MOSAIC WARFARE: SPACE AS ENABLER IN THE INDIAN CONTEXT

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Abstract

Technological advancements in war fighting enables autonomous systems, Artificial Intelligence (AI); Machine Learning (ML) systems, real time ISR operational picture, precision strikes, etc to function across Multi Domain Operations (MDO). This is enabled due to net centricity or Net Cetric Warfare (NCW) which is a pre-requisite to operationally and functionally link all these technologically enabled systems. Shortfalls in NCW and are recommending a modification to NCW terming it as Mosaic Warfare. NCW works on a Kill Chain concept, where this kill chain can easily be disrupted with the cyber warfare; electronic warfare (EW) capabilities as also with targeted precision strikes. Hence, instead of a Kill Chain based OODA loop, Mosaic Warfare works on a Kill Web based OODA loop. Since it is 'Web', it enhances survivability.

Space being the common frontier over land, sea and air can act as an enabler and facilitator for implementing Mosaic concept. Thus, Indian Armed Forces can directly adopt tenets of Mosaic Warfare instead of first adopting NCW and then transforming to Mosaic Warfare. In previous wars, the units at tactical level operations alone sufficed for victory. However, in any future conflict especially on Northern borders, conflicts will be more in the non-contact domain and will reduce effectiveness of tactical level operations. Hence, it is imperative that our armed forces transform and adopt these

technological advances (AI, ML, autonomous systems, precision systems, etc) networking them in a Mosaic Concept – for which Space is an effective enabler.

INTRODUCTION

War fighting is being impacted due to the rapid technological advancements and is undergoing transformations, as evident from Russia-Ukraine and Israel-Hamas conflicts. This technological revolution enables autonomous systems, Artificial Intelligence (AI) & Machine Learning (ML) systems, real time ISR operational picture, precision strikes, etc to function across Multi Domain Operations (MDO). However, this is enabled due to **net centricity or *Net Cetric Warfare (NCW)*** which is a *pre-requisite to operationally and functionally link all these technologically enabled systems*. The Think Tanks of warfighting in USA have noticed some shortfalls in **NCW** and are *recommending a modification to NCW* terming it as Mosaic Warfare[1] - an ***improvement to* NCW**.

Mosaic Warfare is the latest buzzword in war fighting and is being discussed intensely in the concept and doctrine formulation in the USA.[2] Mosaic is basically a **command-and-control function**, an innovative approach to military command and control that employs a networked, distributed architecture to enhance flexibility, resilience and decision-making speed.

Applicability of Mosaic Warfare is across all domains i.e., Space, Cyber, Land, Sea and Air. Since, ***Space has the advantage of being the common frontier over land, sea & air; thus, it can act as an enabler and facilitator for implementing Mosaic concept which is now a war fighting imperative to link all technological systems. Thus, Indian Armed Forces can directly adopt tenets of Mosaic Warfare*** instead of first adopting NCW and then transforming to Mosaic Warfare. Mosaic Warfare is also referred as the *5th Generation Warfare* or *Kill Web strategy.*

Space is the next frontier and its immense potential is still untapped. To discern and define the future military concepts with respect to space,

it is imperative that visualisation of how the space is going to manifest & transform is done correctly. As a reference to an analogy, "air power in WW I", was largely only a source for observation/surveillance, (akin to what space is/was some years ago) & air power since then has transformed manifolds. However, transformations in space would be more significant and disruptive owing to enhanced rapid technological advancements taking place. Therefore, *to capitalise on the intent to use Space as an enabler for Mosaic Warfare, decisions and affirmative actions have to be taken in time.*

TECHNOLOGY DRIVERS

In the commercial space as well as in the military domain, the technological advancements are becoming a big facilitator in enhancing efficiency all across human functional sphere. In the military space also, these technological drivers are facilitating better connectivity amongst various weapon systems and the sensors, so that the sensor to shooter link referred as the Observe-Orient-Decide-Act (OODA) loop is speeded up. The major technology drivers which will impact warfare in current and future scenarios are listed below, ***their usage needs to be defined in our concepts and doctrines***:

- Unmanned Systems – Aerial, Ground, Sea and Sub-surface.
- Artificial Intelligence (AI) & Machine Learning (ML) driving software applications and military equipment.
- Communications and connectivity.
- Space based systems – control of space.
- Cyber Warfare.
- Electromagnetic Spectrum – control & usage, Electronic Warfare (EW).

NETWORK CENTRIC WARFARE (NCW)

It is collaborative information sharing for optimum utilisation of available resources to enhance combat efficiency. Its implementation/execution is best with US Armed Forces, wherein they have common and integrated Tactics, Techniques, Procedures (TTPs) across their armed forces and they are networked. This technological advantage initially was seen in the Gulf

War in 1991, gave them an edge and has been a subject of much study by rival militaries especially China.

Net centricity would be sine qua non for current and future technology enabled environment.[3] In simplistic terms, net centricity can be considered analogous to internet, wherein it is the internet which has harnessed power of computing (computers) and has revolutionised every aspect of human development - global economy, business, transportation, banking, science, etc. In a standalone mode, computers have limited abilities. *Likewise inducting the force multipliers, unmanned systems, AI enabled system, etc into the armed forces would not achieve the desired outcomes if they are not networked & become a part of Net Centric Operations (NCO).* **NCO is not about technology alone** but more so pertains to methods and means to harness & synergise all information and resources for greater combat effectiveness. Technology acts as an enabler and assists in achieving this by ensuring communications, generating common operational picture and faster computation thus enabling Effect Based Operations (EBO).

In NCW, the decision-making is structured, control is centralised & command is hierarchical. *US think tanks and their foremost think tank on warfighting strategies & technology – Defence Advanced Research Projects Agency (DARPA) have recently wargamed*[4] *that in current or future war, based on their major adversary's counter capabilities (i.e., China and Russia), NCW architecture with a centralised control would be targeted by soft or kinetic kill and render them ineffective.* NCW works on a **Kill Chain** concept, where in all decisions, command, control, collation, and analysis is largely centralised at one point/ location. Thus, this *kill chain* can easily be disrupted with the cyber warfare & electronic warfare (EW) capabilities as also with targeted precision strikes. This will render their whole war fighting machinery ineffective and isolate their combat forces for piece meal destruction, even when having the best of the equipment. Herein comes the *Mosaic warfare concept which in actuality is a modification of the net centric warfare concept. And in the Indian context, in an adversity we will also face similar challenges; thus, it is an imperative to adopt the concept of Mosaic Warfare.*

Despite the recent misgivings of NCW, even in its existing form it still remains a work in progress in most militaries *including ours*. NCW is a necessity for effective combat efficiency, by ensuring connectivity, collaborating & sharing information (ISR), and shortening the OODA Loop.

MOSAIC WARFARE

Mosaic warfare is the latest concept over current net centric approach. Hence, instead of a *Kill Chain based OODA loop, Mosaic Warfare works on a Kill Web based OODA loop.* Since it is 'Web', it enhances survivability.

Mosaic Warfare is described as an innovative approach to military command and control that employs the network distributed architecture to enhance flexibility, resilience and decision-making speed. Key characteristics are as follows:

- Distributed architecture: decentralises decision making across multiple nodes, reducing vulnerability and enhancing operational resilience.
- Adaptability: rapidly adjust to changing operational environments and threats, enabling forces to respond with agility.
- Resilience: minimises single points of failure through redundancy, ensuring continuous operation even after attack.

Under the mosaic approach, air, cyber, land, sea and space domains will focus on operating in a more integrated framework. Advances in microelectronics and communications are making possible a degree of networked coordination and collaboration between different systems almost unimaginable just a few years ago. This, in turn, is enabling distributed system–of–systems architectures that will be more resilient to attack, less costly to develop and faster to upgrade when compared to today's *centralised expensive monolithic system*.

MULTI DOMAIN OPERATIONS (MDO)

MDO is not just conducting operations in all these domains separately, an actual MDO is when all domains collaborate and create effects as desired.

"Using dominance in one domain or many, blending a few capabilities or many, to produce multiple dilemmas for our adversaries in a way that will overwhelm them."

Thus, **Mosaic Warfare facilitates MDO**, wherein cross domain operations are possible. An example of ***distributed and linked cross domain operation*** for *a common operational/tactical action* where all domains are collaborating will be as follows:

- **Space**.
    o   Overhead ISR and data relay (Common Operational Picture).
    o   Navigation and timing.
    o   Beyond-line-of-sight communications.
- **Air**.
    o   Airborne ISR – aircraft and drones (High Altitude Long Endurance HALE, Medium Altitude Long Endurance MALE).
    o   Long Range Strikes – aircraft and autonomous systems.
- **Cyber and Electronic Warfare (EW)**.
    o   Integrated air defence system network monitoring.
    o   Cyber Attacks on enemy air defence/other systems.
    o   Jamming and spoofing – systems, drones etc.
    o   Deception - Insert false targets.
- **Land and Sea**.
    o   ISR – tactical battle area.
    o   Combat actions – domination, destruction and capture.
    o   Autonomous systems – swarm drones, drones, manned unmanned teaming MUM-T, etc.
    o   Long-range fires (ship/land based).

MOSAIC WARFARE FOCUS: LETHALITY & SURVIVABILITY

The various domains (largely Land, Sea, Air) work *in independent silos* spend too much time, money and effort in trying to ensure its weapons systems are more advanced than adversaries. However, the high cost and sometimes decades–long development timelines of new systems is unable

to compete with the technological advancements, which can make new military systems obsolete before they are even delivered.

Mosaic Warfare propagates to focus on **lethality and survivability** with the ability to win *regardless of whose individual weapons system is the best*:

- **A fundamental way to achieve this survivability** is by distributing and disaggregating the sensors and weapons that today are tightly bound together and may not survive in an EW/Cyber environment. Disaggregation can take place by having multiple systems, incorporating autonomous systems like swarm drones (cheaper systems), cross domain operations (synergy of all domains), by deception, operational/tactical acumen, etc.

- **Lethality is achieved through aggregation of the disaggregated systems** through decision support systems which connects all weapons and sensors enabled through AI & ML to perform an Effects Based Operation (EBO).

- **Artificial Intelligence (AI) & Machine Learning (ML)**. *It is no good if machines think but humans do not.* With numerous sensors and weapons, if they are disaggregated, manually collating information and taking decision will not be feasible. AI and ML comes in to speed up this process and also automate many functions. The enabling role of Artificial Intelligence and Machine Learning is as follows:

  o AI facilitates hardware/machines undertake intelligent functions. For e.g. in a swarm drone, the drones will interact with each other using AI and perform the tasks as given in an automated fashion *as one entity.*

  o ML is a subfield of AI that concerns machines performing tasks without first receiving explicit instructions. Instead, the machine learns to perform the task from training data or through interactions with a simulation environment, like a machine trained to identify an adversary's tank from a data library will assist a drone in identifying the same practically in field.

BUILDING A MOSAIC C2 FRAMEWORK THROUGH SPACE

ISRO has produced remarkable results with indigenous efforts at extremely low costs. ISRO[5] has many cutting-edge technologies and expertise which can facilitate building the mosaic framework.

Compared to US, China our number of satellites for Space control (Space Situational Awareness-SSA and Space Domain Awareness-SDA) are less. Therefore, apart from the ISRO and governmental efforts, *the private sector has to step in for building a Mosaic C2 framework.*

Space Systems - Private Sector. The Indian private sector, *especially the startups have the requisite wherewithal to ensure space becomes an enabler*. This has happened due to reduced hardware costs, densification of electronic components, adoption of COTS components, etc. But *more importantly the HR talent exists within the country.* There are many in the private sector who have the capability but need the right support, financial surety and guidance (including from ISRO). Building this ecosystem is imperative in National interest.

Technology Enablers. Following technology enablers would be essential, which are well within the indigenous capability/industry realm provided the right eco system is created:

- **Ground Infrastructure**. We need ground infrastructure, which is both fixed and mobile. In fact, as part of mosaic framework, we need mmobile satellite data receiving antenna for deployment at the level of operational & tactical level for real time communication/data exchange.

- **Satellites**. For ease of proliferation, requirement is of smaller cheaper satellites *with varying payloads as per operational requirement*, which may not have a long life. This is perfectly in order, as the technologies are changing rapidly, so we do not need large/complex and costly satellites which become outdated very fast. Lower–cost, less complex systems are easier to link in a vast number of ways to create desired, interwoven effects tailored to any scenario. In addition:

- o Another concept, which is gaining ground is of 'Software Defined Satellites' in which the software can be upgraded so that the satellite remains in tune with technology.
- o Deployment on Demand - Deploy on Demand concept envisages the availability in orbit of several small satellites suitably encased to be deployed on requirement for functions as desired.

- **Rockets**. The requirement would be to have launch on demand rockets with very short notice so that multiple launches can be undertaken in a shorter time frame.

- **Communication Links**. Intersatellite optical links, or laser crosslinks,[6] are poised to transform space communication by improving data transmissions speed and reliability. While widespread use of laser crosslinks direct data transmission between satellites could reduce reliance on ground stations. Ground network architectures will change, not go away.

In addition, optical communications are expected to play a critical role in supporting new Earth-observation technologies like 'Synthetic Aperture Radar (SAR)', a technology that enables organisations to send raw data to terrestrial applications in a highly secure manner.

- **Software and Applications**. Software and applications to be put on this space technology infrastructure is the most important aspect. These can be categorised into following major types:
  - o Functional Applications - Part of the hardware & functioning of the system viz, communications, positioning system, etc. Largely a product of the developer.
  - o Operational Applications - Applications required for conduct of military functioning i.e. ISR, generating common operational picture, data relays, etc. The User will be required to provide the 'use case' and define the 'problem statement' and also engage in the development process along with the developer.
  - o Mosaic C2 Applications – These would be complex applications using AI & ML viz. decision support systems, predictive analysis, etc.

User will have to be a proficient specialist to define the concept and then be part of or even lead the development process along with the developer.

As is evident the overall concept and use cases have to be driven by the military user and requires that kind of competency. *Private players are also capable of providing end-to-end solutions even in India similar to* 'Star Link' for communications, Mazar & Planet providing imagery/intelligence etc.

- **Security**. Security should be in design and not as an afterthought. Protection against cyber warfare, hardening against an electro-magnetic pulse and if feasible physical security should be built into every satellite from the ground up.

SPACE AS ENABLER FOR MOSAIC C2 IN INDIAN CONTEXT[7]

The Indian Armed Forces have acquitted themselves in a sterling manner warding off all security challenges both internal & external from the time of independence till date. All three services (Army, Navy & Air Force) have developed capabilities and have effective response mechanisms. However, the transition to net centricity/NCW, integration and jointness (theaterisation), cyber and space capabilities have not been at the desired pace. However, developing space capabilities with the right conceptual framework can help us leapfrog directly to Mosaic Warfare concept of warfare which can mitigate & tide over earlier anomalies. *Major aspects in this regard are highlighted below.*

- **Theaterisation**. Space as a frontier can overlap the various coordination functions (communications, ISR, etc) of the three services assist in greater jointness and integration lending to theaterisation functionality. Undertaking the same through terrestrial means is more cumbersome.
- **Communications**. Communications required in our terrain configurations from super high altitude to deserts has challenges. Space can serve as an alternate means for connectivity and provide redundancy.
- **Space also lends itself to execute cross domain operations**. Fundamentally, C2 modernisation efforts should be anchored in a clearly

defined strategy. The basis of the efforts should be the military's ability to effectively conduct synchronised MDO. The goal is enabling the warfighting effort to employ capabilities from different domains to meet a military objective.

- **MOSAIC C2**. Space also offers an opportunity wherein space/satellites can serve as a major area for dis-aggregation i.e., Mosaic C2. Managing space control, information in a Mosaic C2 environment enabled by effective ground infrastructure is highly feasible.

- **Kill Webs**. Mosaic C2 requires *decentralised functioning*. Smaller 'kill webs' based on space infrastructure in synch with ground elements can be conceptualised and then designed & produced based on terrain, operational requirements and the adversary. *It does not require the whole war fighting machinery to be networked to execute an operational action as in NCW.* A 'kill web' can have varying functionalities to assist the operational actions or decision-making process like surveillance over an area, tracking inimical elements (pirates/rebels in Arabian Sea), communication over inhospitable terrain, etc. Thus, especially in our context based on our terrain and other operational peculiarities designing kill webs for required tasks would be a force multiplier and game changer. Following systems inducted/planned to be inducted ideally describe the decentralised functioning of Mosaic Warfare C2:

  o **Swarm Drones**. A distributed area is surveyed by multiple unmanned aerial vehicles that should randomly search the space, collect information on unwanted objects classifying them as targets, and organise collective reaction on the emerging threats. They invigorate the local OODA loop without reference to the long hierarchical chain, as they have the ISR payloads, decision making and even means to destroy (no requirement of attack helicopter or air support). The Space can provide redundancy by providing it guidance link and communication and transmitting the operational action for info direct to the decision-making authority.

o **High-Altitude Platform Station** (**HAPS**). HAPS, a high-altitude platform station (HAPS,[8] which can also mean high-altitude pseudo-satellite or high-altitude platform systems) also known as atmospheric satellite is a long endurance, high altitude aircraft able to offer observation or communication services similarly to satellites. Mostly, unmanned aerial vehicles (UAVs), they remain aloft through atmospheric lift, either aerodynamic like airplanes or aerostatic like airships or balloons. Such systems will be re-usable, cheaper and difficult to locate and hence would greatly assist in the Mosaic concept for disaggregation.

- **OODA Loop**. The fastest means for information relay is turning out to be space. We live in a digital age in which commercial capabilities promise to dramatically shorten the OODA loop by collecting, processing, storing, and mining data and rapidly recommending actions based on those data. Given the increased complexity of MDO planning and the greater data requirements, space is an asset for this exploitation.

CONCLUSION

In the Indian Armed Forces, *the units (which are the cutting edge) largely ensured victory* in all our wars (1947-48, 1965, 1971 and even Kargil). Our lack of technology i.e., AI & ML, ISR collation, decision support systems, etc did not impact the results; *as our adversaries were in similar state* and *battles fought at tactical level sufficed*. However, now with our adversaries in collusion incorporating these technological advancements and networking them, conflicts will be more in the non-contact domain and will make tactical level operations less important. Hence, to ensure that our armed forces transform and adopt these technological advances (AI & ML, autonomous systems, precision systems, etc) networking them in a Mosaic Concept is imperative. Space will be an enabler in ensuring this.

Fruition of making a technologically enabled armed forces can take place only with the right eco system, where in there is a central decision-making

body, with authority and resources which can synergise various agencies/ stakeholders involved in space, both governmental and private.

Efforts like Indian Space Congress-2023 & DEFSAT-2024 organised by SIA-India and other stakeholders will go a long way is assisting formulation of the right ecosystem by providing platform for discussion, raising awareness and collaborating efforts of all stakeholders including policy and decision-making authorities.

However, the greatest effort would be required in orientation, attitudinal change and training of the combat forces and the military leadership in such strategic & tectonic shift(s) in war fighting strategy. The task will become simpler if the higher echelons drive the change. It goes without saying that a current & future war requires the military leadership to be highly proficient in tech skills. The various training institutes need to orient their curriculum to address these challenges. The Russia-Ukraine and Israel-HAMAS conflicts and also recent challenges faced by us are a stark reminder for the urgency of the situation for need to adapt and transform.

Lt Gen Karanbir Brar, AVSM is currently GOC DBA. Technically and IT qualified, he has executed Light Tank,Swarm Drones and many niche technology projects. He is mentoring startups, other tech projects with regards to defence capability building in association with Academia, IITs, ISRO, DRDO, DPSUs and private industry.

NOTES
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