Impact of Weight on Reliability of Army Ground Vehicles

Increasing demand for modernized armor kits has resulted in a dramatic raise in the weight of the Army ground vehicles, impacting their operational readiness and acquisition and O&S costs adversely. Recent combat operations and testing of up-armored vehicles have shown reliability degraders of collapsed springs, cracked frames, broken upper control arms, crushed air conditioning condensers, broken lower control arms, cracked radiators, failed suspension bushings and failed gear drive hubs. While working to achieve the best capabilities, the Army is struggling to keep the well known reliability characteristics of the legacy systems. This paper presents the lessons learned and recommendations regarding approaches to assess the impact of an increase in weight on vehicle reliability.

While the weight (payload) increase directly impacts the vehicle speed, performance, and its fuel economy, it can inherently contribute to limiting the life of the individual sub-systems and therefore affect the reliability of the full system. The impact of added weight on the fatigue life of suspension components was investigated by comparing the baseline weight configuration with an increased weight configuration. The Army Materiel Systems Analysis Activity (AMSAA) partnered with the Aberdeen Test Center (ATC) to determine the reliability of a vehicle suspension as rear axle weights are increased in weight. The test and analysis showed component degradation with weight growth; however it indicated that sufficient time to failure based on operational usage may still exist. Damage to the suspension components occurred due to the combination of several factors: test courses, stresses in components, and different dominant failure mechanisms at different payloads. This work revealed the difficulty assessing the true impact of weight in regards to reliability.

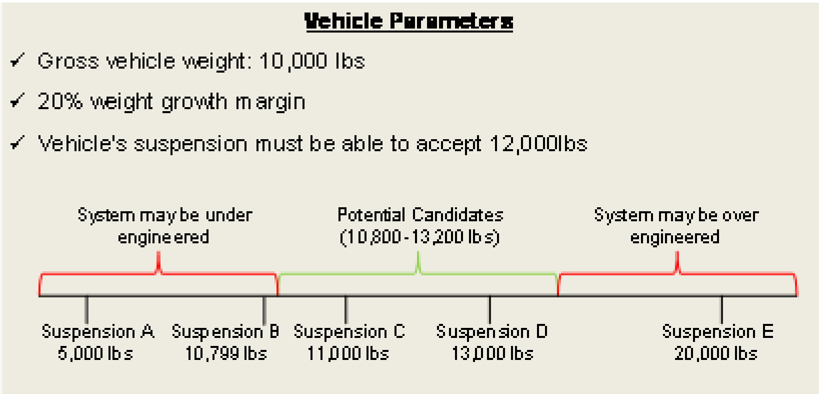
In another set of studies, a number of wheeled and tracked vehicles were looked at to determine if a relationship between weight and system reliability exists. In one study, counter - intuitive, some heavy vehicles were found to be reliable; yet, some light vehicles were found to be unreliable. In another study, Mean Miles between Unscheduled (MMBU) Visits and Actions of various light and heavy vehicles showed no consistent trends when comparing regular loads (Light) with up-armor loads (Heavy). Studies on overall part replacement data from theater showed that component replacements are expected to increase by 20% to 60% with a 30% increase in vehicle weight. Further studies on vehicle suspensions showed that the fleet was replacing some components mainly due to chassis failures with the increase in vehicle weight. It was also noticed that vehicle reliability was seen to be decreasing but not at a constant rate.

Historically, reliability has been a challenge for vehicles; it is hard to predict the impact of weight on system reliability as every system has its own reliability requirements and reliability is very much design dependent. No consistent relationship (linear or non-linear) has been found to help assess how a weight increase will impact reliability. This is understandable. With different Operational Mode Summary / Mission Profile (OMS/MP) and Failure definition Scoring Criteria (FD/SC) and reliability program incentive for each system, each vehicle is designed to be unique. Based on the specific designs, competing failure mechanisms are at work. The dominant failure mechanism will drive failure and ultimately system reliability.

Assessing reliability requires detailed knowledge of the system and how it is used. In general, it is challenging to find an approach that can estimate the reliability of an entire vehicle system based on weight. Since the reliability is design specific, the system can be, potentially, broken down into sub-systems and investigated. In the case of a new vehicle design, one potential approach is as follows:

- Investigate sub-systems (driveline, engine, suspension, etc…).
- Determine the weight rating for each sub-system. Most components will have a weight rating: the maximum allowable weight for a component without causing damage.
- Use the weight rating as a “Go/No Go Criteria” for the component.
- Determine the weight of overall vehicle. Include weight growth margin (e.g. 20% weight growth potential for vehicle).
- Compare overall weight of vehicle to sub-system weight rating.
- If the sub-system weight rating is between ±10% of the overall rating– sub-system has potential and should be investigated further using failure analysis techniques.
- If sub-system weight rating is outside ±10% of the overall weight– sub-system may not be a good candidate.

For example, when assessing a potential suspension the following chart could be used.



By leveraging both historical U.S. Army reliability test data and Sample Data Collection and Analysis (SDC&A) data, it can be ensured that lessons learned from past programs are applied to current and future acquisition programs. It is also recommended to conduct early Design for Reliability (DfR) activities such as developing Reliability Growth Planning Curve (RGPC) with a realistic initial reliability (Mi) estimate based on Physics of Failure (PoF) analysis techniques / failure modeling to further reduce program risk.

Vehicle weight will continue to grow as changing threat environment and advances in technologies continue to drive the need for increased survivability, lethality and improved communications and automotive performance. It is essential to fully understand the impacts of the weight changes. A detailed understanding of the failure modes and mechanisms is critical. Judicious use of computer-based Modeling and Simulation (M&S) tools and limited testing can enhance this understanding and provide a good estimate of reliability impact. A better understanding of the failures and their mechanisms will help identify reliability improvements and potentially save the Army millions of dollars of acquisition and/or O&S costs.

BIOGRAPHY

Geetha Chary

US AMSAA

392 Hopkins Road

APG, MD 21005-5017

Geetha Chary is a Mechanical Engineer on the Physics of Failure Mechanical Systems Team at the Army Materiel Systems Analysis Activity. She holds a B.S. degree in Mechanical Engineering from M.V.S.R Engineering College *affiliated to Osmania University and a M.S. degree in Mechanical Engineering from University of Maryland Baltimore County.*

Michael Pohland

US AMSAA

392 Hopkins Road

APG, MD 21005-5017

Michael Pohland is a Team Leader of Physics of Failure Mechanical Systems Team at the Army Materiel Systems Analysis Activity. He holds a B.S. degree in Mechanical Engineering from the University of Maryland and a M.S. degree in Mechanical Engineering from Johns Hopkins University.