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ISSUE BRIEF
IB/10/25

THE IMPACT OF MAINTENANCE MANPOWER ON READINESS AND MILITARY EFFECTIVENESS

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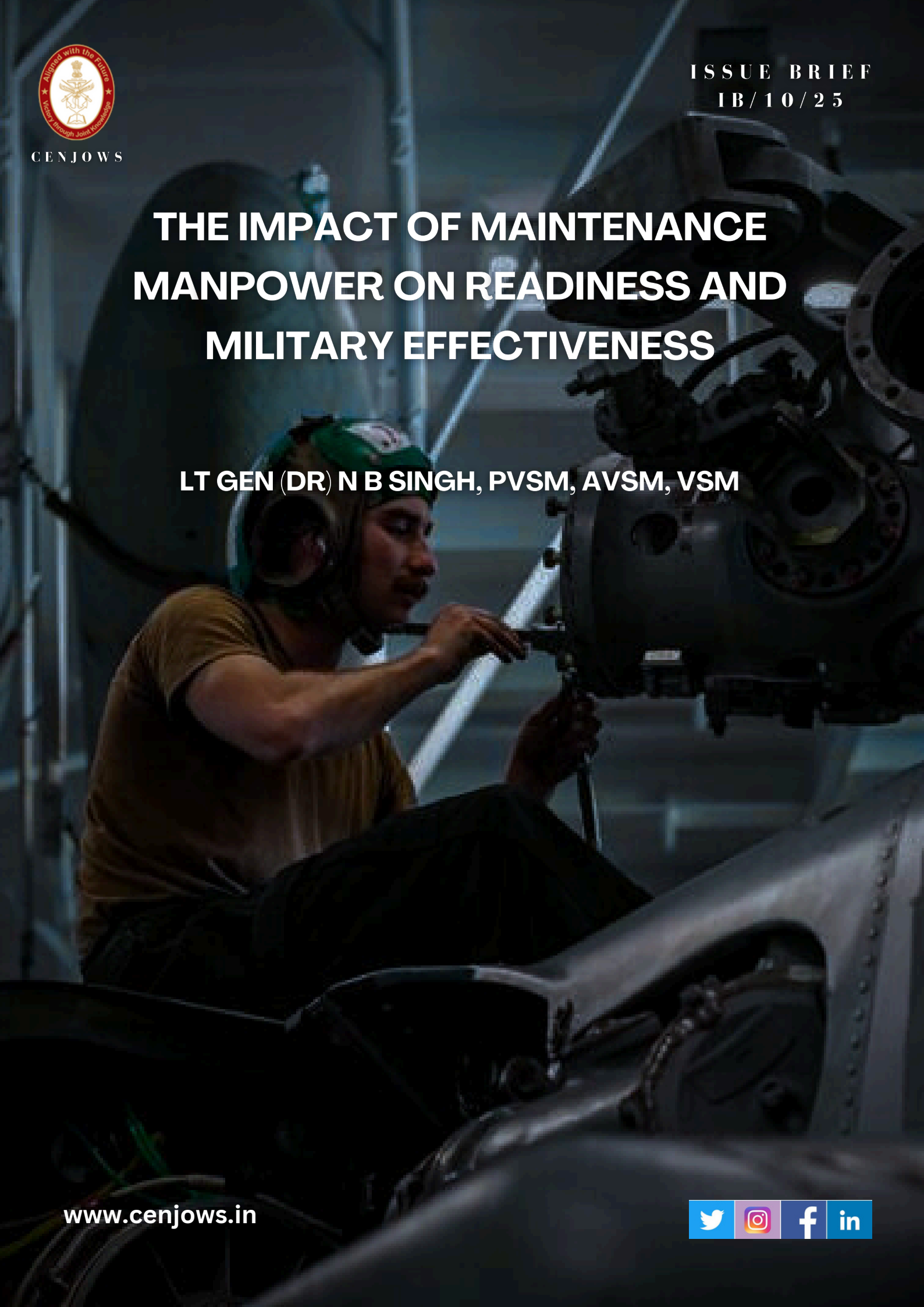

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The Impact of Maintenance Manpower on Readiness and Military Effectiveness

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"An understanding of how a military regards and conducts maintenance sheds light on the extent to which it will be able to improvise during wartime. Maintenance proficiency serves as an indicator of how fast and how frequently new techniques can be developed and applied widely across the force as it fights."

Military capability is a relative notion, dependent to a large extent on the nature of threat and is measured in terms of application of force. Military capability denotes an integrated and agile combination of trained personnel, mission capable equipment,

infrastructure, information systems, organizational structures & process that can create a military effect in a range of operational contingencies. Military effectiveness refers to the competitive advantage that a military possesses over its adversary i.e. the operational and technical overreach, agility and depth with which it can paralyse its adversary in all warfighting domains. It is important to note that operational capability has to be in a state of high readiness at start of combat operations and has to be sustained in a similar state for the duration of war.

The vast array of weapons and equipment in the inventory of any force represents a major component of military capability which has to be kept mission capable 24x7. Engineering sustainment hence has to be understood as a critical supporting pillar of operational effectiveness and battle endurance – a fact that has been reinforced repeatedly during the war in Ukraine. The traditional approach of defining equipment capability using garage availability has vulnerabilities as it only indicates the no of platforms that are present in a unit`s inventory – may be technically functional but not combat ready, focus being more on mechanical condition. Operational availability on the other hand refers to no of platforms that are fully mission capable and available for operational use when needed, in the intended operational environment. The adverse impacts of inadequate platform maintenance and hence mission readiness has been amply demonstrated in the war in Ukraine. Operational availabilities of platforms may be high to commence with but force ratios get depleted due to attrition (combat damage and fatigue failures) as operations progress. The side that is quick to regenerate platforms in the stride has an edge. Most modern militaries target to keep minimum operational availabilities upwards of 80%-90% for land, air and naval platforms. NATO standards often push for operational availabilities upwards of 75%. This vital fact is often overlooked by planners during peace time and if left unresolved it ends up silently incubating hollowness in the force. Most commanders prefer to leave the complexities of engineering sustainment for successors, focussing more on short term issues needing quick fix remedies.

The aim of this article is to bring out the linkages between capability readiness and close & deep engineering support exploring how operational readiness is affected by maintenance proficiency, skills and competencies of maintenance personnel and the overall cultural orientation of any military towards maintenance – how faithfully the

issue of maintenance routines, servicing schedules and reset activities are supported and implemented.

Analysing Effect of Maintenance Manpower on Readiness Rate

Tanks, armoured vehicles, trucks, and weapon systems, in addition to suffering combat damage, often fail under conditions of intensive use and increased stress like deployment at LAC. Such equipment may not be able to deliver a desired operational outcome or effect if its condition is allowed to deteriorate. At the same time these cannot be frequently replaced with new ones being cost prohibitive. Hence, militaries invest in MRO (maintenance, repair and overhaul) infrastructure to restore platforms to required levels of capability readiness. Combat pulse availability is a critical metric to assess pre mission fighting potential of a combat force. It is linked to combat realism and indicates actual deployability of platforms for the duration of an operation. It is dependent on a number of factors like terrain, operational tempos, vintage, spares support, skill sets and technical orientation of maintenance personnel. Skilled technicians and engineers are a big enabler to keep platforms in a mission capable state and safe to operate. Their routines of technical maintenance, preventive replacements, medium and base resets are meant to restore pre mission reliability and commanders need to provide total support to ensure that comprehensive maintenance is carried out whenever due in place of band aid actions. This can happen only if they understand the relative importance of responsive engineering support as a factor of wartime success. On many occasions maintenance issues get swept under the carpet resulting in catastrophic mission aborts and loss of reputation of a vaunted force. Let us examine some issues that impact system readiness.

Quantity of Maintenance Manpower

The quantity of maintenance personnel directly affects the ability to perform necessary maintenance tasks in a timely manner. Insufficient manpower can lead to backlogs, increased downtime and overworked personnel.

Quality of Maintenance Manpower

The quality of maintenance personnel measured by their training, experience, and expertise is equally important. Highly skilled technicians can diagnose and resolve

issues more efficiently, reducing down time. Key considerations for developing desired skills and competencies are training, experience and certification.

Allocation of Maintenance Manpower

The strategic allocation of maintenance personnel across different platforms and units is crucial. Misallocation leads to resource imbalance and inefficiencies. Effective allocation requires a thorough understanding of the maintenance needs of each platform, as well as the operational demands placed on different units. This ensures that maintenance resources are directed where they are needed most, optimizing overall readiness.

Impact of Operational Tempo

The operational tempo i.e. the rate at which military platforms are used also impacts maintenance manpower. High operational tempos increase wear and tear on platforms, necessitating more frequent and intensive maintenance. If maintenance manpower is not scaled to match repair time with operational tempo, readiness rates will inevitably decline. It is in high tempo; high attrition conflicts that deep support maintenance personnel are also redeployed to ramp up needs at the front line. When operational tempos are low, it is imperative that upgrades, modifications and gaps in maintenance are completed with the aim of enhancing long term fighting capability of the force.

Predictive Maintenance and Combat Development Engineering

Responsive repairs and forward placement of spare parts can cut down mean time to repair (MTTR), thus boosting operational availabilities. Digitalisation and condition monitoring of platforms can restore system reliability by identifying parts that are likely to malfunction. With advancement in technology, all types of sensors, data mining techniques and analytical tools are available that can enable predictive maintenance –what and when to replace or perform corrective maintenance.AI can be used to analyse, illustrate and predict by taking a larger systems view of warfighting. The war in Ukraine has shown that one has to be prepared for an industrial scale war in the future – heavy requirement of men, material, ammunition, fuel and such other

resources. AI should be able to analyse these requirements beforehand and backorder resources in advance. Finally, technology should enable mission readiness vs vulnerability matching. Can AI be employed to do mission engineering and conclude if Regt A has greater chances of success vis a vis Regt B when employed for a specific mission? May be possible if one is able to convincingly predict the failure rates of major platforms over a period / distance and forecast combat damage by assessing the relative strengths of the adversary during an operation.

Historical Perspective

The impact of maintenance manpower and good maintenance practices on the outcomes of war can be best illustrated by analysing events throughout military history , providing contexts and identifying patterns and lessons.**US military's ability to maintain high readiness rates during the Gulf War was largely attributed to its robust maintenance infrastructure and well-trained personnel.**[1] But three years after the Iraq war , strains began to appear in the Army`s equipment readiness and deployed units could maintain high levels of readiness only at the cost of readiness of non-deployed units. In Ukraine war, forces with inadequate maintenance capabilities have struggled to keep platforms operational, leading to mission failures.

The Russians had a lot of equipment breakdowns early in the invasion. For instance, there were reports of tanks and armoured vehicles being abandoned due to mechanical failures. The Ukrainian side, relied heavily on donated Western equipment. Lack of enough trained personnel and spare parts, slowed down operations. **Any military with excessive dependence on imported systems can face similar consequences.**

The Yom Kippur war represents a fine example of how ingenuity of maintainers changed the course of war. In our own context, battle of Zojila demonstrates how mission outcomes were impacted positively.

Let`s examine some details:

Ukraine War.

- **Russian Ground Forces: Breakdown of Armoured Vehicles**
  Early in the invasion (February–March 2022), Russian armoured columns suffered widespread mechanical failures due to poor pre-war maintenance and insufficient logistics. T-72/80 tanks, BMP infantry fighting vehicles, and trucks broke down en masse, stranding entire units which became easy targets for ambushes. The 40-mile convoy stalled near Kyiv in March 2022 was partly immobilized by breakdowns. Underfunding of peacetime maintenance programs left equipment in disrepair. Units lacked spare parts, recovery vehicles, and trained mechanics to address failures under combat stress.[2]

Fig 1. Unreliable Logistics Vehicles can ground Operational Plan

- **Russian Airborne Forces (VDV)- Loss of Key Assets at Hostomel Airport.** During the assault on Hostomel Airport (February 2022), Russian VDV forces relied on aging Mi-8 helicopters and BMD-4 armoured vehicles. Many vehicles broke down mid-operation, while helicopters faced engine failures due to deferred maintenance. The failure to secure Hostomel allowed Ukrainian forces to regroup and retake the area, undermining Russia's plan to rapidly capture Kyiv. Poorly maintained rotary-wing assets and inadequate pre-combat inspections reduced operational reliability.

- **Ukrainian Artillery: Barrel Wear and Ammunition Shortages.** Ukrainian artillery units, relying heavily on Soviet-era systems (e.g., 2S1 Gvozdika, BM-21 Grad), faced accelerated barrel wear due to sustained high-tempo firing. By late 2022, many barrels were rendered inaccurate or unsafe. Reduced precision and range forced units to ration fire missions, weakening counterbattery efforts. Limited access to replacement barrels and specialized maintenance tools lowered readiness rates.

- **Russian Black Sea Fleet: Loss of the *Moskva*.** The sinking of guided-missile cruiser *Moskva* (April 2022) highlighted broader maintenance failures in Russia's naval forces. Prior to its loss, the ship's air defence systems (e.g., S-300F) were reportedly poorly maintained, leaving it vulnerable to Ukrainian Neptune missiles. The loss of the flagship disrupted Russian naval operations and morale, emboldening Ukrainian coastal defences. Chronic underinvestment in shipyard maintenance can degrade a fleet's combat readiness.[3]

- **Ukrainian Soviet-Era Aircraft- Strain on Aging Fleets.** Ukraine's air force relied on Soviet-era MiG-29 fighters and Su-25 attack aircraft, many of which were poorly maintained before the war. By 2023, airframe fatigue and engine wear reduced sortie rates. Limited air support forced Ukraine to prioritize ground-based defences (SAMs) and drone warfare. Spare parts shortages and lack of access to OEM support for legacy systems impacted sortie availability.

- **Russian T-62 Tanks- Deploying Obsolete Systems.** In 2023, Russia began reactivating mothballed T-62 tanks (designed in the 1960s) to compensate for losses. Many lacked modern optics, reactive armour, and functional engines. These tanks were easily targeted by Ukrainian anti-tank teams and drones, contributing to high attrition rates. Fielding vintage equipment without refurbishment and technology insertion could be self-defeating.
- **Western-Donated Systems- Maintenance Challenges for Ukraine.** NATO-donated platforms (e.g., Leopard 2 tanks, M777 howitzers) require specialized maintenance. Ukrainian crews initially lacked training and access to proprietary

tools/spare parts, leading to extended downtime. Delays in deploying advanced systems reduced their battlefield impact during critical phases (the 2023 counteroffensive). Logistical hurdles in establishing Western-style maintenance ecosystems under combat conditions reduced combat effectiveness of Ukrainians despite possessing superior platforms. Hi tech platforms alone are not enough, it`s their ability to deliver a mission failure free.[4]

Yom Kippur War

In contrast, Yom Kippur war provides an exemplary account of how the technical competence of IDF maintainers played a crucial role, significantly impacting the course of the conflict. The critical impact of equipment availabilities on the outcome of wars was very well demonstrated in the war. Israeli Defence Forces (IDF) were shaken to the core due to destruction of 400 tanks in the first three days of war, by swarms of Egyptian infantrymen equipped with anti -tank missiles. Post the impressive victory of 1967, where the IDF had taken full control of Sinai, Egypt started preparation to take back the peninsula. On 6 Oct 73 the Egyptians managed to spring a surprise and secured several shallow bridgeheads across the Suez Canal. Egypt moved 90000 soldiers and 800 tanks into Sinai in the first three days and managed to send reserves forward. Israels depot maintenance was in a bad shape, close to 300 tanks were not fully equipped. Many tanks failed during the rushed deployments, but it was the high level of repair skills of the maintainers duly supported by tank crews that most platforms could be repaired in the stride, often very close to the front, in minimum time. The distinctive technical and qualitative skills of IDF enabled its personnel to quickly adapt its weapon system capability to tactical demands on ground. Installation of grenade launchers on T54s, modifications to enhance engine and transmission life and modification to quadruple track life were some innovations from the Egyptian side. However, in the ultimate analysis it was the overall technical advantage of IDF that enabled it to create resilience on the fly and regain control.

Here's how:

- **Recover, Regenerate and Return Platforms to Combat**
    - **High Recovery Rate.** The IDF was able to leverage its technical competence to recover combat platforms, carry out repairs in situ and return these to the front in minimum time. They not only regenerated half

of the 840 tanks that had suffered combat damage, but using their ingenuity recycled close to 300 repairable Egyptian tanks that were employed by Division Commander Maj Gen Bren Adan to encircle the Egyptian Third Army before cease fire. These examples demonstrate the high levels of organizational creativity prevalent in IDF as also the engineering excellence of maintainers and crews who accomplished such feats. **These examples show the intrinsic linkages between engineering support and operations and how engineering sustainment can shape mission outcomes on the battle field.**

- **On-the-Spot Repairs.** Each tank crew was equipped and trained to perform minor repairs, while technical teams handled major damage, enabling quick turnaround times. Can`t our weapon platform crews replicate this practice.
- **Strategic Advantage:** The rapid repair capability allowed Israel to maintain higher number of operational tanks, giving them a crucial edge in a war where they were outnumbered.

- **Adaptability and Innovation**
  - Responding to New Threats**.** The war saw the debut of advanced Soviet anti-tank weapons like the Sagger. IDF maintainers quickly adapted, devising countermeasures and repair techniques to mitigate the effectiveness of these new threats.
  - **Improvisation.** Faced with unexpected challenges, maintainers often improvised solutions. For example, during the fighting, General Bren Adan set up a "checkpoint" behind the front lines where technicians and medics could quickly repair tanks and combine crews, getting them back into battle faster.
- **Maintaining Morale and Momentum**
  - **Psychological Impact.** The knowledge that damaged tanks could be quickly repaired and that crews could return to battle had a positive psychological effect on Israeli soldiers. It reinforced their belief in their ability to overcome adversity.

- **Sustaining the Fight.** By ensuring a steady supply of combat platforms, IDF maintainers helped sustain the war, preventing degradation of combat effectiveness due to equipment losses.

- **Contrasting with the Enemy.** Unlike the IDF, the Egyptian army had limitations; lacked technical expertise and capability for rapid repairs. This meant that damaged Egyptian tanks were out of action for extended periods, lowering overall force ratios.
- **Impact on Mission Outcome:** While not the sole factor, the difference in maintenance capabilities contributed to Israel's ability to withstand the initial Arab assault and eventually turn the tide of the war. The key lessons learnt were that **pre-war maintenance matters, high tempo operations expose weaknesses and** adaptation **is critical. In East Europe, Ukraine's** use of decentralized repair hubs and 3D-printed spare parts highlights technology driven innovative responses to maintenance gaps.

Sustainment - How Poor Maintenance Loses Wars

The amazing statistics that out of 840 tanks that were lost by Israel in the initial stages of war, more than half were recovered, repaired and returned to fight **is credited to Israeli military`s mindset that considered damaged tanks as *soon-to-be-repaired tanks*, rather than lost out of battle.** The fact that commanders thought on these lines gave impetus to sustainment engineering related resource planning during peace time. **A best practice which the Indian military needs to adopt. The Egyptians lacked capability for in theatre repairs.**

Ukraine repaired its armoured vehicles as well as Russia's, in a similar fashion. Complex platforms are so robust that most battle damage is fixable. "Every tank could be repaired, as long as it's not been cut in half," said an official at Ukraine's tank factory. Ukrainian repair facilities were highly mobile and operated close to the front, with depots capable of deep reset in the rear. If a platform is subjected to high operational tempo, it has to be maintained painstakingly**. The howitzers in Ukraine fired continuously resulting in a third being out of action for repairs or replacement of barrels after firing over 2,500 rounds**. Ukraine converted many captured tanks into repair and recovery vehicles. The Deputy Chief of America's Army Materiel

Command commented, “The Ukrainian maintainers are very resourceful and very good at keeping weapons systems that we provide, in the fight.”[5]

Fig 2. An M777 team at work.

Two examples in the Indian context stand out. A fine example of operational innovation in the Indian context can be found in the battle of Zojila where Stuart tanks were dismantled and carried in manageable packs up the mountains, assembled and made to operate at those icy tops, rattling the adversary who finally fled the pass. On the contrary, in 1962 at Chushul AMX light tanks available in location were non mission capable when Rezangla came under attack, resulting in the loss of many gallant infantrymen. In high tempo, attrition heavy operations, technically oriented junior leaders and competent maintainers are top commodities; military`s have to invest in creating a pool of these for enhancing military effectiveness.

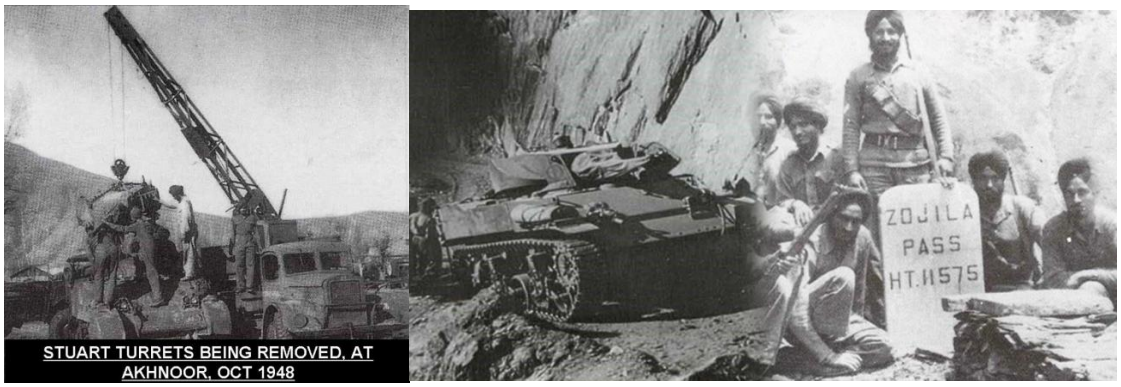

Fig 3. ZOJILA 1948

Tech Forward Orientation

Ukraine has a world-class, global tech sector adept at solving problems with whatever resources available, at digital speed like India. “Ukraine has digitized its military on a shoestring,” noted an article in the *Wall Street Journal*. A new concept has emerged from the war in East Europe. Ukrainian soldiers had to learn how to operate, maintain and repair Western hi tech systems. One of these was skilful use of internet for “tele maintenance.” For every platform, a team of SMEs advised Ukrainian soldiers via an encrypted chat line, with the OEM on call. Certain fast-moving parts required full spectrum ingenuity like use of CAD to draw up design, get it vetted by specialists and fabricate locally.

Use of the internet for real time situational awareness was another. In 2020, Ukraine began building an “e-government” tool called Diia. It was a mobile app designated as “State in a Smartphone.” By 2023 half of Ukraine`s residents were using it. After Russian invasion, it was used as a tool for citizens to report precise location and nature of enemy activity. These inputs were fed into the Delta battlefield awareness system thus providing real time situational awareness of the battlefield.

Maintenance Orientation

In current day operations it is critical to develop a maintenance mind in all junior leaders. **These officers and men have to live, breathe and eat preventive maintenance as a Mantra.**[6] They will do so if it is drilled in courses like YO, JC, SC, HC, HDMC that equipment readiness alongside soldier readiness wins wars. Maintenance includes repair alongside activities like reset and upgrades necessary to defeat obsolescence and keep systems mission capable. **New technologies fail in unexpected ways and hence the need to be proactively armed.**

Any neglect of maintenance will have its impact during the course of battle and lead to enormous loss of men and steel. Skilled technicians, recovery vehicles, tools and equipment and spare parts are an inseparable part of a fighting force. **MRO personnel need to be viewed as combat development engineers, a valuable source of knowledge, innovation and improvisation and as a source of sustainable competitive advantage. They can positively impact the outcome of battle through force regeneration in the TBA as military history has shown.** These

personnel in combat formations have to be supported by a team of extremely skilled maintenance personnel, both military and civilians from base repair workshops for deep repair and innovation. Today with intense usage and much larger attrition, full tempo combat engineering support will help win wars by providing the maintenance surge to build lasting battle endurance.

The Indian military has around 200,000 maintainers on its rolls along with industrial infrastructure for field and base refit. The IAF and Navy have a much higher percentage of maintainers (35 to 45%) as compared to Army (8-9%). These sister services have a tradition of providing full support to maintainers to modernise, digitise and operate for enhancing military effectiveness. The Army has a tradition to repeatedly engage in actions to unsettle its maintenance set up through impulsive actions, without much strategic thought. Transformational initiatives like placing spare parts under maintainers or placing engineering sustainment under capability development branch have been stymied on specious considerations. **By resorting to such retrograde actions, it ends up creating an insidious downward spiral that results in its own self-fulfilling prophecy of failure, as the Ukraine war has demonstrated.** The following analysis may help bring in awareness about the operational role of maintainers:

Fig 4. M109 in action in Ukraine.

Fig 4 shows an image of M109 SP guns in action in Ukraine. Notice the intense ammunition usage and the need for in situ maintenance and frequent repairs. Pre combat focus of maintainers is to restore all platforms to a predictable level of mission

reliability. A tank needs 3-4 hours of maintenance and checks for each hour of high tempo operation, a helicopter much more to ensure a combat sortie failure free. During combat, where hard usage and battle damage can cause breakdowns, maintainers aim to return systems to operational status as quickly and as near as possible to the point of failure. Battle damage and repair is accomplished by bypassing components or safety devices, fabricating parts, taking short cuts to standard maintenance, jury - rigging or improvisation like using alternate fluids, materials, components, etc.[7]

Figure 5 below gives out a relational ship between the mean time to repair (MTTR) & operational availability of an artillery regiment in combat. It demonstrates how high reliability & maintainer capacity sustains firepower. Assuming a stipulated operational availability of 90% at start.[8]

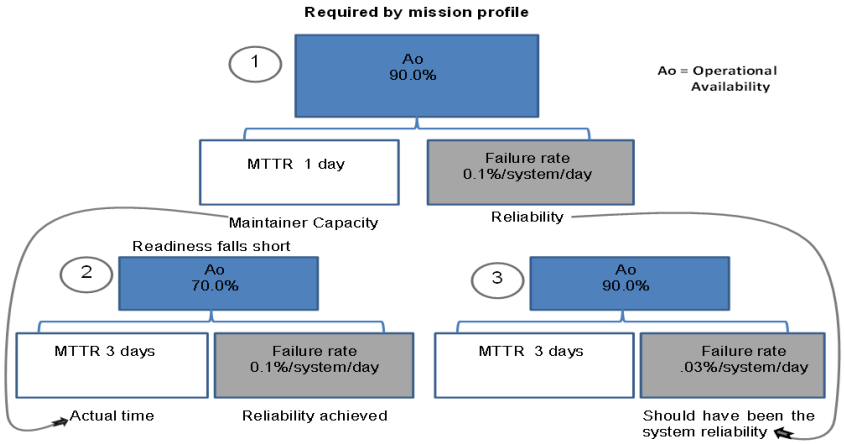

Fig 5: **Effect of Maintainer Capability on Operational Availability.**

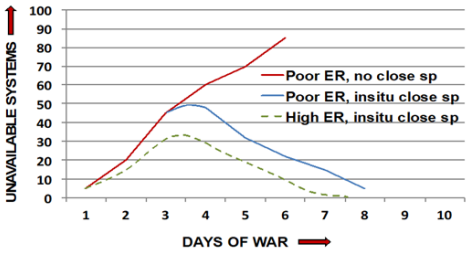

Fig 6 : **CONTRIBUTION OF MAINTENANCE MANPOWER ON FORCE SURVIVABILITY**

Unification of Engineering Support Levers

The Ukraine war underscores how maintenance manpower is a force multiplier. Inadequate investment in peacetime equipment readiness (deferring rest/refit), directly undermined operational tempos, turning maintenance shortfalls into strategic vulnerabilities. Three years after the LAC standoff the Army has managed to keep its equipment deployed in the harshest of terrains. It is time to audit the state of readiness. Soon signs of equipment stress and strains will be visible necessitating reset, resuscitation or replacement.

Instead of targeting maintenance manpower and maintainer assets the Army`s brass needs to consider a period of stabilisation operations for close and deep engineering support; to enable maintainers to prepare for the tsunami of reset arisings likely in a few years. Modernisation of field and base reset infrastructure, development of technical skills and competencies, recruitment of personnel, acquiring new recovery platforms, creating local supply chains are some areas of work to be done asap. Intelligence efforts need to be put in to understanding the maintenance practices of adversaries so as to get an understanding of the extent of their military effectiveness and wartime vulnerabilities.

Next Generation Recovery and Engineering Vehicles

One of the most important lessons from Ukraine war is the need for unification of all elements of technical support like most modern militaries including IAF and IN. This will enable a full systems view to equipment readiness. Unification of military technical services like acquisitions, MRO and spares management under a single vertical of capability development is indispensable to usher in the concept of life cycle capability readiness and sustained military effectiveness. The present arrangement has been largely ineffective in sustaining readiness. Retaining 5–7-decade old organizations (jettisoned by the British) to fight wars of 21st century could introduce serious vulnerabilities. The Army should cease deferring recapitalization of aging equipment and request a level of reset funding consistent with fully revitalizing the force for future challenges. Future conflicts will most likely see dynamics similar to Ukraine, emphasizing the need for agile, well-resourced maintenance frameworks. Finally, if the Army is serious about cost savings it must review its internal workings and relevance of several organizations. Theaterization must be driven through despite reservations, as it is one high impact reform that will bring in greater military effectiveness and cost savings. As new platforms become more complex, maintaining a robust and adaptable maintenance workforce will remain indispensable to sustaining military effectiveness.

“*It is only when they break down, machines remind you how powerful they are.”*

DISCLAIMER

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References:

1. Army Equipment after Iraq, Loren B. Thompson, Lawrence J. Korb Caroline, P. Wadhams Lexington Institute, Centre for American Progress
2. Analysis of Land Army Maintenance Techniques in the War in Ukraine, Col. Marinko Aleksić, Col. Sead Cvrk, Col. Dražen Božović, Military Review May Jun 2013, US Army University Press
3. O'Brien, P. P. 2023, February 25), Three Lessons From a Year of War in Ukraine. The Atlantic. https://www.theatlantic.com/ideas/archive/2023/02/russia-ukraine-war-one-year-national-identity/673192/
4. Ibid
5. Taking a Look under the Hood, The October War and What Maintenance Approaches Reveal about Military Operations, Colonel James S. Powell, U.S. Army Land Warfare paper 128 / August 2019
6. Ibid
7. Maintenance: Of Everything by Stewart Brand
8. Ibid
9. Equipment Sustainment requirements for the transforming Army, Eric Peltz, RAND Arroyo Centre,2003