Equipment Readiness:
A Systems View

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The concept of life cycle system management is a best practice that most governments are increasingly adopting to achieve a fine balance between weapon system capability or performance and an acceptable cost of ownership. Mission readiness of equipment can be sustained by reasonable investments in supportability features in the weapon system and necessary support infrastructure. The need to keep our weapon systems available with requisite reliability levels is a combat requirement that needs to be addressed both for the present and the future.

Designing for reliability and supportability will have a significant influence on pre-mission and during mission operational availabilities of weapon system and help achieve the required operational over reach. A life cycle focus gives a systems view to the weapon/equipment over its complete life. The phases in the life cycle could broadly be categorised as:

- Pre-acquisition
- System acquisition
- Sustainment

Pre-Acquisition The acquisition cycle commences when the need for a new equipment is identified which could be based on the inabilities of an existing weapon system or the need to carry out a change in the war fighting methods to ensure success. In both cases, it is based on the mission requirements of the present/future. It becomes essential to define the system requirements or operational requirements (also called operating tempos) after an objective assessment of the proposed mission profile for the new weapon system, the operating environment (mountains, high-altitudes, plains, humidity, temperature, dust and dirt etc), storage conditions, the deployment etc. It becomes relevant for users and systems engineers (EME) to continuously scan technologies that could be incorporated for enhanced performance (operability), reliability, maintainability and durability (RAM-D features). All possible options need to be identified and the pros and cons evaluated. The feasible options can then be prioritised based on the assessment of positive attributes and risks like time and cost overruns, technology denial restrictions etc. It needs to be understood that the system being acquired/ developed has to have capabilities to meet/ match enemy capabilities and technological superiority, degradation due to weather, terrain, age and help achieve superior force ratios through higher operating tempos.

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System Acquisition Phase Herein the feasible performance parameters that had been identified, are analysed deeply and compared with the mission needs. Thereafter, either a system is evolved from scratch to meet the qualitative requirement stipulated or a system is acquired with the requisite Qualitative Requirements (QR). In either cases, the salient Key Performance Parameter (KPP) is the present and future mission needs. The acquisition programme may be an upgrade programme, off the shelf buy, modify (software solutions) programme, integration programme and new design programme. The last named takes maximum time to come to fruition and needs incorporation of the flexible teaming concept with designers, users, supportability engineers, quality personnel collaborating for the end cause. Full scale engineering development (FSED) is intended to construct a system that meets the envisaged needs. Actual manufacturing of equipment is the last stage of this phase when the equipment gets rolled out from the assembly line according to a production plan. As it rolls out, the system gets deployed with its support infrastructure so that the user can train, conduct exercises and perform mission, if required.

Sustainment Phase We traditionally have focused much of the time and resources on the first two phases of the life cycle i.e. research and development/

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acquisition, production and kitting of units/ supply of equipment. This typically represents 30-35 per cent of the overall cost of ownership of the system over its in-service life. Hence a need for renewed focus on the sustainment phase is important from the cost effectiveness angle. If we do this with the same details and focus, we can ensure 360^0 equipment readiness of the Army at affordable costs. A weapon system should ideally not fail in the middle of a combat mission and if it fails, it must be reset in quick time with processes and resources that are available in situ.

The acquisition wing needs to understand this critical requirement, since high mission readiness with high performance of the inducted equipment is vital for combat effectiveness. It is important that acquisition and sustainment communities develop a closer integration and understand the imperatives of engineering support perspective, the crucial reset capabilities that must be acquired alongside main weapon system. This alone will ensure that we are more prepared than we ever have been and failure rates/ downtimes are minimised. Sustainment systems are required to develop industrial and technical capabilities to ramp up workload in times of war. Looking at the complexities of modern weapons and equipment, this could take anything between 5-7 years post induction of the main equipment. A suitable budgetary provision has to be made.

Reliability Engineering

As weapon systems come in the hand of troops, their functions in various operating environment available in the country and ability to fulfill operational needs is to be continuously evaluated. This will assist us to firm up performance requirements of futuristic systems. This is also the culmination of the acquisitions cycle, however a long journey of in-service phases commences. Operational sustainment looks at keeping the cutting edge sharp during the in-service period. Sustainment phase also looks at discard and disposal of the system.

Reliability engineering aims at developing systems with very low failure rates. It is a critical requirement for us since our systems are deployed/ employed in all terrains and weather conditions unlike most countries that manufacture and export weapons. The extremes of temperature may call for heating and cooling of systems, high levels of humidity lead to corrosion while low humidity causes accelerated deterioration of rubber parts. Dust can pose serious abrasive wear and lower expected endurance levels of systems, while near sea, systems get damaged due to salt fog. Similarly, vibrations, EMI (Electro Magnetic Induction) etc degrade systems and lead to onset of ageing at an average land systems age @ 3-4 per cent every year. This gets aggravated in HAA (High Altitude Area) as also with incorrect/rough usage. All these decrease operational availability and increase the cost of ownership. Reliability centric development has to be the norm now for indigenous systems with a number of good ideas and proven practices for improving reliability. However, a reliability gap exists in current systems because of our production practices and will be there in future systems too, unless addressed. When deployed systems will suffer failures and will need to be reset, it is important to restore the system to full mission capability through prompt close support. The organic industrial base of the Army must comprise a trained and ready workforce, institutionalised reset processes and requisite resources to decrease response time and provide the Army the desired operational availability. Most of the times the work has to be executed on the system where it is deployed and is closer to the teeth. Back end elements of the life cycle process will work to Army's advantage from cradle to grave and the acquisition process has to support this capability building.

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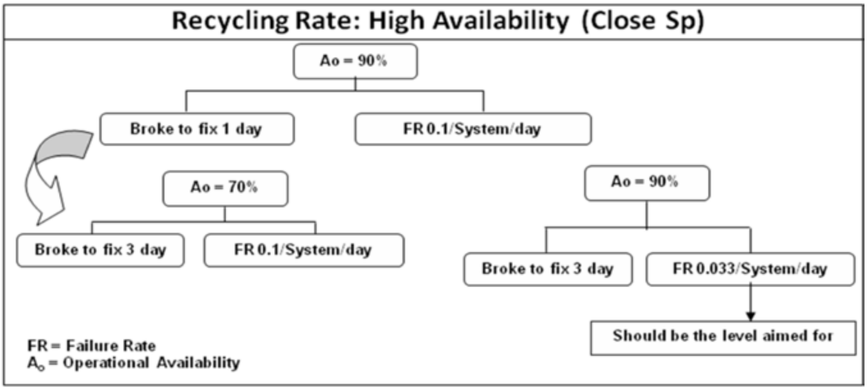
Mission Reliability

Mission reliability is the probability that a weapon system will not experience a complete failure or loss of all functions, during the performance of a mission. Two metrics become important to measure mission/task reliability. One is failure rate and the other is mean time between critical failures. Another metric which has not been given due importance is MTTR (Mean Time Taken to replace/repair), a measure of maintainability. The Arjun scores all pluses vis-à-vis the other tanks in this regard. These metrics have a great impact on war time availability as the following equations show:

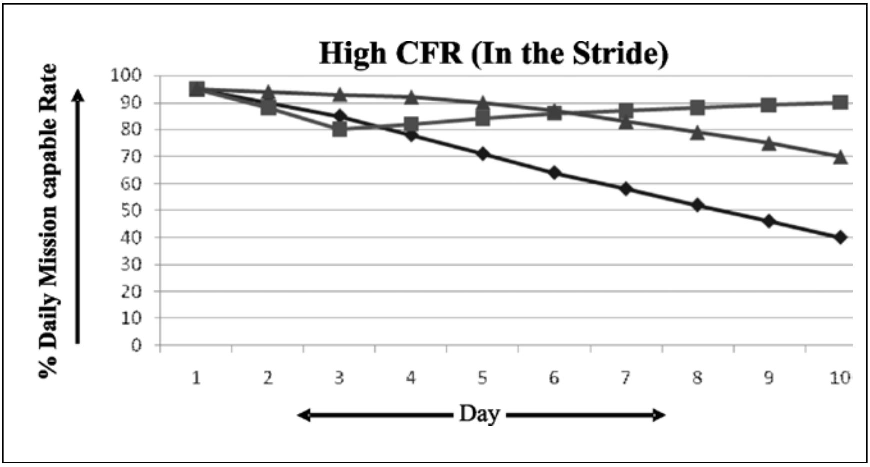
$$P_b = e^{-\left(\frac{M}{MTBCF}\right)}$$

Where :-
P_b = Probability of Success
M = Intended Mission
MTBCF = Mean Time Between Critical Failure.



Combat Force Regeneration (CFR)

During war, systems will fail on account of enemy action and mechanical failures. Combat force regeneration looks at capabilities for quick on-site, in the stride equipment reset to create the desired force ratios. The graph below gives out the daily availabilities of a force over a 10 days combat pulse. It is evident that to retain balance of the manoeuvre force a strong network of forward repair teams with ready to fight spares has to be integrated on a systems approach with a secure stream of readily accessible information or common operating picture of residual combat power at the end of a day's war fighting. Getting the right equipment, at the right place, in the required numbers is crucial for sustaining high force ratios during the combat pulse. Domination of the battle field by own forces will enable recovery and subsequent reset actions to be taken up in the stride.



Resetting the Force On a rough count the Army has over 1500 types of weapons and equipment numbering over 25 Lakh. EME generally resets close to 10,000 pieces each year in its industrial base; these include tanks, ICV's, guns, radars, dozers, radio sets, rocket systems, bridging systems, high mobility vehicles (HMV) etc. This industrial base has to be modernised and optimised to neutralise current workloads and ramp up for the surge needed in times of war.

The Financial Cost of Maintaining the Army's Equipment Typically 70-75 per cent of a system's ownership cost over its life cycle is incurred during the in service phase. This generally will comprise costs like initial spare parts provisioning cost, annual military personnel costs, annual civil maintainer cost, annual maintenance contract cost, annual recapitalisation costs, investments on maintenance, upgrade and replacement of special tools and test equipment, technical data package and software support, civil infrastructure costs and reliability/maintainability up-gradation cost.

In the US Army, in 2007, the cost of depot level maintenance was 2.3 billion USD and cost of field maintenance 2.96 billion USD. Cost of overhaul of M1A1 is $0.9m and cost of overhaul cum upgrade is $1.8m. Cost of overhaul of a HMV is $20,000 - $30,000.

Performance and capability degradation of equipment capability is a stark reality in our context in view of the extremely harsh conditions of deployment of our equipment. The resultant need for reset and recapitalization is indispensable for upscaling equipment readiness for higher operating tempos. A life cycle focus will assist us to retain/sustain force capabilities for warfighting in the mountains and plains at short notice.

In conclusion, I would like to end with an important lesson from the Yom Kippur war :

- Counting tanks before the war was a necessary but insufficient exercise. It didn't tell you what you needed to know for assessing the net strength of each side in the conflict.
- What impressed me about the 73 war, was how asymmetric it was. Israel was not only much better prepared **to recover and repair its tanks,** it also dominated the battlefield making recovery possible.

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