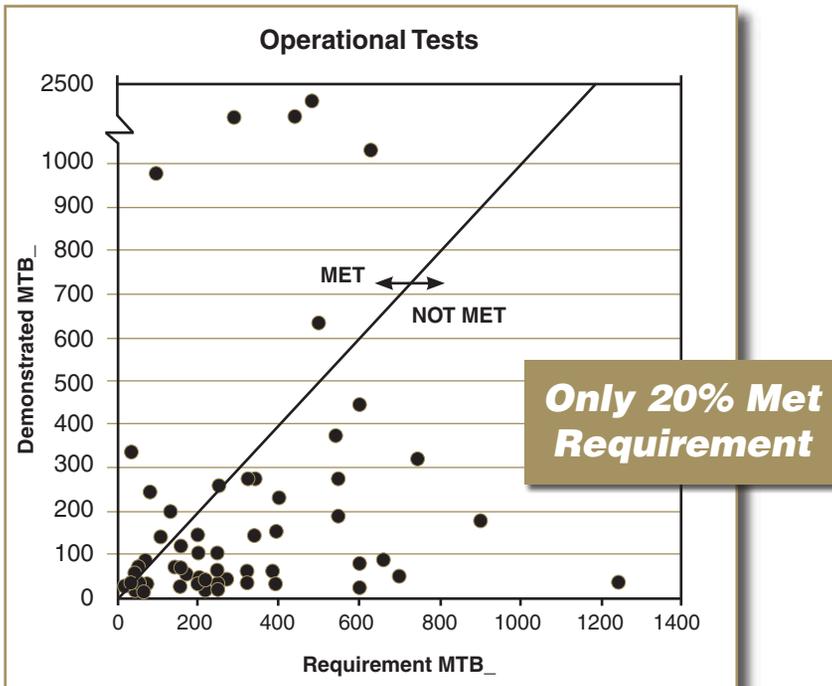
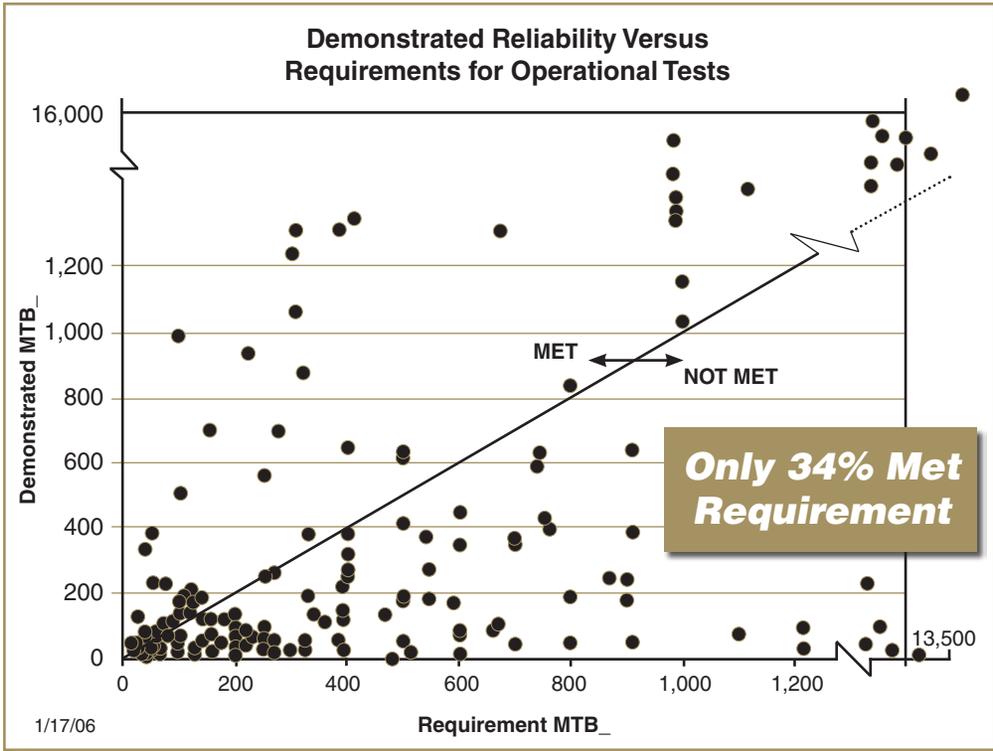


FIGURE 3. RELIABILITY DURING OPERATIONAL TESTS (1996–2005)



Stryker was a new Army program in 2000, but suitability issues were certainly not a new problem. The Defense Science Board (DSB) pointed out in 2000 that 80 percent of U.S. Army defense systems fail to achieve even half of their required reliability parameters (National Research Council, 2006). Steps have been taken to help address this concern. In November 2004, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]) directed that acquisition programs measure performance in terms of operational availability, mission reliability, and cost per unit of usage (USD[AT&L], 2004). Three months later, the USD(AT&L) issued a memorandum on Total Life Cycle Systems Management (TLCSM) Metrics, which provided specific definitions, formulas, and metrics for calculating important suitability parameters, such as operational availability and mission reliability. In 2005, the DSB recommended that DoD aggressively pursue implementation of performance-based logistics for all weapon systems. The USD(AT&L) has also directed that the TLCSM Executive Council develop a metrics handbook to be used in performance-based contracts and sustainment oversight (USD[AT&L], 2004); 2006). In August 2006, the Joint Requirements Oversight Council (JROC) mandated a Key Performance Parameter (KPP) of *materiel availability* including key system attributes of *materiel reliability and ownership costs* (Joint Requirements Oversight Council, 2006). These initiatives were designed to improve operational performance, establish standard suitability metrics, and reduce life-cycle support costs of new DoD weapon systems.

McQueary's third observation in his FY 2006 Annual Report is the basis for this research article. Many times systems receiving favorable effectiveness evaluations but unfavorable suitability evaluations from IOT&E are fielded before suitability shortcomings are corrected. Even though there may be good reasons for deploying these systems before correcting all suitability issues (such as an urgent combat need or the negative consequences of stopping a hot production line), fielding systems before suitability deficiencies are corrected will result in reduced operational availability and increased support costs. Low suitability directly results in increased life-cycle support costs. These costs can appear in many forms, such as: increased spares, increased contractor support, increased maintenance actions, increased maintenance man-hours, decreased reliability, decreased availability, and decreased combat capability. Costs over and above the planned costs of life-cycle support can represent a large and unbudgeted expense for DoD. This undesirable trend of low suitability during major weapon system development has been observed for at least 20 years across all Services, and this trend is not improving. For example, the reliability success rate of Army systems tested in 1996–2005 (34 percent) is lower than the reliability success rate for 1985–1990 (41 percent).

OVERVIEW

The Stryker family of vehicles was conceived as part of the Army's Transformation Campaign Plan. In 1999, General Eric Shinseki, the Army Chief of Staff, came to the conclusion that the Army had serious deployability and mobility issues (Military.com, 2007). Though the Army was capable of full-spectrum dominance, its organization and force structure were not optimized for strategic responsiveness. Army light forces could deploy rapidly, but they lacked the lethality, mobility, and staying power necessary to be effective in peacekeeping scenarios. On the other hand, Army mechanized forces possessed the necessary lethality and staying power, but required a large logistics footprint, which hindered their ability to be quickly deployed.

Subsequently, the Secretary of the Army announced a new Army vision in October 1999 to build a landpower force capable of strategic dominance across the full spectrum of ground combat operations. The key to implementing this vision was for the Army to become more strategically responsive. Stryker was designed as a full-spectrum, early-entry combat force and optimized primarily for employment in small-scale contingencies. It was developed to operate in a complex environment, including urban terrain, while confronting low- to mid-range threats with conventional and asymmetric capabilities. Requirements for the Stryker include rapid deployment, early entry execution, and the ability to conduct effective combat operations immediately upon arrival (Training and Doctrine Command, 2000a).

SCHEDULE-DRIVEN COMPROMISES

Stryker was initially deployed to Iraq in 2003 due to an urgent combat requirement. Prior to deployment, Stryker underwent an aggressive and accelerated development and

test program. The urgency of the war prevented the complete spectrum of operational testing to be completed within allowable time constraints. Only a few selected missions, types of terrain, and levels of conflict intensity were evaluated during IOT&E. Also, vehicles used did not have sufficient operating time to produce reliable repair and maintenance (R&M) data. In addition, a major configuration change was not included as part of IOT&E or PVT (Production Verification Tests) because add-on armor was not available for installation when testing was performed. The add-on armor package increased vehicle weight by approximately 20 percent. Since these tests were done in under-stressed conditions (without add-on armor), long-term durability problems were unlikely to be detected (National Research Council, 2004).

Schedule-driven compromises in T&E are not unusual to DoD programs.

Pressures on program officials to meet budgets and deadlines, due to congressional and other oversight, result in test strategies geared toward demonstrating “successful” performance. Thus, testing is often carried out under benign or typical stresses and operating conditions, rather than striving to determine failure modes and system limitations under more extreme circumstances. (National Research Council, 2006, p. 19)

According to an article printed in the *Detroit News* (2005), the Project on Government Oversight, a nonprofit government accountability organization, reported that Stryker was rushed through development, and lack of complete testing could give operators a false sense of security if failure modes are not understood (Zagaroli, 2005). However, the same newspaper article acknowledged that reports from the field overwhelmingly indicated that Stryker was performing in an outstanding manner. One of the early decisions made by the Army to support an accelerated development and deployment timeline was to rely on contractor performance-based logistics (PBL) support within the Stryker brigades. Some of the duties of the contractor personnel included conducting maintenance on the Stryker vehicle and managing the Stryker-specific supply chain. When Stryker was first deployed to Iraq, the Army did not have the institutional capability to train soldiers on conducting Stryker vehicle maintenance, and therefore faced an immediate need for contractor maintenance personnel to support the deployment (Government Accountability office [GAO], 2006a).

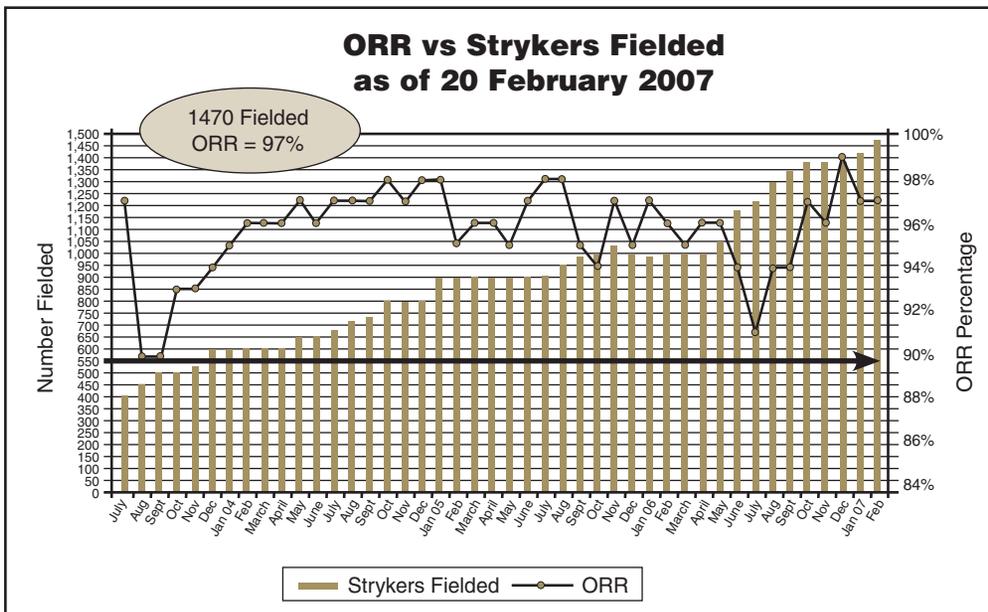
Each deployed Stryker brigade was fielded with 45 embedded vehicle maintenance contractor personnel. The Army desires to eventually replace the 45 contractors with active duty soldiers. Current plans call for implementation (removal of embedded contractors) to begin in 2008; however, the GAO reported that this goal will be difficult for the Army to achieve for several reasons. First, the 45 embedded contractor maintenance personnel must be replaced by 71 soldiers due to other collateral duties and common training requirements of soldiers. Second, the Army is very short of personnel with the five military occupational specialties for wheeled vehicle mechanics, resulting in a very difficult recruiting challenge for the Army. Currently, as reported by the *Washington Post* (White, 2007) and the *New York Times* (Cloud, 2007), the Army is indeed falling short of current recruiting goals.

OPERATIONAL READINESS

A key factor affecting Stryker suitability performance is deployed operational tempo (OPTEMPO). The program office estimates that the operational tempo is 6 times greater than the originally planned OPTEMPO. Other interviews yielded estimates of operational tempo up to 10 times the planned OPTEMPO. Harry Levins (2007) reports that vehicles in Iraq are using up 7 years of service life for each year of service in Iraq. The Government Accountability Office (GAO, 2006a), estimates that service life is being expended 800 percent faster than expected. This greatly increased operational tempo results in unexpected failure modes and increased failure rates.

A general finding of this study was that the Army is satisfied with Stryker’s performance in the field. System performance in an asymmetric combat scenario under difficult environmental conditions exceeds Army expectations. Brigade commanders have consistently reported high operational readiness rates (greater than 90 percent) since Stryker was fielded, despite the fact that combat conditions in Iraq have been much different than expected (Figure 4). For example, from October 2003 to September 2005 the first two Stryker brigades that deployed to Iraq reported an average Operational Readiness Rate (ORR) of 96 percent, well above the Army-established ORR performance goal of 90 percent.

FIGURE 4. OPERATIONAL READINESS RATES



Due to the asymmetric nature of the threat forces, and to the highly adaptive nature of the enemy, the combat scenarios and operating environment have been much different than expected. According to the Stryker Interim Armored Vehicle Operational Mode Summary/Mission Profile (IAV OMS/MP) (Training and Doctrine

Command, 2000b), the Stryker planned mission profile called for operations on hard roads 20 percent of the time, and cross-country operations 80 percent of the time. The actual Stryker usage in Iraq has been almost exactly the opposite (~ 80 percent on hard roads, 20 percent cross-country). Most missions resemble police actions in the urban environment on paved roads, and crews must routinely drive over curbs and other small obstacles to navigate in the urban environment. This requires a higher tire pressure than normal causing more vibration and shock loads and high structural stress on the vehicles.

In response to the greater threat of rocket propelled grenades (RPGs), improvised explosive devices (IEDs), and small projectiles, the Army configured Stryker with an add-on slat armor package and crews added sand bags. The additional weight affected the performance of the Stryker family of vehicles as follows:

- To operate with the increased vehicle weight, the operating tire pressure had to be increased from the design specification of 80 psi to 95 psi. Stryker is configured with a centralized tire pressure system that is designed to automatically keep the tire pressure at the optimum value for specific terrain conditions, speed, and traction. The automatic inflation system was not designed to maintain 95 psi, so soldiers must set tire pressure manually and check it three times daily (Smith, 2005). The requirement to over-inflate the tires to 95 psi and to physically check tire pressure three times per day is an operational nuisance because these are unplanned, but necessary, preventive maintenance actions. Additionally, the combination of routine excessive structural stress and increased tire pressure causes unanticipated structural failures. For example, a large number of wheel spindles developed fatigue cracks and had to be replaced early. Drive shafts are also failing sooner than expected.
- Due to the issues of added weight, excessive tire pressure, and severe operating conditions, tires are also failing at a high rate. In one 96-hour test period at Fort Irwin, CA, with 16 Stryker vehicles, 13 tires had to be changed (*WorldNetDaily*, 2003). The *Washington Post* reported that 11 tire and wheel assemblies fail every day, and GAO asserts that each Stryker vehicle is going through one tire per day on average (Smith, 2005). The additional maintenance actions (checking/adjusting tire pressures and changing tires) are extremely burdensome to the crews since changing tires is not crew-level maintenance and requires special tools.
- The 5,000 pounds of armor to counter RPG threats is generally effective but has many negative operational consequences, such as limited maneuverability, increased component stresses, safety issues, and transportability issues. The extra weight and increased physical dimensions caused by the add-on slat armor adversely impacts performance, especially when maneuvering in spaces with narrow clearance and maneuvering in wet conditions. Operations in soft sand or wet conditions (mud) place additional stress on engines, drive shafts, and differentials; and these items have experienced higher than normal failure rates (Dougherty, 2004).

- Also, the slat armor causes multiple problems for safe and effective operations. Slat armor can deform during normal operations, sometimes blocking escape hatches and the rear troop egress door. The armor adds approximately 3 feet to the vehicle's width and can interfere with the driver's vision. Armor also makes it difficult for others to see the Stryker at night, which is a safety hazard in the urban environment. The armor is very heavy for the rear ramp and strains lifting equipment, requiring crews to sometimes manually assist raising or lowering the rear ramp. The armor attaching bolts on the rear ramp can break off with normal use (increasing the maintenance burden) and may generate an unsafe condition. In addition, slat armor prohibits normal use of storage racks, which may impact operations. Lastly, slat armor affects the transportability of the vehicle in a C-130 cargo aircraft, since the extra weight greatly reduces transport range (GAO, 2004).

A very important contractual requirement for the prime contractor, General Dynamics Land Systems (GDLS), is to maintain an Operational Readiness Rate (ORR) of 90 percent or better . . . Since initial deployment, Stryker has routinely exceeded this operational requirement.

Even though these operational issues caused by the add-on slat armor place additional maintenance burdens on crews, Stryker has been reported to be well-suited for the urban fight. Unlike the M-1 tank, Stryker can operate very quietly at high speed, which can be a tremendous tactical advantage (Tyson, 2003). Most Army personnel interviewed felt strongly that Stryker's tactical performance in the urban environment in Iraq was significantly better than the M113A3, HMMWV, Bradley Fighting Vehicle, or Abrams Tank.

In response to unanticipated urgent combat needs in Iraq, some engineering improvements (configuration changes) were performed on the Stryker since deployment. Since the Army did not buy the technical data package because of its cost, these engineering changes have resulted in increased costs and potential risks (GAO, 2006b). The GAO reports that current DoD acquisition policies do not specifically address long-term technical data rights for weapon system sustainment. As part of the department's acquisition reforms and performance-based strategies, DoD has de-emphasized the acquisition of technical data rights. The GAO has recommended that DoD recognize the need for the acquisition of technical data rights and asserts that without technical data rights, DoD may face challenges in efficiently sustaining weapon systems throughout their life cycle.

A very important contractual requirement for the prime contractor, General Dynamics Land Systems (GDLS), is to maintain an Operational Readiness Rate (ORR) of 90 percent or better. This requirement pertains only to the base vehicle

configuration and does not include Government-Furnished Equipment (GFE). Since initial deployment, Stryker has routinely exceeded this operational requirement. The Cost Plus Fixed Fee (CPFF) contract effectively motivates GDLS to exceed 90 percent ORR; however, the contract is not necessarily effective at controlling support costs, and this may be a risk to the government (U.S. Army Audit Agency, 2005). One example of this is the repair and replacement of a high failure item, for example, cracked hydraulic reservoirs in the power pack. Maintenance procedures call for the entire power pack to be replaced as a unit, rather than removing and repairing/replacing the hydraulic reservoir within the power pack. Replacing entire power packs (instead of repairing/replacing hydraulic reservoirs within the power packs) results in shorter down-times and higher ORR, but it also requires more power packs (very large, expensive units) to be purchased and shipped to operating bases and forward maintenance facilities. The net result is that higher operational readiness is being purchased with increased transportation and storage costs.

SUSTAINABILITY CHALLENGES

Since Stryker's initial deployment was accelerated to meet an urgent combat need, the Stryker program team was performing the following activities concurrently: testing, production, fielding, training, and combat. In addition to the many challenges caused by these concurrent activities, the threat and operational environment in Iraq were different than anticipated, as previously mentioned. Several other factors added to the difficulty of maintaining Stryker vehicles in the field.

First, the Interactive Electronic Technical Manuals (IETMs) were not mature at the time of initial fielding. Many maintenance procedures could not be performed based on the IETMs because they were either not characterized correctly or crews were not adequately trained on their use. This situation led to *tribal system maintenance*, where units depended on soldiers and contractors with experience on similar systems (like the M-113 armored personnel carrier) to figure out how to perform the maintenance actions correctly.

Second, since a large portion of maintenance actions was supported by contractor personnel, soldiers developed a *rental car mentality*. This lack of *ownership mentality* resulted in soldiers being overly dependent on contractor personnel to perform routine preventive maintenance actions, such as checking fluid levels. One vehicle was lost because the pre-mission engine oil check was ignored.

FINDINGS

Stryker is performing well in the field. The system is exceeding expectations of Army management and soldiers. In spite of a changing threat environment (improved IEDs and excessive operations in the urban environment) and major configuration changes (5000 pounds of add-on armor), Stryker is accomplishing its mission. The Operational Readiness Rate has consistently been over 90 percent.

Due to the increased threat of RPGs and IEDs, Stryker was outfitted with an add-

on armor package. The additional 5,000 pounds of armor has been generally effective at mitigating the threat, but has resulted in some negative operational/support consequences. The extra weight requires increased tire pressure, which causes operational problems and more structural stresses. Additionally, the armor limits crew visibility during operations and restricts airlift transportability on a C-130 aircraft.

Army decisions regarding contractor logistics support may remain with the Stryker program for years. When Stryker was first deployed to Iraq in 2003, the Army faced an immediate need for contractor maintenance personnel to support operations (45 vehicle maintenance personnel per brigade). The Army plans to eventually replace the 45 contractor maintenance personnel with soldiers, but it will take approximately 71 soldiers per brigade to perform the same level of vehicle maintenance as the 45 contractors because of other duties and responsibilities of active duty personnel. The current plan is to begin the transition to soldier maintenance in 2008, but the transition will probably be very difficult to implement due to the poor recruiting/retention outlook in general, and to the shortage of appropriate active duty maintenance personnel.

The general issue of suitability shortfalls in DoD acquisition programs is recognized at high levels of management and is being addressed.

Stryker program development was accelerated to meet the Army's combat needs in Operation Iraqi Freedom. Due to the compressed developmental schedule, Stryker DT/OT was unable to fully test all configuration changes. DT revealed relevant problem areas, but there was insufficient time or priority to correct all problems before OT and fielding.

For many DoD acquisition programs, the maturity of suitability parameters lags the maturity of effectiveness parameters during program development. Suitability determinants (such as reliability and maintainability) are not addressed early enough and are not prioritized with the same vigor and discipline as performance parameters like speed, accuracy, and lethality.

The general issue of suitability shortfalls in DoD acquisition programs is recognized at high levels of management and is being addressed. JROC, DOT&E, and USD(AT&L) have each called for increased attention to suitability improvements. For example, a new requirement exists for a Materiel Availability KPP.

The operational tempo of Stryker vehicles in Iraq far exceeds original usage estimates by at least 500 percent. Also, the mission profile of Stryker is much different than expected (80 percent on paved roads). This, in combination with the added weight of slat armor, has resulted in excessive stresses to the suspension, wheels, and tire assemblies causing increased failure rates of these items.

Since Stryker was fielded in 2003 in Iraq, the operational situation has been dynamic, unpredictable, and volatile. Four factors have made it very difficult to obtain complete and reliable data for trend analyses. The first factor is the rapidly evolving

adaptive nature of the threat in an asymmetric combat environment. The second factor is that the operational environment for deployed Stryker vehicles is more severe than anticipated during design/development. The third factor is that, in response to the first two factors, configuration changes have precluded a stable baseline. The fourth factor is that in a dangerous combat scenario, recording and reporting data is not a high priority for operational crews.

CONCLUSIONS

In response to Operation Iraqi Freedom, there was an urgent operational need to deploy the Stryker system. Therefore, the development and test programs were greatly accelerated to get Stryker units into the field as quickly as possible. At the same time, the mission was changing as the threat quickly adapted and evolved in this asymmetric combat environment. The continually changing configuration baseline and changing tactical conditions made it very difficult to evaluate or predict reliability and suitability performance across all mission scenarios. The operational situation has been dynamic, as well as unpredictable and volatile, because Stryker was deployed in operational combat conditions that were different from, and much more complex than, those originally anticipated. In many ways, the system was not adequately designed for the actual threat it is facing today. However, this is certainly not the first time nor the last time this type of situation will occur. As a result, this case is a good example of how incomplete or incorrect maintenance/support planning can significantly add to the logistics burden. Due to the adaptive nature of the threat in the asymmetric warfare environment of Iraq and Afghanistan, our acquisition managers and operational planners are challenged to consider more complex and dynamic combat scenarios and contingencies than ever before.



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