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Geetha Chary & Michael Pohland

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.

Russell A. Vacante, Ph.D.

Defense & Auto Industries: Peas in the Same Pod?

There is one high level or "big picture" characteristic that has contributed to current global competitive difficulties for both the U.S. auto and defense industries, and it is this—a resistance to promoting and embracing change.

From an institutional perspective, managing and implementing change involves a willingness of senior leaders to recognize and accept the impact of new influences, e.g., globalization and technological advances. Since these influences are, for the most part, "external" to an organization, successful implementation requires that they be accepted and managed "internally." This is where the "rub," or primary challenge, is found. The structure, culture, deep-rooted processes and routines of an organization's leadership can be the biggest hurdle to accepting and adopting new influences. This is particularly

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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 chart above (Figure 1) could be used.

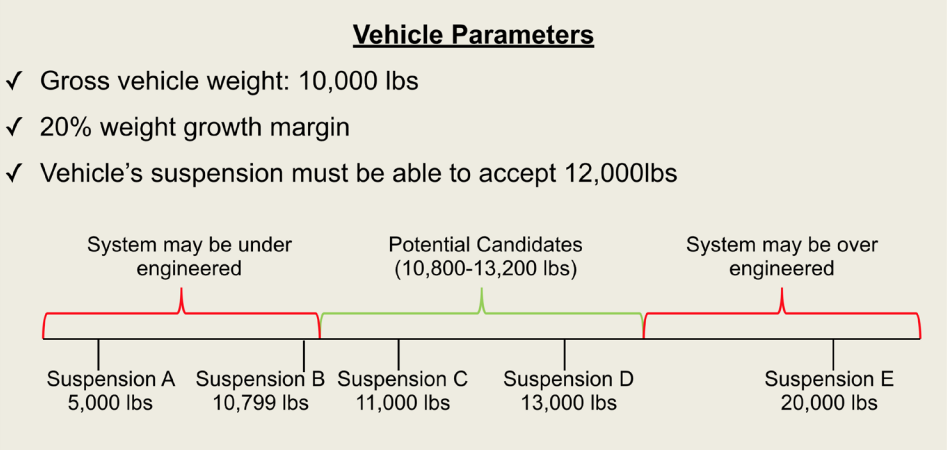

Figure 1

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. ●

About the Authors

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Interested In Contributing?

If you are interested in sharing your knowledge in future editions, please contact Russ Vacante at russv@comcast.net
Articles can range from one page to five pages and should be of general interest to our members.

Chris Peterson

MIL-STD-810G Change Notice Has Been Released

On April 15, 2014, the MIL-STD-810G Change Notice was released. To start with, what is MIL-STD-810G? And then, what is a Change Notice?

MIL-STD-810 is a Department of Defense Test Method Standard. Its actual name is *Environmental Engineering Considerations and Laboratory Tests*. While it holds 29 different Test Methods, including such things as vibration, shock, humidity, high and low temperature, it also delves into management, engineering and technical roles.

This document is actually a guidance document, helping the user to think of realistic situations and using that information to perform the best testing possible. Tailoring is encouraged, the ability to modify a test—not to make it easier to pass but to use information to make sure that the testing will reflect the expected life cycle. Default values are given but basing tests on known data is preferred.

What is a Change Notice?

The original version of MIL-STD-810 was released in 1962, over 50 years ago. Clearly there have been many changes in technology since then, and also increased knowledge. Instead of replacing what was a good foundation, changes were introduced. These came about many times in Changes Notices. It is like what it sounds: a notice is sent out that there is a change. The changes tended to be smaller, with one Change Notice being only five pages long.

Originally, documents like -810 were kept in notebooks. The Change Notice would be released, printed off, the original pages pulled from the notebook and the new pages dropped in. A new title page would be inserted showing that it was a document including the change notice. Ideally this was reflected in test reports.

This could get confusing, however. Revision B had four change notices, two of which were released just three days apart. Revisions E and F both had three different change notices. You can imagine the confusion that might have been caused—especially if a test was already underway when the change notice was released yet the test report may have included a statement such as "performed with the latest version of..." Another confusion could be that maybe one main notebook got updated, but it wasn't universal throughout the organization.

As of August 1, 2003, all standards and handbooks with changes were re-released with changes already incorporated into the original document. This takes care of many issues:

- Sometimes the changes cannot fit within the original space and will nudge everything after them ahead.
- If the document is printed out it is much simpler to make sure that everyone has identical copies instead of the possibility that not all changed pages were incorporated.
- Through the use of "change bars" in the left margin it is easy to see what is new (the only way to see what was there previously was to pull up an older version).
- For those using an electronic reader—including a computer—it makes scrolling through much easier instead of worrying about checking to make sure you are reading the Change Notices as well.

The Practicality of Changes

MIL-STD-810 started as a 68 page document. Originally it focused on aircraft as well as ground support equipment. There was one single statement which allowed for test tailoring, something that no one was used to at the time. It was easier just to follow a list of directions and assume that it was the best possible way to do things.

Over time, not only was new technology added that needed to be tested but there were also updates in test equipment. For instance, controllers for vibration shakers were introduced that allowed random vibration testing as well as sinusoidal.

Not only was the technological side considered but also user understanding was taken into account. Feedback would come in—questions, requests, criticisms, etc.—and it was considered. While it is invisible to the reader, the MIL-STD-810 committee is always at work in the background getting ready for the next round of updates.

What Makes This Change Notice So Important

This Change Notice was sweeping, with updates to every single Test Method. In the case of Shock (meaning mechanical shock) virtually the whole section was rewritten. A lot of information was also added in Vibration. Don't get the idea that only dynamic tests were updated because a lot of fine tuning was done in the climatic tests.

The original version of MIL-STD-810G had 804 pages; the Change Notice has 1086. No new tests were added but instead that material is guidance to the user. Most users would never lug around a notebook containing over 1000 pages. In fact, some organizations have become virtually paperless. Many users will print, or look at, just the specific tests that they need. A table of contents for each of the Methods is now included as well as the main one.

There is more emphasis on tailoring

than ever with good practical information on how to do so. Internet addresses were verified, and if a secure site is available (HTTPS as opposed to HTTP) that was used. Figures and tables were added and/or clarified. There is more standardization between tests through both wording and placement of topics within clauses.

Those are all good things, but it is what went on behind the scenes that made the real difference. If you run a test day in and day out you tend to know it like the back of your hand. You overlook things that a newbie might not understand. This time around there was a vast amount of input that came about through questions of students taking courses to understand -810 better. Having someone look at something with fresh eyes can help to point out spots that really don't make a lot of sense but are simply understood by old pros.

In other cases questions were asked where it turns out there really was no firm answer. It was deemed that it would be useful to have that information added in to avoid future confusion.

Great input came not only from students but also from commercial test labs. Many were questioned in person about the greatest difficulties they had with -810 tests, and answers were extremely frank (and often loud). These weren't people griping because they found the work too hard and would rather be lazy. These were folks legitimately trying to do their best and finding it almost impossible to do what was in writing.

What Happens with that Information

When a Change Notice is announced a draft is published in advance with a period for making comments. Invitations to specific organizations are sent out as well as being available to the general public. Comments are compiled into a spreadsheet, and then the real work begins.

Each comment is reviewed by the committee. There is a head to the committee but he never makes a decision alone on information that needs to be changed. Instead it is discussed by experts in that field. It is not unusual to go beyond the original comment while looking at the existing version of -810 and realize that other changes should also be made.

Please note that every single comment is reviewed—there is no picking and choosing which ones should be, but anything that is sent in gets looked at. In some cases it is as simple as noting that there is a missing period at the end of a sentence, while other comments may be sweeping.

How Does This Tie in with the RMS Philosophy?

While the tests within MIL-STD-810 are not specifically reliability tests (and that point is made right up front) the ability to pass environmental testing gives information to the testing organization on whether the items are reliable enough to even pass through what they are expected to see during a lifetime of service. The tests aren't designed to find out how long that lifetime might be, but whether something could hold up during the extremes of it—a subset of the overall reliability picture.

Issues may be found that would help point to maintenance issues that weren't originally considered. Could it be maintained in the field or would it have to be sent back to a depot? In the low temperature tests the idea of maintenance was added to the manipulation test (done with the tester wearing full winter gear) to make certain that the tasks could be completed even with limited dexterity.

Sustainability issues may include shipping something from one area to another. This might take place using trucks, trains, ships, aircraft, or some combination. While something might work great during service, could it actually withstand transportation? (Keep in mind that transportation doesn't just add shock—especially handling shock—and vibration but also may introduce things like low pressure, salt fog, the proper temperature and humidity conditions to encourage fungal growth, etc.)

By taking a close look at the expected life cycle in advance of testing, and then going all of the way back to the acquisition process and moving forward from there, results in a much greater understanding of what environments the materiel will have to meet and therefore the best testing practices available to make sure that it does.

In Summary

Testing is no longer cookbook—turn the oven on to 350 and bake for eight hours. This new Change Notice includes hundreds of pages of guidance to make sure that the user understands not just the test but the thinking behind it. More information is in place as to whether the item should be operational or not, what to do in case of a test interruption, things to be included in test reports, what to look for during analysis after test, and so much more.

Even if your organization never uses this particular set of tests but relies on other documents for those, I heartily recommend that this document be used for the invaluable guidance information. The section on writing a Life Cycle Environmental Profile (LCEP) has been greatly expanded and is one of the few sources where such guidance can be found. (Test tailoring is based upon the data that goes into this document.)

- Copies are free and are available at *https://assist.dla.mil/online/start/*
- In the introductory section there are contacts listed in case of questions or comments
- The work is ongoing in this "living document"

Download a copy and see just how full of

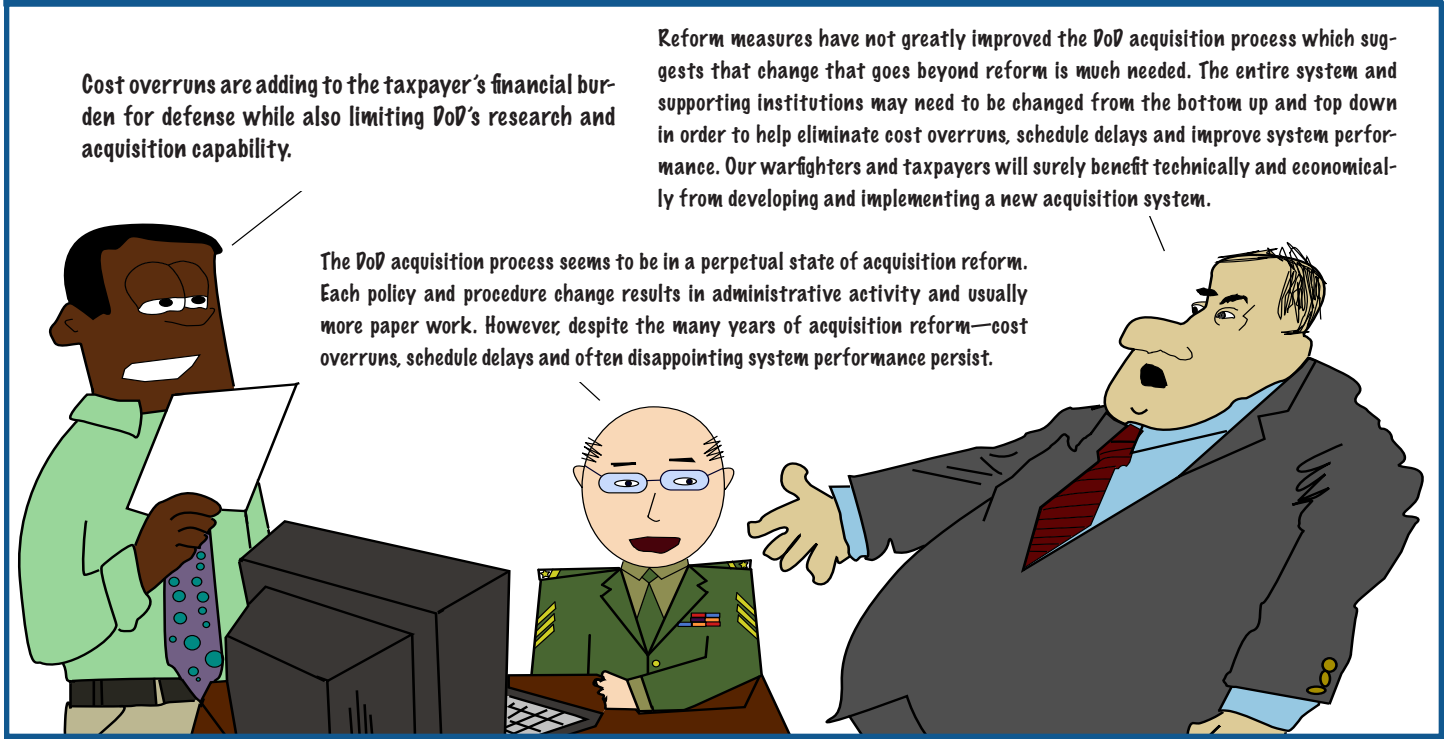
treasure it is. Ask questions if you have them. It is a tool without compare.

About the Author

Chris Peterson *has been involved with environmental testing since 1990. Her award winning work with international standards began soon after. Her reasoning for becoming so deeply involved was that she felt sorry for the poor tester who had to try to understand writing that made no sense, and she set out to make it more understandable. To do so she has worked with thousands of students, lab workers, equipment manufacturers, and others from around the world to get the best overall view of the problems involved in understanding and applying specifications and standards. She is an independent consultant who writes a blog, Test to Be Your Best, which is on testing and reliability issues. (It can be found at chamber-queen.blogspot.com.)*

Another Day At The Office

by Russell A. Vacante, Ph.D.



Defense & Auto Industries, from page 1

evident in both the U.S. automobile and defense industries, where leadership often resists the need for change when new influences come up against "the way it has always been done."

Many professionals within the automobile and defense industries are familiar with the challenges associated with career development. Employees know that in order to be promoted they are expected to regularly attend change management and technical training sessions. The employer's intention is: employee training will serve to keep the organization competitive, particularly when it comes to technological advancements. A partial reason for this is training sessions don't usually require organizations to make huge financial investments and employee's training opportunities can, and often are, turned off and on at will. Conversely, employees are at the beck and call of their employers when it pertains to training. Often the employees return to the workplace with knowledge and information from a training session that will prove beneficial to their organization and possibly to their career, if properly implemented. However, it should not be a surprise to most that employee recommended changes frequently are not implemented by the employer. Conversely, employers often blame employees for the inability of their organization to accommodate change. For the sake of our discussion, let's call institutional change initiated or suggested by employees "micro" organizational change. With this said, it is acknowledged that instances of micro organizational change, that is, change from the bottom up, rarely occur.

Change at the macro institutional level, i.e., top down, is more likely to occur than change from the bottom up. When macro changes do occur within an organization, it usually is at a snail's pace. For instance, the U.S. automobile industry's reluctance to retool its factories to accommodate "green" technology continues to keep it at a competitive disadvantage to foreign auto makers, in particular, Japan and Germany.

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Maintaining the status quo seems to be the modus operandi of U.S. auto makers, an industry whose leadership, incrementally and slowly, implements change only after serious competitive coercion from the marketplace forces.

The U.S. automobile industry's precipitous decline in the global marketplace began years ago and parallels Japan's auto industry's accession in the international automobile market. Leading Japan's charge to change were two change management advocates, Deming and Taguchi. The Japanese auto industry's willingness to accommodate macro organizational change, based on their recommendations, led to significant product improvements in quality and reliability. Thus, Japanese vehicles became more reliable, easier to maintain and support than U.S. automobiles and as a result captured the buying public's attention and dollars. Japan's automobile initiative towards producing "greener" cars is the proverbial frosting on the cake that will help the Japanese auto industry guarantee customer satisfaction well into the future.

It also comes as no surprise to professionals within the government that change does not come easy to the U.S. defense industry. Cost overruns, schedule delays, and poor performance of many defense systems can be attributed to institutional resistance to change. The defense establishment, government and private industry alike, often requires its employees to be flexible. In place of recognizing the necessity of making important institutional changes the defense industry seemingly laboriously develops and implements new policy and procedural reforms in accordance to which way the political winds are blowing in Washington D.C. We have seen the demise of the Willoughby templates and experienced standardization reform, and have endured numerous other "reforms" to the DoD 5000 document series. Our collective attention to the addressing of institutional changes has been ignored, in large part, due to our preoccupation with implementing micro level "reforms." The Under Secretary of Defense (AT&L), Frank Kendall, memorandum dated August 21, 2014 and the accompanying guidance entitled "Guidelines for Creating and Maintaining a Competitive Environment for Supplies and Services in the Department of Defense" apparently is a micro, as opposed to a macro, attempt once again at acquisition reform.

Similar to the U.S. automobile

makers who have lost the attention and "voice" of the customer, the U.S. defense industry appears to have lost the message regarding present and future global defense challenges. The defense community has spent years reforming administrative policies and procedures that have resulted in questionable results. Little, if any, measurable progress has been made towards controlling cost overruns, reducing schedule delays and improving system requirements definition and associated performance. With this said, let us hope that the Kendall's recent reform measures, at a minimum, help control escalating acquisition cost. However, a macro initiative such as this would require a comprehensive innovative institutional change from the top down with full upper management buy-in. The Japanese automakers implemented macro institutional change that has led to improved quality and reliability of their automobiles—could this be a lesson to the U.S. automobile and defense industries?

The fundamental story line in this editorial is `the U.S. automobile and defense industry's resistance to change is proving to be an important factor in contributing to their global competitive decline. Books have been written that cite the causes of institutional resistance to change; issues covered in these books include changing educational priorities, changing work ethics and entrenched leadership and outdated organizational values and interests. Most literature of this nature leads us down the path of micro level reform as opposed to macro level institutional change and often is written by "experts" who have long-standing and vested interests in prevailing institutional structures. We cannot expect these experts to recommend an "out with the old and in with the new" approach to any organization. As a result, their micro advocacy to change reinforces the automobile and defense industry's "bandage" approach to correcting organizational deficiencies, while missing the opportunity for macro institutional change that can improve their global competitiveness.

To meet the competitive challenges of the 21st century the U.S. automobile and defense industries need to embrace macro rather than micro institutional change. Institutions that refuse to change get sidelined or die. The U.S. steel industry is a shadow of its previous self and unless the U.S. auto and defense industry leadership begins focusing on making more macro level changes they will likely suffer a similar demise. ●