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CIVIL MILITARY FUSION IN COMMUNICATIONS AND SPECTRUM MANAGEMENT

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Introduction

Spectrum management and communication are closely intertwined subjects; efficient management and exploitation of spectrum by a nation leads to robust capabilities in the many manifestations in the communication realm. While considering the various fields under the ambit of Civil Military Fusion (CMF), spectrum management in particular presents itself as an **interesting** and **peculiar** test case. The civil and the military are both **gainers** through sharing of mutually beneficial and converging technologies and infrastructures flowing out of pragmatic handholding in spectrum. However, unlike most other vistas involving CMF, here the two stakeholders are also in **direct competition** in partaking of this scarce resource.

The paper aims to highlight the existing challenges in CMF in the domains of spectrum management and communications, measures under implementation for plugging them and recommends a way ahead for a viable fusion in spectrum management and communications in India in this era of Atmanirbharta.

Growth of Communication Technologies and Need for Spectrum Management

In an interconnected world, ubiquitous communication using wired and wireless technologies is essential for both the civil and the military. In the domain of wireless communication, starting with the 1st Gen mobile systems in the late 1980s, the academia and industry have continued to evolve and adopt newer technologies. A new generation of communication systems has emerged roughly every decade (1G to 5G) enabling digital communications, higher bandwidths, lower latencies and greater reliability in wireless communications. In the wired domain too, there have been various technology enhancements that have complimented the growth in wireless technology—by enabling capacities and Quality of Service to support increasing backhaul network traffic. It has also enabled growth of the internet and helped extend broadband services across the world.

The advent of 4G and 4G LTE services has led to an exponential growth of mobile applications and digital services. This is being leveraged by governments and businesses to provide better services to its citizens and customers, besides fuelling the internet boom. As of 2022, 5.25 billion of the 7.9 billion people worldwide have access to internet.[1] This is about 2/3rd of the global population with mobiles accounting for 59.72% of global internet traffic[2]. In comparison, only about 0.7% of internet traffic worldwide was from mobile devices in 2009.

5G communication systems support much higher bandwidths including ultra-high band services in the millimetric wavelengths. It also facilitates Ultra-Reliable Low-Latency Communications (URLLC) with enhanced reliability and support for network slicing which is supporting new use-cases in wireless solutions. Applications of 5G include IoT, autonomous systems/ platforms, factory automation, tactile internet, Virtual and Augmented Reality, enhanced Mobile Broadband (eMBB) etc. The 5G services utilise different frequency bands - lower band (less than 2GHz), medium band (2 to 6 GHz) and high mm-Wave (24 to 39 GHz band). The evolution of WiFi and High-Altitude Platform Stations (HAPS) connectivity have brought in additional competing requirements. In addition to previous use of 900 MHz, 2.4 GHz and 5 GHz bands, newer Wi-Fi technologies are being implemented in 60 GHz (57 - 66 GHz) and 6 GHz (5925 - 7125 MHz) bands to support high bandwidth low latency applications facilitated by 5G.[3] New applications are also being explored in the Terahertz band (100 to 3000 Ghz, at presently used mainly for space-based research- that could provide much larger bandwidths, albeit over relatively shorter distances for communication between satellites, drones, within/ across buildings, mobile towers etc.

The Defence services have been the avant-garde users of most modern communication technologies in all domains of warfare, manifested in improved intelligence, situational awareness and robust Network Centric Operations. With the development and economic viability of space technologies, space is being increasingly used for communication services and sensing applications, and greater numbers of LEO and MEO satellites (of different sizes) are being regularly launched. This use of satellite technologies, high endurance manned/ unmanned platforms, and precision targeting have expanded the battlefield, with the use of cyber space opening a new dimension in warfare. Apart from communication systems, the Defence services also need to operate sensors in various frequency bands for navigation, surveillance, target acquisition, tracking and signal intelligence. The operations in dense EM environment requires use of suitable mechanisms to ensure EM compatibility as also the ability of spectrum to use EW, ECM and ECCM measures, while denying the adversary similar use of the spectrum. Select frequencies/ bands are also kept aside for use during hostilities. Further, the communication needs to be supported by a robust backhaul core network with adequate redundancies to ensure that the information is available on demand to authorised personnel at different levels in the hierarchy.

While the higher frequency bands were traditionally reserved for use by military radars, the advent of wireless technologies and increased usage of space with promise to contribute significantly to a country's growth and GDP, have inspired a relook at the usage of the limited spectrum by both the civil and the military. Though Defence requirements have contributed to development of many technologies, it is the economic viability that has driven further developments and use-cases in the civil world. A classic example of technological growth due to CMF is the present day internet. Conceived for Defence requirements, it was initially funded by US DoD, but the real advancements happened on realisation of its commercial potential by the private industry. Similarly, the Defence services are expected to immensely benefit from the technological advances that arise out of 4G, 5G and 6G use cases. As the technological advancements would benefit both the civil and the military and the spectrum is limited, CMF in spectrum management and communication technologies is essential for the growth of the nation.

Challenges in Spectrum Management

The increasing demand for Radio Frequency (RF) spectrum poses challenges due to competing requirements of different kinds of communication devices, systems (both terrestrial and space) and need to co-operate with RF based sensors in different frequency bands. Unregulated use of the spectrum may not only lead to mutual interference resulting in degraded performance, but may also result in system burn-out and non-functionality. Historically, the Defence services have always coordinated spectrum usage both during peace and war. Spectacular growth of major cellular networks in the country could not have been possible without major readjustments by the Defence services to make way for the commercial segments in the larger national interest. The roll-out of 5G services in the country requires further release/ harmonization/ co-existence in requisite bands of the spectrum, some of which are also being utilised by the Defence.

A major challenge for the Defence Services to support the CMF initiatives is the perceived 'big inventory' they hold. There are persistent queries on portions of the Defence band spectrum that are not being populated or utilised by the Services. This involves placing details on the spectrum used by sensitive Defence emitters in the public domain, which the services are loath to, and justifiably so. Additionally, it is a painstaking regular exercise to convince the civilian stakeholders and government functionaries that much of the 'unused' spectrum is earmarked for operations/ hostilities. Any attempt to constrict the spectrum band seriously compromises the operational capability of the emitter in question.

Vacation of Defence spectrum, when effected, is irretrievable due to industry investments in infrastructure and its impact on services to the citizens/ end-users in civil domain. A case in point on the adverse implications of spectrum release without comprehensive diligence relates to that of M/s Ligado Networks of US. The US Federal Communications Commission (FCC) in April 2020 had permitted Ligado to deploy a low-power network. However, in Sep 2022, the US DoD said that a study ordered into possible interference issues had found that Ligado's planned nationwide mobile broadband network would interfere with military GPS receivers, and that it was impractical to mitigate the impact of that interference. It further noted that the proposed mitigation and replacement measures '*are impractical, cost prohibitive, and possibly ineffective*.'[4] Additional challenges lie in vacation in the bands in which sensors and equipment are already operating or where the Defence services have plans for induction of new equipment/ capabilities. Retro-mods are costly, require additional resources and the transition process may necessitate significant lead time. Even if the modification or replacement costs incurred by services are borne by the government through the inflow of funds accruing out of spectrum auction, the migration process may entail security vulnerabilities and voids in capabilities.

The Defence services, therefore, remain uncomfortable with co-existence, as EM compatibility may not be guaranteed, and any restrictions could adversely impact both operations and training. Further, applications using the spectrum can have both licensed and unlicensed usage and regulators must be mindful of this and the potential value of unlicensed technologies when allocating and designating the spectrum. In effect, the CMF in spectrum management requires striking a fine balance to ensure that the needs of both the civil and military are effectively met. This not only needs effective collaboration across various government verticals including Defence, but also suitable tools and applications developed by academia and industry, with institutionalised mechanisms to ensure efficient spectrum management and allocation.

Global Trends: CMF in Management of Spectrum

Civil-military fusion in spectrum management has been implemented variously in different countries; some have a more centralised approach, while others have a more distributed mechanism with stronger roles for private actors. All strive to improve spectral efficiencies, and effectively manage and monetise spectrum, while balancing the requirements for the Defence services and national security. In many countries, a central agency at the cabinet level has been set up to oversee management of the spectrum for commercial mobile and broadcast. The Defence usually still occupies large bands of the spectrum and a separate organisation manages the Defence spectrum. In addition to use of flexible mechanisms for sharing spectrum, many countries, including India, have enacted policies to share both passive and active infrastructure. This has enabled ISPs and mobile network operators to share the available spectrum.

In the UK, the Spectrum Board comprises of Office of Communications (Ofcom) and MoD (Spectrum team). The Ofcom regulates and assigns radio frequencies to civil users, while the spectrum governance of the MoD is managed by the Defence Spectrum team which has three separate constituents handling Defence spectrum policy, Defence spectrum for military capabilities and impact of EM environment on the operational capabilities of Defence Forces, systems, equipment and platforms.[5]

In the United States, the FCC and the DoD work together through organisations such as National Telecommunications and Information Administration (NTIA), Inter-department Radio Advisory Committee (IRAC) and National Coordination Committee (NCC) to ensure that the RF spectrum is used in the most efficient and effective manner possible, using approaches such as Dynamic Spectrum Access and Cognitive Radio etc to mitigate issues of interference. In the US, 93.8 percent of the spectrum in 0–300 GHz band is shared between the private sector and the federal government on a shared non-exclusive basis.[6]

In Netherlands, its Telecommunications Agency is launching a ‘Dynamic Spectrum Management and Sharing’ (DSMS) pilot project, which will explore mechanisms for local private industrial networks to co-exist in the 3.8 – 4.2 GHz band, without interference of the reception by satellite ground stations. Results are expected by mid 2023, and if successful the new technology would demonstrate that larger protection zones around satellite ground stations may not be required. This could open new possibilities and methods for frequency spectrum allocation in Europe.[7] In France, to enable the reallocation of frequencies in defence band,

and bear the costs for re-development, the government has initiated a Spectrum Reallocation Fund (FRS). Through this model new users of the released spectrum pay the fund after their licensing. This method has been used to release defence spectrum for Digital Terrestrial TV and mobile.[8]

China has long recognised the crucial role telecommunications play as an engine of growth and development, and has taken the pole position in manufacturing of high-tech goods, thanks to the expansion of its mobile telephony and information technology industries. Telecommunications are governed by the Ministry of Industry and Information Technology (MIIT), which also has control over other manufacturing sectors. Planning, allocating, assigning, and monitoring of radio spectrum for mobile, satellite, radio, and related fields is solely under the purview of the MIIT's Bureau of Radio Regulation. It does not formally allocate spectrum for the Defence Department, though it collaborates with the Central Military Commission (CMC) on civil radio management issues.[9]

The UN's International Telecommunication Union (ITU), arbitrates on all policy regulations for global spectrum usage. The ITU constitution clearly highlights every State's sovereign right to regulate its telecommunication, and emphasises that since propagation of spectrum frequencies does not recognise man-made boundaries, its effective management needs suitable regulation at all levels; national, regional, and global. The constant spectrum review for future technologies does not always go well with all members. Specifically, the World Radio Conference (WRC) is the forum that provides an arena for all technology, telecommunication, scientific and business providers and developers to showcase their wares, as also provide a voice to various policy formulators from the member countries. The forum is witness to intense debates, disagreements and mitigation methods for adoption and proliferation of future developments.

CMF in Management of Spectrum in India

India's National Broadband Mission policy document mentions that in Sep 2019, the broad band penetration in India stood at 625.42 million, an increase of over 100% since 4G networks were introduced in the country in 2015. The data usage now is about 12 GB per user per month.[10] India is also the largest consumer of mobile data in the world. The National Digital Communications Policy-2018 recognises digital communications infrastructure and services as key enablers and critical determinants of India's growth and well-being. A report published by the Indian Council for Research on International Economic Relations (ICRIER) found that a 10% increase in India's mobile internet traffic, delivers on an average a 1.6 percent increase in India's GDP.

In India, coordination for allocation of frequency spectrum is undertaken at a national level with due cognisance to guidelines promulgated by globally recognised institutions, discussed earlier. DoT, Ministry of Communications, is responsible for planning, management, and spectrum allocation in India. The Wireless Planning and Coordination (WPC) wing of DoT is the regulatory body responsible for management of spectrum, including licensing, catering to all users (private and government) in the country. The Telecommunications Regulatory Authority of India (TRAI) is an independent sector regulator instituted by the GoI. The allocation of spectrum for various applications and services within the country is undertaken in accordance with the National Frequency Allocation Plan (NFAP). The revision of the NFAP is done usually after the ITU, World Radio Conference, and though this is mandated to be undertaken 'no later than every two years', there are slippages in this.[11] The NFAP committee is chaired by the Wireless Advisor to the GoI. The committee comprises of various stakeholders including large users of the spectrum.[12] To manage the radio spectrum globally, the ITU has divided the world into three regions, with each region having its own set of frequency allocations. India is a part of Region 3 of the ITU.

The Directorate of Joint Communications and Electronics Staff (JCES), a vertical under the Information, Communication & Technology Division of HQ IDS functions as the spectrum administrator, including handling of Standing Advisory Committee on Frequency Allocation (SACFA) for the Defence services, DRDO and DPSUs. It spearheads all deliberations with WPC on Defence Band spectrum. JCES also participates alongwith the WPC in the regular 'spectrum wars' fought in the WRC under the aegis of ITU. It keeps a careful eye on any unreasonable attempts of the industry to nibble away at the Defence Band spectrum, since the mitigation options manifesting as retro-adjustments of frequency usage, forced modifications/ changes to equipment profile etc are complex and time-consuming. The rationalising skills of Defence interlocutors in realistic give and take, accommodation, and adjustment are the order of the day in this complex domain of civil military fusion.

CMF in Communications

While CMF to manage the RF spectrum effectively is important for a nation’s security, economic growth and societal well-being, it is equally relevant for developing communications technologies and systems. A key aspect of CMF in communication is sharing of communication infrastructure, such as towers and satellites, as well as sharing of communication technologies, both software and hardware based. This sharing of resource lends itself to effective use of resources, and reduction of costs. The challenges in CMF in communication relate to the need to balance the requirements of the military and civilian sectors. The former requires secure and robust communication systems, while the latter is concerned more with user-friendly and easily accessible systems.

The Chinese government is effecting CMF through significant investment in R&D in 5G and quantum communication, aimed at building a strong domestic communication industry that can support the needs of both the military and civilian sectors. For this, the government is working closely with companies and researchers in the private sector, providing funding and other support for R&D, and encouraging collaboration between the military and civilian sectors. Some Chinese universities have established research centres involved in developing advanced communication technologies that can be used by both the military and civilian sectors. CMF is also being applied to communication infrastructure, as the Chinese government is working to build a dedicated military communication network that is separate from the civilian network, while still having capabilities to link the two seamlessly. Additionally, CMF is also increasing in the field of satellite communication in China, with many military-owned satellite manufacturers and civilian companies jointly developing satellite communication systems and applications, including earth observation, positioning, and navigation services. CMF in communication technologies has also enabled the Chinese government to better monitor and control information flow within the country. Advanced AI technologies developed by military research institutions are known to be used to keep tabs on inter and intra country flow of communication through internet, in order to suppress dissent.

Terrestrial communication systems like Software Defined Radios (SDRs) also have immense civil and military usages, as do various other wired communication and network devices. In the US, the Joint Tactical Radio System (JTRS) initiative is aimed at developing SDRs that can be used by both the military and civilian agencies. While the use of SDRs provides many benefits, an important requirement is to address the interoperability of SDRs from different sources. While standards like SCA and ESSOR have been defined, it is practically seen that mere compliance to these standards does not ensure portability of waveforms. The reasons include use of proprietary implementations/ interfaces; and required technical details for porting applications, integrating indigenous security modules not being available to the end user. In addition, waveforms/ applications need to be tweaked for use on different hardware platforms (GPP, FPGA, ADSP etc). There is also a need for the SDRs to operate with legacy communication sets already in use, and this is a complex task. Given the utility of SDRs of different form-factors across both the civil and the military, a need is felt to develop India Standards for SDRs to enable porting of waveforms and facilitate secure communication. Suitable testing and certification facilities within the country are also required to be set up for this purpose. Further, sustaining the standards and productionising SDRs in large volumes for both the civil and the military will require building an eco-system within the country. Towards this, attempt is being made to utilise the talent, capabilities and capacities available in the Indian academia and industry. Developing a strong technology base in this domain will enable *'Atmanirbharta'*, and also contribute to economic growth.

Security of networks and data at rest and in transit is paramount for safe and effective usage of ICT infra and services. While security of communication systems is aspired by the civilian sector too, the difference lies in the level of protection. The influx of 5G and IoT devices will create another layer of networked systems, in an already interconnected world, bringing with it related issues of cyber security. Development of indigenous solutions in the domains of perimeter and end-point security, cloud security, development of network devices and management systems, enhancing the ecosystem for use of open standards, and customised open source solutions would be key to improving transparency and building more secure communication systems. While the armed forces lay much score by relying on air-gapped captive networks due security concerns, there may be a case for also considering redundant or fall-back means of communication that ride on open networks being used in the civil domain. Adoption of the 'best in industry' tools such as zero trust frameworks for data and communication security may be necessary, which ought to be developed indigenously by the civil IT industry for them to be used with confidence by the military.

The Way Ahead

The inevitable demand for spectrum with the advent of new technologies has led the Defence services to migrate, vacate, harmonise or share its spectrum. This has impacted the usage of the concerned military equipment and in some cases restricted its full exploitation. That said, one cannot refrain from adopting the latest communication technologies being progressed in the civil sector and reaping the attendant benefits, though this may entail giving away certain portions of spectrum that are not planned to be gainfully utilised. Thus there is a clear and present need for civil military fusion to do a careful balancing act and pragmatically manage this 'gold rush'.

In India, while the mantle of coordinating all spectrum usage rests with the WPC, MoC, the military requirements are looked after and monitored closely by the JCES in HQ IDS, and no effort is spared in articulation of specific requirements of the Defence Services. In order to meet the growing demands of the Defence Forces with reduced exclusive access of the spectrum, there is a pressing need for more involved collaboration between the military and civil (academia and industry). The forces would be keen to encourage R&D with industry to develop new technologies that can improve spectral efficiency, and implement systems that are more agile, flexible and have better resilience to interference. Collaboration effort is already underway with the academia and industry to help in EMI and EMC studies, modelling spectrum footprint, and developing pragmatic spectrum management solutions and applications. This needs to be stepped up. A number of use-cases are being developed by various departments of the Government and industry for use of 5G, IoT, AV/ VR and tactile internet. Going forward, applications in the Terhertz communication band would also be of relevance to both the civil and the military. CMF and knowledge sharing will help in re-use of solutions developed and reduce duplication of effort.

The academia and industry can play a vital role in development of required CMF eco-system within the country. Use of open source and open standards initiative can be galvanised through the academic institutions that have a large and continual pool of students, supported by the industry. The government may suitably incentivise this sector by giving policy incentives to solutions built through using or supporting open source technologies and those using open standards. The industry can also actively participate in setting up testing and certification labs for ICT products. The testing and certification could be monetised by the industry to become a financially viable and profitable model. The government could suitably hand-hold such endeavours that will benefit both the civil and the military.

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