NETWORK-CENTRIC WARFARE AND ITS STRATEGIC IMPLICATIONS

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The world is entering a new period. The economy of nations, which depended upon natural resource, labour, accumulation of capital and even upon weaponry during its agricultural and industrial phases, will, in the future, depend upon information, knowledge, and intelligence.

INTRODUCTION

Throughout history, the central factor deciding the outcome of war has been how effectively information has been used. Effective use of information is a time sensitive issue. Information, when not acquired, processed and used in the right time, at the right place, by the right individual or leadership, and used in the right environment , does not have any value and ceases to become knowledge and wisdom. Information dominance has always been the crux of winning wars. The Mongols, Chengiz Khan in particular, were the pioneers who demonstrated the art of information dominance and conquered most of the then known world. The 21st century is the century of aerospace power. It is becoming evident that information technology is a critical element of aerospace power. Networking to make efficient and rapid use of information is a natural development consequent to exponential growth in computing and communication capabilities. During the last decade, major air forces of the world have moved with extreme rapidity towards net-related, net-enabled and net-centric operations.

The future battlespace will be, or is becoming, different in one significant

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way–it is becoming information rich. The level of information available and the ability of commanders to resolve the totality of what has been presented will depend upon the level of illumination reflecting the amount of information and the understanding achieved. These illumination levels would be in a state of constant flux. Increasing the information available in only one dimension might not lead to sufficient overall resolution. Information collected from surveillance, intelligence and identification systems combined with that received from other sources, if supported with an effective communication backbone and real-time processing power, would increase the level of resolution, allowing commanders and staff elements to observe the battlefield more clearly, share the information, decide and take action in the most efficient way.

BACKGROUND

Since military power is the foundation upon which the structure of national security is raised, it becomes obvious that this military power is reflected in terms of time relevant force structure, and hardware, including weapons, and technology. The composition of military power, in terms of manpower, equipment and weapons, and technology is governed by the nature of warfare, current as well as that evolving in the future. The nature of warfare, therefore, is a critical determinant of the structure of the national security mechanism. This nature of warfare can be seen from two basic dimensions: the first is the essential nature of warfare which remains unchanged; the second is the dynamic nature in terms of how the war is fought or the technique of warfare, which is fundamentally driven by new technologies and related concepts and doctrines. This dynamic nature affecting the transformations in the technique of war was conditioned, fundamentally, by technology but also by three other related drivers which are strategy, organisational change necessary to exploit technology, and time. Effective war-fighting capability can be achieved only when these four dimensions of the 'dynamic nature of warfare' are recognised and appreciated. The military dimension of aerospace power in the

The nature of warfare, therefore, is a critical determinant of the structure of the national security mechanism.

21st century rests on the critical strategies of ensuring information dominance and effective use of resources. Network-centric warfare (NCW) is a natural development under the aerospace paradigm.

The origins of aerospace warfare can be truly traced to the 1982 Bekaa Valley campaign by Israel but the first large scale integration of space capabilities in war was made in the 1991 Gulf War. The NCW as a concept evolved in the mid-Nineties. During Operation Enduring Freedom, Afghanistan proved to be a laboratory for military transformations. Units from different branches of the US military worked in unprecedented unison and were able to flatten the Taliban with minimum casualties and less damage to civilians than occurred during the Vietnam War.

Lessons from Afghanistan were later applied on a broader scale in Operation Iraqi Freedom (OIF). As news rolled out of Iraq, more and more stories spoke of "network-centric warfare." There were reports of troops using the global positioning systems (GPS), tactical data links (TDL), and high-powered computers to relay information between command centres and troops, speeding the pace of combat. The media repeatedly showed the animations of troopers calling in air strikes with laser pointers. There were TV talk-shows on cutting-edge technology such as smart bombs, collaboration tools, and satellite-based tracking, which provided unprecedented levels of situational awareness (SA) and precision engagement, even under adverse conditions.

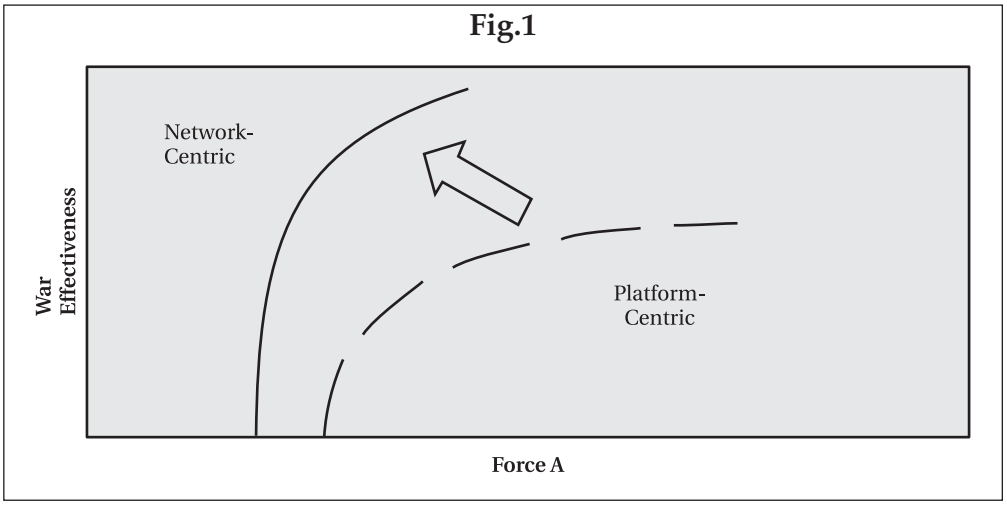
Networked information technologies, some used for the first time, allowed military commanders in the war theatre and in the US to watch the battle of Iraq unfold in near real-time. The operation was a practical demonstration of how network-centric capabilities can improve the military's ability to fight by sharing information and situational awareness.

THE CONCEPT OF NETWORK-CENTRIC WARFARE (NCW)

Information technology (IT) in the modern era has been undergoing a fundamental transformation from platform-centric computing (PCC) to network-centric computing (NCC). The concept of NCW is a derivative of NCC, where the 'computer' is replaced with 'computing', i.e. every element of war

(aircraft, soldiers, ships, etc) becomes a computing node on the network to collectively operate in a synchronised manner so that the sum of the whole is greater than the sum of the parts. The platform-centric operations enable each pilot to develop his situational awareness based on three types of inputs: (a) direct observation of the physical domain; (b) indirect observation of the physical domain through onboard sensor; (c) voice communications with other war-fighters. With network-centric operations, a fourth input is added – 'digital information' that is exchanged from external sources, such as other fighter aircraft, or airborne/ground surveillance and command and control (C2) centres, over a network.

Fig.1



Network-centric warfare is an emerging theory of war in the modern era. The network-centric approach to warfare is the military embodiment of information age concepts. NCW relies on computer processing power and networked communications technology to provide a shared awareness of the battlespace. This 'networking' is not merely a communications network implemented over physical cables, radio links, TCP/IP, etc. Instead, the 'network' in NCW emphasises a network of connections between people in the information and cognitive domains. The term 'network-centric warfare' broadly describes the combination of strategies, emerging tactics, techniques and procedures, and organisations that a fully or even a partially networked force can employ to

create a decisive war-fighting advantage. The working hypothesis of network-centric warfare is that forces, when in the networked condition, will outperform forces that are not so networked.

Network-centric warfare generates increased combat power by networking geographically dispersed sensors, decision-makers, and shooters to achieve shared awareness, increased speed of command, high tempo of operations, greater lethality, increased survivability, and a degree of self-synchronisation. In essence, it translates an, 'information advantage' into 'combat power' and a decisive 'war-fighting advantage' by:

- Effectively linking friendly forces within the battlespace.
- Providing much improved shared situational awareness.
- Enabling more rapid and effective decision-making at all levels of military operations.
- Thereby permitting increased speed of command and dissemination of the 'commander's intent.'
- Facilitating a higher tempo of military operations than would otherwise be possible
- Achieving greater lethality with the same military forces through synergy of efforts and sharing of target data with all possible shooters
- Providing increased survivability by networking sensors.
- Permitting a degree of self-synchronisation, as non-contiguous forces can instantaneously see all known movements on the battlefield of friendly, neutral and hostile forces.

To get a clear grasp of the concept of NCW, one needs to understand the basic tenets and governing principles of NCW.

Basic Tenets of NCW

The net-centric approach to warfare is governed by four basic tenets as identified the world over. These tenets comprise the core of NCW that help enhance the power of networked forces and also constitute a working hypothesis as a source of war-fighting advantage as follows:

(a) Information sharing is improved in a robustly networked force.
(b) Improved information sharing permits enhanced situational awareness
(c) Enhanced situational awareness permits coordination of military action between units and enables self-synchronisation of all networked units
(d) These factors, taken together, dramatically increase mission effectiveness in terms of lethality, survivability, and speed of execution

Governing Principles of NCW.

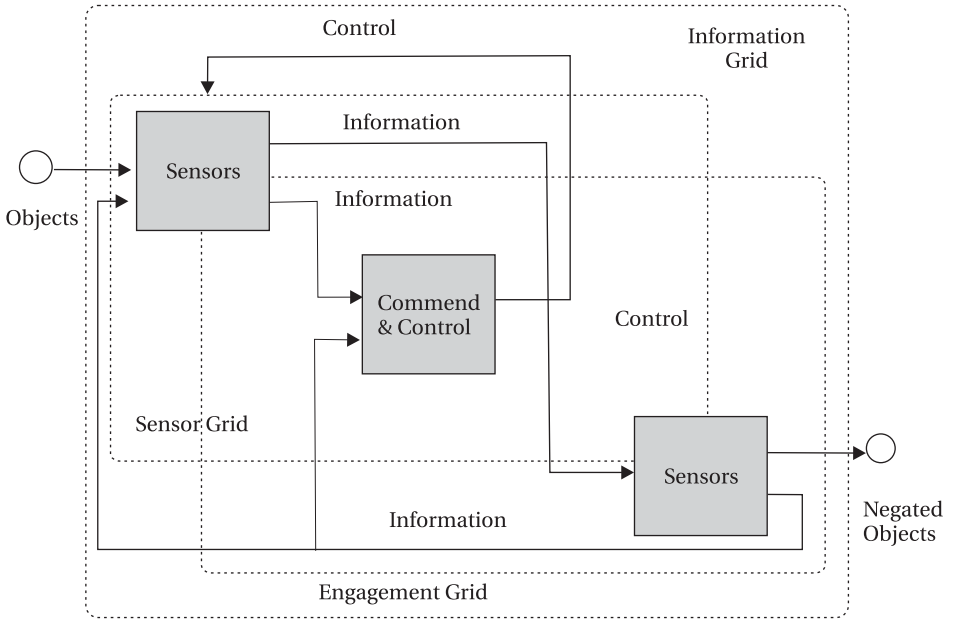
Although the principles of NCW may not replace the time-tested principles of war – mass, objective, offensive, security, economy of force, manoeuvre, unity of command, surprise and simplicity – nevertheless, they provide added direction for executing military operations in the information age. Principles that govern a network-centric force constitute the rules by which it organises, trains and operates. These are:

(a) Fight first for information superiority.
(b) Access to information leads to shared awareness.
(c) Speed of command and decision-making is vital.
(d) Self-synchronisation is a key goal.
(e) Dispersed forces and non-contiguous operations are possible.
(f) Demassification reduces target signature.
(g) Deep sensor reach is a vital component.
(h) Alter initial conditions at higher rates of exchange.
(i) Compressed operations and levels of war

ARCHITECTURE OF NCW

NCW focusses on greater synergy by networking and electronically linking all components of the war machinery into one "sensor-to-shooter" engagement grid. The operational concepts of NCW are enabled by an architecture that closely couples the capabilities of sensors, command and control, and shooters. The underlying architecture that creates a network of these basic components, consists of potential sub- architectures: sensor grids and engagement grids hosted by a high performance information grid that provides a backplane for computing and

Fig 2: Architecture of The Network-Centric Warfare



communications that, in turn, is empowered by a common message standard wherein everybody 'speaks the same language,' access to appropriate information sources, information on weapons, value-added C2 processes, and integrated sensor grids closely coupled to shooters.. Sensor grids rapidly generate high levels of SA and synchronise military operations. The engagement grid exploits this awareness and translates it into increased combat power. These elements will provide a shared awareness of the battlespace for fighting forces. This sharing of information and decision-making throughout the range of command and control is referred to as giving "power to the edges." NCW is a prime example of promoting power to the edges. A logical model of the NCW architecture is shown in Fig 2.

Fundamentally, the concept of **NCW is about maintaining information superiority i.e. defeating or deterring the enemy by getting the right information, at the right place, in the right format, with the right level of accuracy, at the right time.** In this context, the paradigm has now shifted from

"pushing the information to the user on time" to the "user pulling the information as required and when required." If the new paradigm is properly established, the right amount of combat potential can be placed at the right location in the right time. This effectively puts 'more mass' in 'less amount' of armed forces.

Domains of Warfare

The jigsaw puzzle of warfare comprise four intersecting domains:

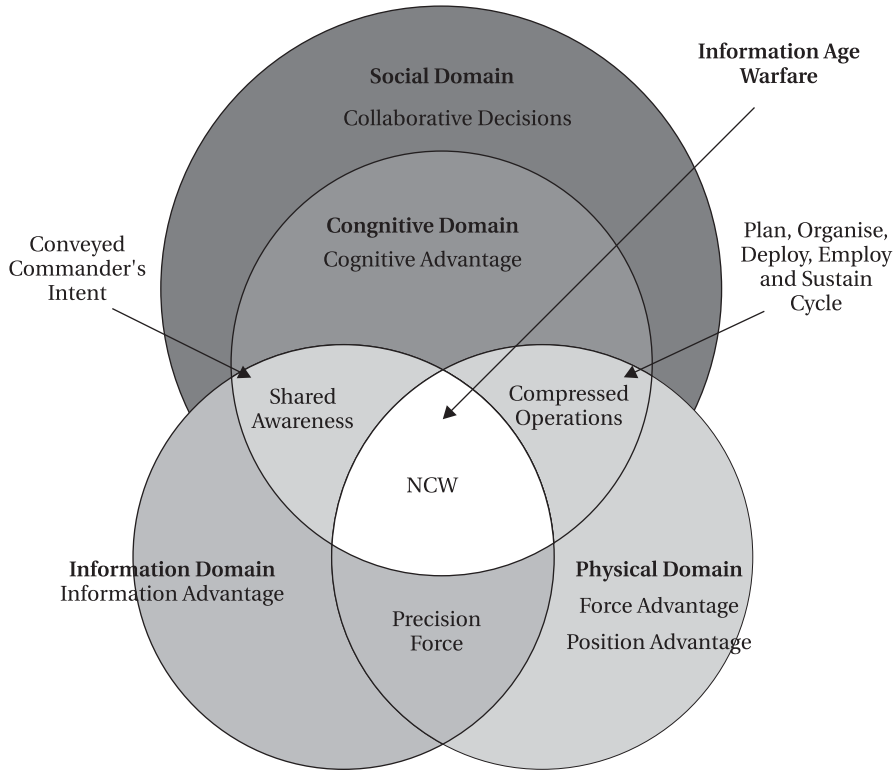
(a) **Physical Domain**. This is the traditional domain of warfare where a force is moved through time and space, spanning the land, sea, air and space environments where military forces execute the range of military operations and where the physical platforms and the communications networks that connect them reside.

(b) **The Information Domain**. The information domain is the domain where information is created, manipulated and shared. It is the domain that facilitates the communication of information among war-fighters. This is where command and control of military forces is communicated and the commander's intent is conveyed, and, therefore, is a crucial domain, to be protected and defended.

(c) **The Cognitive Domain**. The cognitive domain is in the mind of the war-fighter. Many, though not all, battles, campaigns, and wars are won in this domain. The intangibles of leadership, morale, unit cohesion, level of training and experience and situational awareness are elements of this domain. This is the domain where the commander's intent, doctrine, tactics, techniques and procedures reside. And lastly, this is where decisive battlespace concepts and tactics emerge.

(d) **The Social Domain**. The social domain describes the necessary elements of any human enterprise. It is where humans interact, exchange information, form shared awareness and understandings and make collaborative decisions. This is also the domain of culture, the set of values, attitudes, and beliefs held and conveyed by leaders to the society, whether military or civil. It overlaps with the information and cognitive domains, but is distinct from

Fig. 3: Venn Diagram Representation of Warfare Domains



both. Cognitive activities by their nature are individualistic; they occur in the minds of individuals.

Network-centric warfare is concerned with the nexus or intersection of all four of these domains of warfare and, hence, it is located at the intersection of all four domains. An intersecting Venn diagram representation of these four domains is shown in Fig. 3.

The precision force, so vital to the conduct of successful joint operations, is created at the intersection of the information and physical domains. Shared awareness and tactical innovation occur at the intersection between the information and cognitive domains. The intersection between the physical and

cognitive domains is where the time compression and 'lock-out' phenomenon occurs, where tactics achieve operational and even strategic effects, and where high rates of change are developed. NCW exists at the very centre, where all four domains intersect and, thus, where information age warfare is conducted.

BUILDING BLOCKS OF NCW

NCW, being a system of systems, consists of a group of interconnected systems. Its building blocks are as discussed in the subsequent paragraphs.

Intelligence, Surveillance, and Reconnaissance (ISR)

ISR functions are principal elements of defence capabilities. ISR covers a multitude of programmes ranging from billion dollar satellites to hand-held cameras. They include a wide variety of systems for acquiring and processing information needed by decision-makers and military commanders. ISR has been one of the critical mission areas of aerospace power. It enriches decision-makers at all levels of command with knowledge – not merely data – about the adversary's capabilities and intentions. Advanced integrated ISR combined with effective C2 capabilities, can improve the capabilities to find, fix, assess, track, target, and engage anything of military significance, anywhere. NCW emphasises using networked intelligence, surveillance, and reconnaissance capabilities, and pre-determined decision criteria, to support automated responses from the 'network' to threats against individual platforms. NCW is aimed at the opponent's command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) to make its forces blind, deaf, and unable to control themselves, thus, rendering them easy targets should they not surrender. To realise the potential of NCW, we must turn ISR data into actionable combat information, knowledge and intelligence; disseminate knowledge over robust communications networks to decision-makers and leverage;

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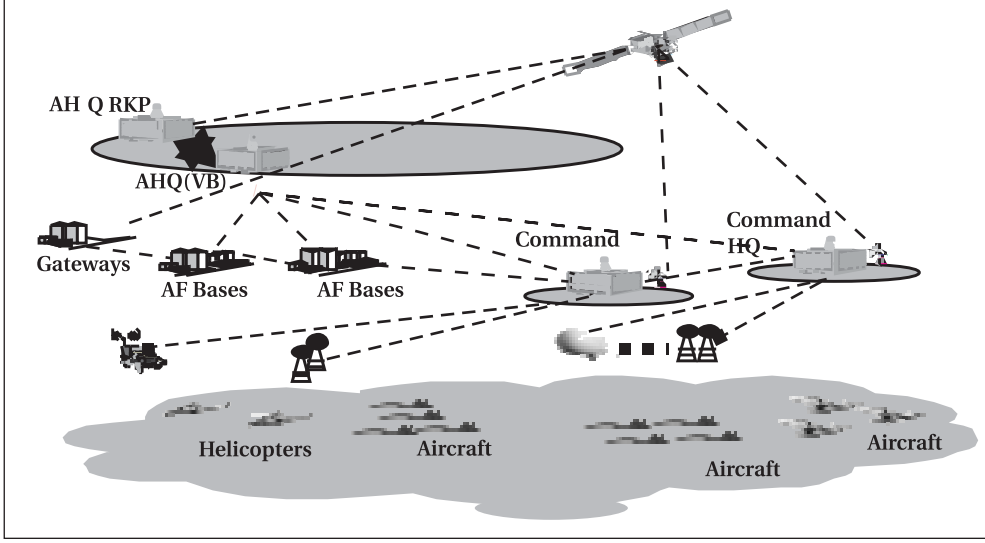
technologies that allow for greater access to databases and analytical efforts located outside the theatre of operations, thus, enabling split-based operations.

(a) **Unmanned Vehicles (UVs).** Unmanned vehicles represent technologies that bring new capabilities such as persistence and battlespace awareness in air, ground and sea domains. They include unmanned aerial vehicles (UAVs), unmanned aerial combat vehicles (UCAVs, which are UAVs armed with weapons), unmanned surface vehicles (USVs), unmanned underwater vehicles (UUVs), and unmanned ground vehicles (UGVs). They can serve as 'eyes and ears' for manoeuvring ground forces. Long-range responsive UAVs, flying at altitudes of up to 60,000 ft, at high speed, controlled through a communications network from ground stations thousands of miles away, with their synthetic aperture radar, electro-optical camera, and infrared (IR) and other sensors, can see through bad weather and at night. They can be launched when needed to enhance the battlefield picture for commanders. UAVs are valued as force multipliers, as augmenters of the force, and as adding a new component to the military force mix. They do not, however, have the capability to remain overhead for long periods (long-dwell capability), and they may be vulnerable to attack.

Fig 4: Communication Infrastructure Backbone



(b) **Reconnaissance Satellites.** The new generation of reconnaissance satellites form another expensive and technologically sophisticated platform for intelligence and reconnaissance that can identify small objects from space. Satellite imagery has long been one of the most valuable tools of the intelligence profession. They can stay in orbit for years and can be shifted from target to target as needs change.

Communication Infrastructure Backbone

This comprises the physical communication infrastructure on the ground with the requisite/perceived band width (BW). The resources include OFC, land lines, routers, switches, mobile radio relays, LOS microwave links and satellite links. This forms the physical, media access, data link, transportation and protocol layers in the network. The network protocol selections such as IP are a part of this block. A schematic diagram of the communication connectivity is shown in Fig. 4.

Computers and IT Infrastructure Backbone

This consists of computers/servers located at each node and gateway containing databases and software that decide what is to be sent where and at what priority/speed. These components, both software and hardware, provide interoperability among various systems. The information content is segregated and stored based on its importance and time criticality. Some of the broad classifications are as follows:

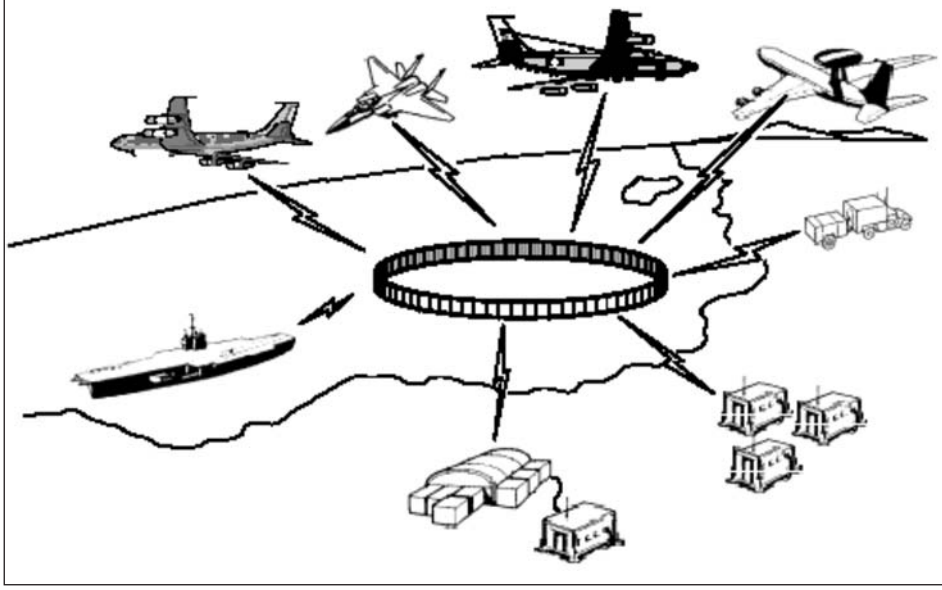
(i) **Real-Time Information.** It comprises information with latency times less than a second such as RT, voice, live video, and tactical data such as radar pickups, weapon launch data, aircraft emergencies and video conferencing.

(ii) **Near Real-Time.** It would comprise information with latency times of a few seconds/minutes such as aircraft serviceability, aircrew and nav-aids availability states, BDA, tactical intelligence data, target pictures, etc.

(iii) **Non-Real-Time but Time-Critical and Important.** This could comprise information with latency times of minutes/few hours such as met, mission plans like CATOs, target folders, operations orders, priority mail, etc.

(iv) **Non-Time-Critical and Routine.** Information, where latency could be up to

Fig. 5 : ODL Connectivity Between all Elements of NCW



a maximum of a day, will comprise manpower state, mail, routine orders, equipment holding state and other MIS data.

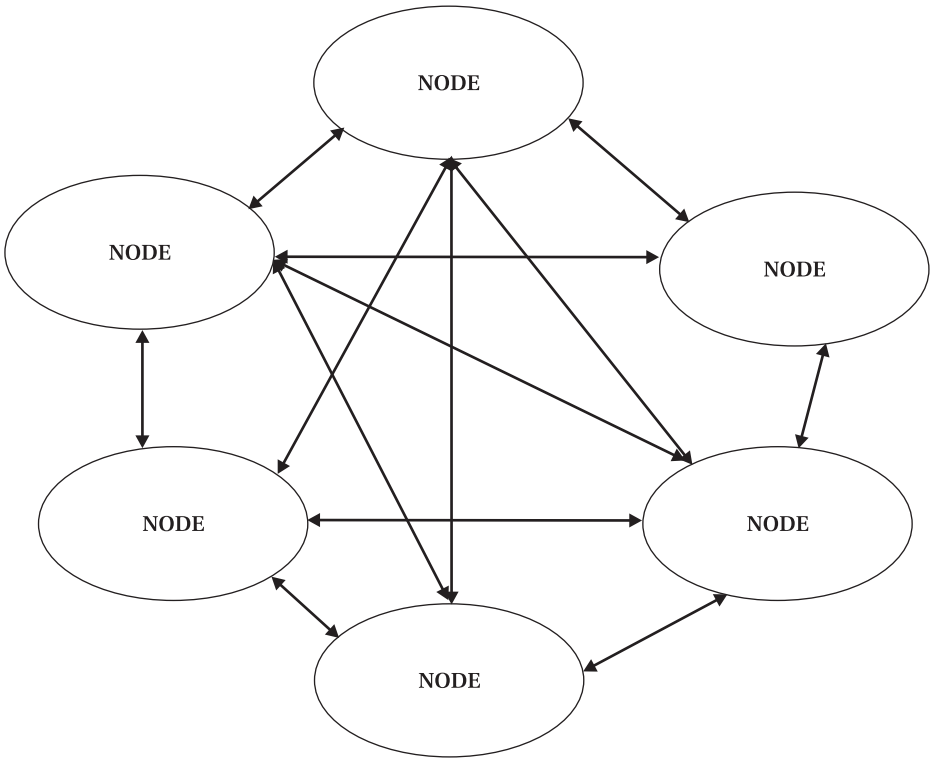
Tactical or Operational Data Link

Tactical or operational data links (ODLs) are used in combat for machine-to-machine exchange of real-time information such as radar tracks, target information, platform status, imagery, and command assignments. It is a communication, navigation, and identification system that supports information exchange between tactical command and control, communications, computers, and intelligence (C4I) systems. A schematic diagram of ODL connectivity between all elements of NCW is shown in Fig. 5.

Essential features of the ODL include the following:

(a) **Nodeless Architecture.** It should possess a nodeless architecture. As against the star connected based master-slave topology, where each slave node depends on the master for communicating to any other node, the node-less

Fig. 6: Node-less Topological Architecture



topology allows a mesh connectivity among all nodes, and, hence, there is no central point of failure. The responsibility of managing the network in node-less topology is distributed among all participating nodes i.e each node shares its own network management information with all other nodes.

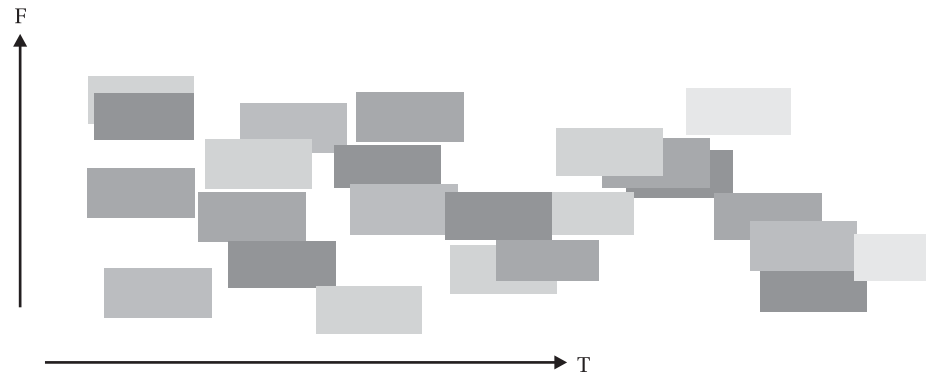
(b) **Multiple-Access Modes.** It should operate in multiple-access modes so as to support a large number of participants. The popular technique used for the purpose is TDMA, wherein each participant accesses the transmission medium only in the allocated time slot. The TDMA could be either static or dynamic. In dynamic TDMA , the time slots are dynamically allotted without any pre-planning on the ground; this allows an unlimited number of participants, each with a net-ID to transparently join and leave the network without any

constraints. On the other hand, in static TDMA, participants are allotted pre-planned fixed time slots based on a plan worked out on the ground. Because of the dynamically expanding and contracting nature of dynamic TDMA-based architecture, the TDL system is flexible and desired in scenarios wherein a large number of participants are expected to participate without previous planning.

(c) **Time Synchronisation.** It should have a net time reference (NTR) unit for time synchronisation of all units entering the TDL network. This is generally achieved using the GPS receivers onboard, alternatively by clock inputs supplied from external sources. In general, GPS-based systems have highly stable internal clocks to cater for synchronisation requirements during periods of GPS jamming/blockings.

(d) **Security**. Encryption for both the incoming and transmitted messages is

Fig. 7



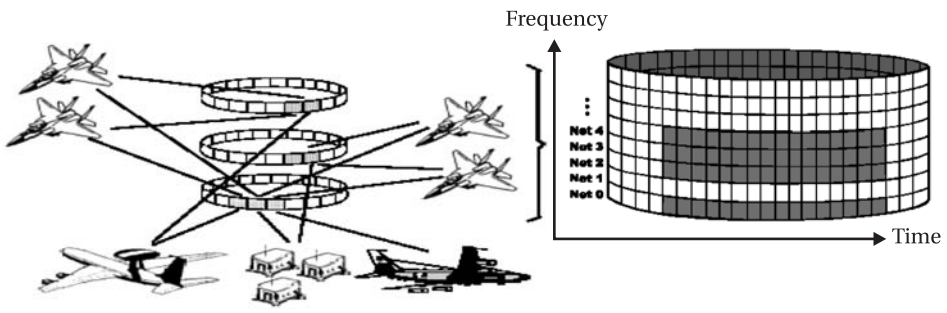
carried out at both message and carrier levels. It should provide cryptographic isolation between two different groups of participants.

(e) **Jam Resistant**. As the TDL is required to operate in a hostile electromagnetic environment, it should employ frequency hopping in a pseudorandom pattern to be jam resistant.

(f) **Compatibility with Legacy Radio.** It should be backward compatible and, hence, must support operations in UHF LOS bands for interoperability with legacy radio.

(g) **Stacked Net Capability**. It should support multi-net operations based on the

Fig. 8: Stacked Net Architecture



stacked net concept i.e. the system should support different groups of participants, each in their respective network. The operation of these so-called orthogonal networks is based on the software controlled time slot allocations. In a particular time slot, each network operates on a distinct frequency hop pattern, thus, enabling the information exchange among all its participants. The exchange of information across the nets takes place by matching their hop patterns at pre-determined time slots within a specified time cycle.

IMPLEMENTATION OF NETWORK-CENTRIC WARFARE

As a new source of power, NCW has a profound impact on the planning and conduct of war by allowing forces to increase the pace and quality of decision-making, in effect changing the rules and pace of military operations. A war-fighting force with networked capabilities allows a commander to more quickly develop situational awareness and understanding, rapidly communicate critical information to friendly combat forces, and marshal the appropriate capabilities to exert massed effects against an adversary.

While NCW is the theory, network-centric operations (NCO) comprise the theory put into action. In other words, the conduct of NCO represents the implementation of NCW. NCO involves the application of the tenets and principles of NCW to military operations across the spectrum of conflict from peace, to crisis, to war. The objective of decision superiority is to turn an information advantage into a competitive advantage. The principles of NCW

provide a new foundation with which to examine and consider changes in military missions, operations, and organisations in the information age. The full application of these principles will accelerate the decision cycle by linking sensors, communications networks, and weapons systems via an interconnected grid, thereby enhancing our ability to achieve information and decision superiority over an adversary during the conduct of military operations.

Transformation and NCW implementation deal with the co-evolution of the key functional areas of technology, doctrine, personnel, leadership, organisation, education and training. A change in any one of these areas necessitates changes in all. Therefore, the progress must be assessed in terms of the maturity of mission capabilities that integrate these key elements. Ultimately, military transformation and NCW implementation are about changing the values, attitudes, and beliefs of the armed forces. The strategy for implementing NCW in today's information age is governed by the following key elements:

(a) **Put the NCW Rules and Metrics in Right Perspective**. Understand the theory of NCW through simulation, testing, and actual experimentation. The rules of information age warfare and the theory of NCW must be continually refined through the process of experimentation and testing and from the real world experience of forces engaged in combat and other military operations worldwide.

(b) **Put the Concept in Practice**. Network the elements of the war-making machinery at the tactical, strategic and operational levels. As new network-centric systems, concepts, and capabilities are developed, they should be deployed to the units and combat squadrons where they can be refined and employed when needed.

(c) **Refine and Fine-Tune the Concept**. Continuously develop and deploy new and better ways to conduct network-centric operations. Rigorous programmes of joint and stand-alone experimentation must be worked out and deployed so as to nurture new and better ways to conduct NCO.

(d) Develop NCW Doctrine, Tactics, Techniques, and Standard Operating Procedures (SOP) for NCO. In order to maximise the potential for increased combat power from NCW, doctrines must evolve as network-centric

capabilities are implemented. Simultaneously, mature SOPs will be needed to facilitate the effective conduct of NCO during military operations.

IMPACT OF NCW ON VARIOUS LEVELS OF WAR

The levels of war are doctrinal perspectives that clarify the links between strategic objectives and tactical actions. There are no distinct boundaries among the strategic, operational, and tactical levels of war. Also, they are not necessarily associated with specific levels of command, size of units, types of equipment, or types of forces or components. However, certain commands tend to operate at particular levels of war, e.g. an operational command typically operates at the strategic and operational levels of war while a fighter squadron will typically operate at the tactical and operational levels of war. Actions are strategic, operational, or tactical based on their effect or contribution to achieving strategic, operational, or tactical objectives. These levels of war help commanders visualise a logical flow of operations, allocate resources, and assign tasks. The rise of information age media reporting has compressed the time-space relationships of event occurrence and awareness; events occurring in one place can be reported with almost instantaneous visibility and implications globally.

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TACTICAL IMPACTS OF NCW

NCW provides the ability to enlarge the engagement envelope, reduce risk profiles, increase responsiveness, improve manoeuvrability, and achieve higher kill probabilities. Some major tactical advantages of NCW operations include the following:

(a) **Reduced Sensor to Shooter Time.** The enhanced SA shrinks the observe-orient-decide-act (OODA) loop because, as the number of questions decrease,

ambiguity decreases, collegiality increases, and timelines shorten. The shortened timelines in integration with, and interaction of, the three major entities of a conflict – sensors, decision-makers and actors – enable the processing of the OODA cycle at a faster pace. These could involve reducing the following:

(i) Time between target detection and delivery of munitions on target.

(ii) Time to plan.

(iii) Time to react i.e. to form and equip forces to conduct operations.

(b) **Cooperative Engagement Capability (CEC).** This provides the ability to conduct effective air defence against threats capable of defeating a platform-centric defence. All elements of air defence in this mission area are stressed to their limits, especially against high speed or low-observable intruders where the time to detect, track, classify, and engage the targets is extremely small. The CEC is enabled by the close coupling of an integrated communications capability with a computational capability. This info-structure, combined with automated decision support capabilities, forms a high performance backplane which is the key to increasing the velocity of information among sensors, C2 and fire control nodes. The final outcomes are extended engagement envelope, enabling incoming targets to be engaged in depth, with multiple shooters with increased probability of kill.

(c) **Self-Synchronisation.** Self-synchronisation is the ability of doing what needs to be done without traditional orders. It enables a well-informed force to organise and synchronise complex warfare activities from the bottom up. This is achieved by the availability of integrated SA, which contains a high level of knowledge of one's own forces, enemy forces, and all appropriate elements of the operating environment. SA, thus, brings out the visualisation of the war scenario from the commander's mind onto the HMI displays for all to see and march in synchronism towards the common goal. Introduction of this concept brings about a shift in the conventional linear logic of effort concentration during war to the non-linear, i.e. the field commander need not wait for the result of a mission before launching another; rather, he may direct his resources into several parallel missions which are self-regulated, based on the minute-to-minute changes in the war scenario. Such 'parallel war' can

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produce the systematic disruption of the enemy's operational functions, create despair, and even lead the enemy to give up.

(d) **Increased Combat Power (Economy of Effort).** The combat power significantly increases through the ability of tactical units to self-synchronise operations based on a shared combat operational picture and shared knowledge of the commander's intent. By reducing duplication of effort, the network allows members to achieve greater results. The engagement grid consisting of shooters, though spread over a large area, would be able to concentrate precision weapons rapidly upon targets hundreds of miles away. Greater destructive power can be delivered more accurately and in a timelier manner than before. With enhanced battlefield transparency and less time taken in decision-making towards force allocation, deployment and redeployment, greater effectiveness can be achieved with fewer quanta of military resources. NCW, thus, facilitates optimum use of weapons through cooperative targeting and optimises employment of the combat assets of all the Services through integration.

(c) **Increased Survivability.** A realistic knowledge of the location of all the friendly/enemy elements during war reduces the chances of fratricide, thus, increasing the survivability in the war scenario.

(d) **Swarm Capability.** Networked forces can fight using 'swarm tactics,' by which unit movements are conducted rapidly. All know each other's location. If one unit gets into trouble, other independent units nearby can quickly come to its their aid, 'swarming' to attack the enemy from all directions at once. The benefits of swarming may include the following:

(i) Networked forces can consist of smaller-size formations that can travel lighter, move rapidly and can perform a mission effectively at a lower cost.

(ii) It is harder for an enemy to effectively tackle a widely dispersed formation.

(iii) Combat formations can cover much more ground, because they do not have

to maintain an unwieldy formation size for reasons of mass as known until now for self-protection.

(iv)Knowledge of the location of all friendly units reduces fratricide during combat operations.

STRATEGIC IMPLICATIONS OF NCW

Impact on Leadership

The success of net-centric operations will depend on leadership, which is defined as "influencing people by providing purpose, direction, and motivation – while operating to accomplish the mission and improving the organisation." The NCW environment will require leaders at all levels, who are comfortable in the information environment, are adaptive and innovative, and who foster these same traits in subordinate leaders. These leaders must also be comfortable in the knowledge that their unit's situation and intra-unit communications may be monitored by the higher levels of commands as part of the increased level of shared situational awareness. This requires a high level of trust between leaders at all levels, who must clearly communicate their intent and provide mission-type orders, allowing subordinates the freedom to execute the missions and providing them with the necessary resources for execution.

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Impact of Networking in the Deployment Process

The deployment process is a direct function of the common visibility of strategic forces. Availability of a common operational picture (COP) in an NCW enabled environment provides sufficiently flexible, transparent, user-friendly and disciplined conditions. The increased level of shared situational

awareness due to the access to the near-real-time COP would allow the supporting command to anticipate, plan and change missions. This process would enable increased collaboration and synchronisation and would increase the effects of strategic firepower. This level of networking exploits friendly capabilities and has the potential for generating increased reach and synergy to the battlespace.

Impact of Information Sharing on Standardisation Across the Force

Sharing information across the forces will require strict adherence to standards. The force cannot afford non-compatible communications and information systems. The rapid acquisition of new information systems and the fielding of these systems to the forces in the theatre would be mandatory for populating the COPs. This would enable the units to benefit from the greater situational awareness afforded by these systems. There is a constant challenge of developing systems that are truly interoperable among the Services, as different commercial vendors providing the systems use different proprietary technologies. This would require development of an architectural standard which all systems must adhere to in order to plug-in and play in the network.

Impact of Increased Situational Awareness on the Decision-Making Process

At the tactical level, the increased situational awareness and the capability to talk with other commanders would change the decision-making process from a staff-centric course of action development process to a commander-centric, directed course of action process. This is a shift to greater collaboration and information sharing between commanders, resulting in rapid situational understanding and knowledge of what would be needed next. Enabled by the information environment, commanders would be able to communicate their intent and rapidly issue mission-type orders that would allow maximum flexibility to their subordinate commanders. Commanders at the tactical through strategic levels would now be able to observe and listen in on the development and the execution of the orders as the campaign is executed.

Impact of NCW on Force Design

NCW plays a central role in the transformation of the military. At the tactical, operational, and even theatre strategic levels of war, the evolving tactics, techniques, and procedures need to rapidly adapt to the new capabilities provided by the networking of sensors, decision-makers, and shooters. At the strategic level, these developments would necessitate evolving new concepts and paradigms so as to move towards achieving forces that are more interconnected and jointly interdependent, with ground forces that are smaller, faster, and lighter. This would provide a strategically agile force and one that should provide a considerable capability for the rapid achievement of national military objectives.

Moore's Law, a Challenge in Maintaining a NCW Concept-Based Force

Moore's Law and its impact on the capacity of computer chips and, therefore, systems are well known. Considering the rapid and continuous advances in information and communications technologies in today's world, we cannot afford a long drawn development, testing, procurement, and implementation process. Military systems today rely on commercial computer technologies with a half-life of eighteen months to two years. On the other hand, our design-develop-acquire-deploy programmes run into decades, ensuring technology obsolescence by the time the systems are fielded. These time schedules would enable our potential adversaries to leapfrog to new generations of commercial technologies, which could be equal to, or more capable than, our own. Only a dramatic reform in the acquisition process can ensure the timely arrival of NCW enabling systems in our country.

Impact on Joint and Coalition Operations

The basic requirement for conducting operations across the spectrum of war necessitates and pre-supposes an ability to communicate, share information, and coordinate actions in allied and coalition environments. It should not only be backward compatible without limiting our own network-enabled capabilities but also seamlessly interoperate with more "high-tech" forces.

CHALLENGES OF NCW

The NCW concept does have some disadvantages which need to be addressed carefully while acquiring the capability. These disadvantages are given below:

(a) **Information Flooding.** Due to the networking, there would be too much of information at each level which may render the same ineffective despite availability. Therefore, it is important to apply the 'need-to-know' paradigm.

(b) **Dependency on NCW Capabilities Leading to Ineffective Performance in a Degraded Environment**. The degradation in the NCW environment and its assured availability may come from technology failures, enemy actions or an enemy adapting asymmetrically to the environment. A level of non-net-centric redundancy needs to be maintained and trained for. We need to determine when, where, and to what degree soldier and leader development is necessary for training both new net-centric skills and maintaining non-net-centric skills.

(c) **Vulnerability.** The network is vulnerable in terms of machine failure during most critical junctures, human errors, virus attacks, electromagnetic fallouts (directed energy devices could theoretically burn out computer circuits at a distance), software dependability for command and control operations, sabotage, bugging, jamming, signals intercepts etc.

CONCLUSION

NCW, together with, ISR promotes the value of information sharing, collaboration, synchronisation, and improved interoperability within the information domain. It suggests that information superiority and victory on the battlefield will be dependent on technological solutions that will help us acquire process, exploit, disseminate, and protect information. It is aimed at paralysing the nerve centres in a battle that is no longer three-dimensional but includes cyberspace as its fourth dimension. By 2020, it will be possible to localise with 90 per cent probability and 10 cm accuracy any event within a 360 x 360 km battlespace within 30 seconds of its occurrence. That means that tomorrow's operational decision-maker will have very accurate knowledge, very rapidly and over a very broad area.

NCW requires changes in behaviour, process and organisation to convert the advances of information age capabilities into combat power. With technology advancing at an incredible speed, we cannot afford to wait any longer. If we decide to fight on a network-centric rather than platform-centric basis, we must change how we train, how we organise, and how we allocate our resources. Delays will mean higher costs and reduced combat power. If adversary targets are neutralised by NCW systems before they can engage in fighting with our forces, then the battle can be finished before it has really begun.

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