A STUDY OF LEVERAGING CIVIL-MILITARY FUSION FOR THE DEVELOPMENT OF DIGITAL INFRASTRUCTURE IN LADAKH

A Dissertation submitted to the Panjab University, Chandigarh for the award of the degree of Master of Arts in Public Administration and Public Policy, in partial fulfillment of the requirement for the Advanced Professional Programme in Public Administration

by

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under the guidance and supervision of

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Certificate

I have the pleasure to certify that **Brigadier P S Sidhu, VSM** has pursued his research work and prepared the present dissertation titled '**A Study of Leveraging Civil-Military Fusion for the Development of Digital Infrastructure in Ladakh**' under my guidance and supervision. The dissertation is the result of his own research and to the best of my knowledge, no part of it has earlier comprised any other monograph, dissertation, or book. This is being submitted to the Panjab University, Chandigarh, for the purpose of Master of Arts in Public Administration and Public Policy in partial fulfillment of the requirement for the Advanced Professional Programme in Public Administration (APPPA) of the Indian Institute of Public Administration (IIPA), New Delhi.

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New Delhi **Brigadier P S Sidhu**

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Declaration

I, the undersigned, hereby declare that the dissertation titled '**A Study of Leveraging Civil-Military Fusion for the Development of Digital Infrastructure in Ladakh**' is my own work and that all the sources I have accessed or quoted have been indicated or acknowledged by means of completed reference. The dissertation has not been submitted for any other degree of this university or elsewhere.

New Delhi **Brigadier P S Sidhu**

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Abstract

In the new age world, digital communications are as essential as water, roads and power. It stimulates economies, accentuates governance and enhances national security. In India, the expansion of digital infrastructure has been a priority, but due to the vast landscape of the Peninsula, some regions remain on the fringes of this transformation. Ladakh, an amazing yet challenging landscape, is one such place where connectivity gaps continue. Given its strategic location along the borders with Pakistan and China, the lack of strong and robust digital infrastructure in Ladakh is not just a developmental concern but also a matter of national security as tomorrow's threats from our Northern adversaries will emerge in digital domain.

The concept of Civil-Military Fusion (CMF) offers a distinctive and realistic approach to tackling these challenges. By integrating military resources with civilian digital infrastructure, connectivity in Ladakh can be improved while ensuring that military communication networks remain secure and operationally proficient. Countries like the United States and China have successfully used CMF to drive technological advancements, but India's approach has been a bit patchy. In a region like Ladakh, where harsh terrain, hostile climate and very low population density make commercial investments less viable, leveraging existing military infrastructure for dual-use purposes could provide a sustainable solution to bridge the digital divide.

Despite several government initiatives aimed at enhancing digital infrastructure in Ladakh, the region continues to face limitations in network proliferation especially in areas close to Line of Actual Control (LAC). The *BharatNet* project, the Universal Service Obligation Fund (USOF) and the Vibrant Villages Program have been launched to improve digital accessibility. However, the implementation of these projects has been sluggish and challenges remain in ensuring

last-mile connectivity, particularly in forward military locations and far flung border villages where the Telecom Service Providers (TSPs) find it economically unviable to invest without adequate revenue in return.

The mobile network coverage in Ladakh is uneven, with 215 out of 229 villages having some level of connectivity. However, only 93 villages have 4G services, while 36 rely on outdated 2G and 3G networks. Additionally, 14 villages still lack any mobile connectivity, with three of them are not even covered under any existing expansion plans. The reliance on erratic and variable mobile networks continues to hamper digital accessibility in remote areas, creating an pressing need for further investment for infrastructure development. The Optical Fiber Cable (OFC) network in Ladakh is another crucial aspect of digital infrastructure. The Indian Army maintains a 7,000 km-long OFC network, but much of it especially in Eastern Ladakh, less the initiative of Project *Kranti*, is outdated and economically exhausting to maintain. The civilian OFC network has seen some growth through the BharatNet project, connecting 193 villages via satellite-based broadband. However, of these, only 43 villages currently have operational broadband services, reflecting a considerable gap in implementation. While private telecom operators such as Reliance Jio, Airtel and BSNL have made significant progress in OFC deployment, many locations important to Military and remote village settlements remain without adequate OFC footprint.

Several challenges hamper the expansion of digital infrastructure in Ladakh, making it difficult for both civilian and military authorities to ensure seamless connectivity in the region. The daunting challenge is the region's rugged terrain and extreme climate. Ladakh's high-altitude passes, harsh winters and frequent landslides make the construction and maintenance of telecom infrastructure a logistical

nightmare and financially taxing. Fiber optic cables are prone to damage due to freezing temperatures, while mobile towers require frequent repairs due to environmental degradation. Security considerations also play a crucial role in restricting digital expansion. Ladakh's proximity to the India-China border necessitates stringent control over communication networks. The military operates sovereign, highly secure communications, which remain isolated from civilian telecom services due to concerns over cyber security, data breaches and potential surveillance activities by adversary. Integrating military and civilian networks would require robust security frameworks, including encrypted communication systems and network segmentation to ensure the protection of sensitive defence data.

Economic practicality remains another decisive factor in the development of digital infrastructure. The sparse population and rugged landscape make it financially unviable for TSPs to invest in large-scale infrastructure projects. Given the high operational costs and low return on investment, private players are often reluctant to develop services in such demanding environments. The government has attempted to bridge this gap through subsidies and viability gap funding, yet many remote areas remain under-connected due to restricted incentives for private companies. Bureaucratic and dogmatic hurdles further worsen the problem. The process of securing Right of Way (RoW) approvals for fiber optic deployment is time-consuming and inefficient, often taking months due to excessive bureaucratic red tape. Land acquisition for telecom tower installation is similarly hampered by multiple clearance requirements from various government agencies, delaying project implementation. Moreover, the lack of coordination between civilian and military authorities leads to duplicated infrastructure efforts, further complicating the implementation of digital infrastructure projects.

Despite these challenges, Civil-Military Fusion is the way forward to find promising solutions for the development of digital infrastructure in Ladakh. The shared use of military owned optical fiber networks could appreciably augment civilian broadband accessibility while reducing the cost and time required for new fiber deployments especially in areas closer to LAC. By leveraging the Indian Army's extensive communication backbone, including satellite resources of Army as also encouraging services like One Web and Star Link, rural communities in Ladakh could gain access to high-speed internet services without compromising national security. However, this would require the implementation of strict cyber security measures to ensure that military communications remain secure and secluded. Military-owned telecom towers could also be repurposed for civilian use, reducing the need for additional infrastructure investments. Many of these towers are strategically positioned in forward locations, making them ideal for extending mobile coverage in unconnected areas. Establishing partnerships between the military and telecom service providers would allow these assets to be used efficiently, improving connectivity while minimizing duplication of infrastructure. Public-Private Partnerships (PPPs) offer another avenue for enhancing digital expansion. The government should actively encourage private investment by providing financial incentives such as tax exemptions, infrastructure cost-sharing and long-term operational contracts. Creating a structured financial model that supports telecom providers in remote regions would help sustain connectivity initiatives, ensuring long-term economic viability.

The study recommends maximizing the potential of Civil-Military Fusion for digital infrastructure expansion; several strategic actions must be taken. Establishing a central CMF digital infrastructure task force would help coordinate military and civilian communication projects, ensuring a unified and efficient approach to

connectivity development. Expanding the use of military-owned OFC and telecom infrastructure for civilian applications, while maintaining security through network segmentation, would significantly accelerate digital accessibility in Ladakh. Encouraging greater private sector participation through Public-Private Partnerships (PPPs) and government-backed funding models would further incentivize investment in remote telecom expansion. Additionally, implementing robust cyber security frameworks, including zero-trust architecture and encrypted communications is essential to safeguard national security while promoting digital connectivity. Alternative communication technologies such as satellite-based broadband systems (GSAT, OneWeb, Starlink) should also be deployed in areas where fiber optic installations are not feasible.

A well-executed Civil-Military Fusion strategy could reform digital connectivity in Ladakh, transforming it into a future-ready digital hub while ensuring national security. By leveraging military resources, enhancing cyber security, promoting and incentivising private investment and nurturing inter-agency collaboration, India can narrow the digital divide in its remote border regions. If implemented effectively, this model could serve as a blueprint for digital expansion in other geographically challenging and strategically significant areas across the country. The integration of military and civilian digital infrastructure will not only strengthen national security but also drives socio-economic development.

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List of Abbreviations

AI	Artificial Intelligence
AFC	Army Future Command
BADP	Border Area Development Program
BSF	Border Security Force
BRO	Border Road Organisation
BSNL	Bharat Sanchar Nigam Limited
CAPEX	Capital Expenditure
CAPS	Centre for Air Power Studies
CDS	Chief of Defence Staff
CENJOWS	Centre for Joint Warfare Studies
CIBMS	Comprehensive Integrated Border Management System
CLAWS	Centre for Land Warfare Studies
CMI	Civil - Military Integration
CMF	Civil - Military Fusion
CPEC	China Pakistan Economic Corridor
DARPA	Defence Advanced Research Project Agency
DBT	Direct Bank Transfer
DBO	Daulat Beg Oldie
DIB	Defence Industrial Base
DLP	Defect Liability Period
DMA	Department of Military Affairs
DoD	Department of Defence
DoT	Department of Telecommunication

GP	Gram Panchayat
GPS	Global Positioning System
IDF	Israeli Defence Forces
IDSA	Institute of Defence Studies and Analysis
IDU	Indian Defence University
ITBP	Indo Tibetian Border Police
IoT	Internet of Things
LAC	Line of Actual Control
NLP	National Logistic Policy
NSS	National Security Strategy
OEM	Original Equipment Manufacturer
OFC	Optical Fiber Cable
OPEX	Operational Expenditure
RoW	Right of Way
SAMBHAV	Secure Army Mobile Bharat Version
SBIR	Small Business Innovation Research
SEZ	Special Economic Zone
SME	Small and Medium Enterprise
SLA	Service Level Agreement
PPP	Public Private Partnership
PSU	Public Sector Undertaking
TSP	Telecom Service Provider
UPI	Universal Payment Interface
VLAN	Virtual Local Area Network

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CHAPTER 1

INTRODUCTION

"The synergy between our armed forces, academia and industry is crucial for India's self-reliance in defence. We must break silos to ensure better coordination and develop a strong ecosystem where innovation thrives for both security and development[1]."

- Prime Minister Shri Narendra Modi

Civil-Military fusion (CMF) is a dynamic concept that involves integrating civilian and military resources, expertise, and technologies to advance national development. In India, the idea of civil-military fusion is becoming increasingly significant, especially in the context of digital infrastructure development. With the country's growing reliance on technology for governance, defence and economic growth, leveraging civil-military collaboration offers a strategic opportunity to enhance India's digital capabilities. The fusion of civilian technological expertise and military innovations can lead to the creation of a robust, secure and efficient digital ecosystem. Prime Minister Narendra Modi's thrust for self-reliance through *Atmanirbhar Bharat* aligns strongly with the principles of civil-military fusion, as it calls for breaking silos between military and civilian institutions to accomplish national growth.

Digital infrastructure is turning out to be the corner stone of India's growth in the 21st century. It encompasses various mechanisms such as high-speed internet, secure data networks, satellite communication systems, artificial intelligence (AI), cloud computing and cyber defence systems and mechanisms. For India, developing these capabilities is not only important for economic prosperity but also critical for

[1] **Modi, N. (2020, February 5).** Address at the Defence Industry Outreach Seminar, Lucknow. Speech presented at Defence Expo 2020. Retrieved from https://www.narendramodi.in

national security. The integration of civil-military resources can act as a force multiplier in achieving these goals. Traditionally, military technologies have driven significant advancements in civilian sectors. For instance, technologies like GPS, the internet and satellite communication initially originated from military research but eventually transformed the civilian world. Similarly, in India, military innovations and expertise can be harnessed to address the challenges in building digital infrastructure, while civilian contributions in research, private sector innovations and academic partnerships can accelerate defence modernization and growth.

Civil-Military fusion is an approach that can effectively be leveraged for harnessing resources, expertise, and capabilities of both civilian and military sectors and offers transformative solutions. By fostering collaboration between the armed forces and civilian authorities, India can accelerate the deployment of critical digital infrastructure in its remote border areas. This fusion not only enhances the defence and surveillance capabilities in these strategically sensitive regions but also brings the benefits of connectivity, education, healthcare, and economic opportunities to the local population.

The development of digital infrastructure in remote border areas of India is not just a technological necessity but a strategic imperative that intertwines national security with inclusive economic growth. These regions, often characterized by harsh terrain, sparse populations, and limited access to essential services, are vital to the country's sovereignty and security. However, their isolation has historically hindered economic development and access to digital services, perpetuating a cycle of underdevelopment and vulnerability.

Statement of Problem

The region of Ladakh, located in the northernmost part of India, is of immense strategic importance due to its proximity to international borders with China and Pakistan. Despite its geopolitical significance, Ladakh remains one of the most remote and underdeveloped areas in the country, particularly in terms of digital infrastructure. The harsh terrain, extreme weather conditions and sparse population have historically limited the expansion of digital networks, leading to significant gaps in connectivity, access to information and essential services. This lack of digital infrastructure not only hinders the socio-economic development of the local population but also poses challenges to India's national security, especially in light of increasing geopolitical tensions in the region. The Indian Armed Forces, with their extensive presence and digital infrastructure capabilities in Ladakh has played a crucial role in maintaining security; however, the potential of civil-military fusion to address both security and developmental needs has not been fully explored.

The research problem, therefore, centers on how civil-military fusion can be effectively leveraged to develop robust digital infrastructure in Ladakh to enhance national security as also economically integrate remote region of Ladakh with mainland India.

Justification of the Study

The development of digital infrastructure in India's remote border areas is crucial not only for enhancing the quality of life for local populations but also for ensuring national security. These regions, often characterized by rugged terrain and limited accessibility are strategically vital due to their proximity to international borders. However, the challenges of developing infrastructure in these areas are significant, including logistical difficulties, high costs and the constant threat of external

aggression. Traditional approaches to infrastructure development have often fallen short in addressing these challenges, leaving many border areas inadequately served. This situation necessitates innovative solutions that can overcome these obstacles while simultaneously advancing national security objectives.

Civil-Military Fusion (CMF) represents a promising approach to address these challenges. By integrating the resources, expertise and capabilities of both civilian and military entities, CMF can facilitate the development of robust digital infrastructure in remote border areas. The military's extensive experience in operating in difficult terrains, coupled with the government's focus on digital inclusion, can create a synergy that ensures the efficient and secure deployment of digital networks. Additionally, the dual-use nature of such infrastructure—serving both civilian needs and defence requirements can optimize resource utilization and ensure that investments in infrastructure development yield maximum benefits.

Despite its potential, the concept of CMF has not been widely applied to the specific context of digital infrastructure development in India's remote border regions. Most studies and policies have treated civilian and military efforts as separate entities, missing the opportunity to harness the full potential of their collaboration. Furthermore, while the military has traditionally played a role in infrastructure development in border areas, this has often been limited to physical infrastructure such as roads and bridges, with less focus on the digital dimension. Given the increasing importance of digital networks for both economic development and security, there is a pressing need to explore how CMF can be effectively leveraged to build digital infrastructure in the strategically important region of Ladakh.

The significance of this research lies in its potential to bridge this gap in the existing literature and policy frameworks. By examining successful models of civil-

military collaboration in infrastructure development, both within India and internationally, this research aims to provide insights into how CMF can be applied to the unique challenges of digital infrastructure in remote border areas of Ladakh. The study will also explore the broader implications of this approach for national security and inclusive growth, considering how enhanced digital connectivity can contribute to economic development, social inclusion and improved governance in Ladakh.

The reserach is justified by the critical need to develop digital infrastructure in India's remote border areas of Ladakh, their strategic importance and the potential of CMF to address the unique challenges involved. By providing a detailed analysis of how Civil-Military Collaboration can be optimized for digital infrastructure development, the research aims to contribute to both academic understanding and practical policy-making, ultimately supporting the dual goal of national security and inclusive growth.

Research Objectives

1. To assess the current state of digital infrastructure and CMF initiatives in Border Areas.
2. To identify the challenges and opportunities associated with implementing CMF in Ladakh.
3. To explore how CMF can be leveraged to develop digital infrastructure in Ladakh, enhancing national security and promoting inclusive growth.
4. To identify best practices and strategies for effective collaboration between civil and military agencies in the context of developing digital infrastructure in Ladakh.
5. To recommend measures to enhance Civil Military Fusion in Ladakh.

Research Questions

1. What is the current state of digital infrastructure in India's remote Border Areas?
2. How can the collaboration between military and civilian authorities accelerate the deployment of digital infrastructure in Ladakh?
3. What are the key challenges and opportunities in implementing Civil-Military Fusion for digital development in such a remote and strategic region?
4. How can enhanced digital infrastructure in Ladakh contribute to both national security and the socio-economic upliftment of local communities?

Hypothesis (H1). Civil-Military Fusion significantly enhances the development of digital infrastructure in remote border areas of India, thereby strengthening national security and promoting inclusive economic growth in the region.

Hypothesis (H0). Civil-Military Fusion does not significantly enhance the development of digital infrastructure in remote border areas of India, nor does it strengthen national security or promote inclusive economic growth in the region.

Research Strategy and Design

The study will adopt a mixed-methods approach, combining both qualitative and quantitative research methods to provide a comprehensive analysis of the topic. The integration of different methods will help in capturing the complexity of CMF in the development of digital infrastructure, particularly in a challenging and strategically important region of Ladakh.

- **Qualitative Approach**. The qualitative component of the research will involve in-depth interviews, and document analysis. This approach will help in understanding the nuanced dynamics of CMF, the experiences of stakeholders, and the broader context of infrastructure development in Ladakh.

Semi-structured interviews will be conducted with key stakeholders, including military officials, civil administrators, public and private service providers. Relevant policy documents, government reports, and development plans will be analyzed to understand the framework within which CMF operates in Ladakh. This will include examining existing infrastructure policies, military doctrines related to border management, and digital inclusion initiatives.

- **Quantitative Approach**. The quantitative component will involve the collection and analysis of numerical data to complement the qualitative findings. This will include questionnaire and statistical analysis. Questionnaire will be distributed to various stakeholders, government officials, and military personnel. Response will be analyzed using statistical software (e.g., Jamovi) to identify trends, correlations, and significant differences between groups.
- **Sampling Strategy**. Purposive Sampling will be used to select participants who have direct experience or significant knowledge about CMF and digital infrastructure development in Ladakh. Stratified random sampling will be used for Questionnaire response.

Limitations of the Study

Civil Military Fusion is a relatively new concept; however Civil Military Relations often has been discussed in various forums including with the top hierarchy of Governance. The procedures in the domain of Civil Military Relations has been fairly well defined at all levels, whereas Civil Military Fusion has totally different connotations and availability of structured material is very difficult and no institutional knowledge exists neither with Military hierarchy nor with the pillars of governance or academia or industry for that matter.

The research has been focussed on Ladakh region, therefore remoteness and rugged terrain of Ladakh, along with extreme weather conditions, may pose challenges for data collection, particularly for physical field observations and interactions with local stakeholders. Access to certain military confidential data may also be limited, which could constrain the depth of some analysis. The outcome of research being specific to Ladakh may not be generalised for other border regions in the country.

Chapterisation

The thesis has been covered in following chapters:-

Chapter 1: Introduction. The chapter gives a brief insight into the concept of Civil Military Fusion and how this can leverage civilian technological expertise and military infrastructure and innovations to create a robust, secure and efficient digital ecosystem in the border areas. It covers the Background, Importance and Relevance of Study, Research Problem, Research Objectives, Research Questions and Limitations of the Study.

Chapter 2: Literature Review. The chapter elaborates on the survey of literature with a view to understand the Concept of Civil-Military Fusion and its relevance in border areas of Ladakh. The chapter will also highlight the Research Gaps existing in Civil Military Fusion for development of digital infrastructure in Ladakh.

Chapter 3: Overview of Ladakh. This chapter will cover the Demographic, Geopolitical and Strategic Importance of Ladakh in India's National Security.

Chapter 4: Civil-Military Fusion in Ladakh. This chapter will focus on concept of Civil Military Fusion, the Global Scan on CMF initiatives, the current state of digital infrastructure in Ladakh , opportunities for Civil-Military Fusion in Ladakh for developing digital Infrastructure and will also bring out challenges and barriers to

Civil Military Fusion for development of digital infrastructure in Ladakh. The chapter will also analyse the development and deployment of Project SAMBHAV of Indian Army in Ladakh as case study of Civil Military Fusion.

Chapter 5: Impact of Digital Infrastructure on Socio-Economic Development and National Security. This chapter will trace the potential socio-economic benefits in e- Governance with development of digital infrastructure as also its impact in enhancing National Security through use of common Infrastructure for surveillance, communication and military logistics.

Chapter 6: Data Analysis & Interpretation. This chapter will dwell upon the analysis of primary data (interviews, Questionnaire) and secondary data (Policy analysis). The chapter will also cover the detailed data analysis both qualitative and quantitative and interpretation to study impact and potential of Civil – Military Fusion.

Chapter 7: Findings, Recommendations and Conclusion. This Chapter will highlight the findings of the study and give out recommendations for enhancing Civil-Military Fusion for developing robust digital infrastructure and for strategic policies for developing digital Infrastructure in remote border areas in Ladakh.

CHAPTER 2

LITERATURE REVIEW

The strategic importance of developing digital infrastructure in remote border areas of India, particularly in Ladakh, is increasingly recognized as a crucial component of national security and socio-economic development. The unique geographical and political landscape of Ladakh presents both challenges and opportunities, making Civil-Military Fusion (CMF) an essential approach to enhancing connectivity and resilience in the region. CMF refers to the collaborative efforts between military and civilian sectors, leveraging the strengths of both to optimize resources and strategies for development. Since the concept is new in Indian context, not many books have been written on the subject though a large number of articles, both by eminent military leaders as well civilian scholars is available. A significant number of panel discussions conducted by institutes like CLAWS, CENJOWS, Manohar Parrikar Institute of Defence Studies and Analysis, Observer Research Foundation and Centre for Air Power Studies (CAPS) have also been surveyed to identify the Research Gaps. Literature Review of major books/ Articles and Panel Discussions are as under:-

(a) **Zhang, L. (2019). Military and Civil Integration: A New Paradigm. Beijing: PLA Press.** In his book, Military and Civil Integration: A New Paradigm (2019), Zhang discusses various models of CMF worldwide, emphasizing their synergetic benefits. Applied to the context of Ladakh, CMF can potentially catalyze infrastructure development that not only bolsters national security but also serves the socio-economic needs of local communities.

(b) **Das, P. (2021). India's approach to border management: From Barriers to Bridges.** The book by Dr Pushpita Das comprehensively

explores the challenges and strategies surrounding India's border management practices. The underdeveloped Infrastructure is a major challenge in many border regions, which hampers security operations, trade and the quality of life for local residents. The author has studied the details of efforts under Border Area Development Program (BADP) and other schemes to address these gaps, such as road and rail connectivity projects. The book effectively captures the evolution of India’s border management approach, from a predominantly security-focused framework to one that incorporates regional development, connectivity, and multilateral cooperation. It provides a detailed exploration of programs like BADP and highlights the challenges of balancing security imperatives with developmental goals. By emphasizing an integrated approach, the book offers valuable insights into how India can transform its borders into zones of economic opportunity and security. The book serves as a roadmap for enhancing border management through strategic planning, technological integration, and regional cooperation. It presents a rich analysis of the socio-political dynamics of border regions. Overall, it underscores the importance of viewing borders as bridges rather than barriers, aligning with India’s vision for inclusive and secure development. The book examines the strategies deployed by India, including deploying border guarding forces and implementing surveillance systems like the Comprehensive Integrated Border Management System (CIBMS). The findings in the book are specific to Diversity of Borders and are focussed on development of infrastructure in domain of road and rail network. The book is silent on developing dual use technical infrastructure that can not only enhance security in the border regions but also boost economic growth in the

remote border regions. The books also don't study the dynamics of developing digital infrastructure in Ladakh.

(c) **Swartz, J. (2023). Tracking India's Infrastructure Development near the Line of Actual Control. Occasional Paper, (417). J**ohn Swartz's paper provides a comprehensive analysis of India's infrastructure development along the Line of Actual Control (LAC), focusing on strategic imperatives, challenges and the role of institutional reforms in ensuring progress. The author argues that India's infrastructure development near the LAC in the past was always hindered by a defensive doctrine that prioritized natural barriers over connectivity. This approach, compounded by bureaucratic impediments, financial inadequacies and the challenging terrain of Northern Borders, left India lagging behind China in border infrastructure. However, recent years have witnessed a significant shift, with increased investments in road, air, and rail connectivity aimed at reducing asymmetries with China and enhancing India's strategic preparedness. The paper highlights the events such as the Doklam standoff (2017) and the Galwan incident (2020) as monumental moments that shifted India's focus towards border infrastructure. The paper also brings into focus the improved pace and quality of road construction led by the Border Roads Organisation (BRO), supported by increased funding. Initiatives such as general approvals for forest clearances and empowered state-level committees reduced bureaucratic delays. Enhanced road networks, featuring tunnels and all-weather routes have bolstered troop mobility and supply chain efficiency. Air infrastructure has also been strategically upgraded, with reopened and newly constructed airstrips and helipads in critical locations. These developments enhance

India’s airlift capacity and offset the disadvantages posed by the region’s rugged topography. Rail infrastructure, however, remains underdeveloped, with projects like the Jammu–Baramulla line plagued by delays and cost overruns. While plans for new rail links in Arunachal Pradesh and Ladakh signal progress, the rail network’s expansion is still far from matching the strategic demands of the region.

A recurring theme in the paper is the integration of developmental goals with security imperatives. By addressing the socio-economic marginalization of border areas, initiatives such as advanced connectivity and resource allocation aim to strengthen local communities, thereby aligning national security with regional development. However, the review also exposes critical gaps in the domain of civil-military fusion. Although there is greater coordination between the BRO and defense forces, the role of civilian academia, private-sector innovation, and technological collaboration remains underexplored. For instance, leveraging artificial intelligence (AI) and satellite imagery for predictive maintenance or deploying dual-use technologies for border development and security has not been integrated into the current strategy of developing digital infrastructure. The paper also misses out and possibly underscores the absence of a cohesive framework for Public-Private Partnerships (PPPs) in digital infrastructure development. While outsourcing projects has improved efficiency, the lack of a structured approach for long-term collaborations with private industry and academic institutions hinders innovation and scalability. Civil-military fusion in the context of border infrastructure also requires a more robust mechanism for knowledge sharing between defense forces, civilian agencies and local

governments. The paper could further explore how other nations with similar geopolitical challenges have successfully integrated these domains, offering lessons for India's context.

While the paper successfully maps the progress and challenges in India's LAC infrastructure, it does not reveal any significant opportunities to enhance civil-military fusion. Developing a structured framework that incorporates civilian expertise, private-sector innovation and advanced technologies could transform India's LAC management strategy. Such measures would not only reinforce national security but also serve as a model for sustainable regional development.

(d) **Srivastava, S. (2023). Civil Military Fusion in India: Promising Pathways. Centre for Joint Warfare Studies (CENJOWS) Journal, (1), 1-26.** In this paper, the author provides an in-depth examination of India's efforts to integrate civil and military domains for national security and development. It identifies civil-military fusion as a crucial mechanism for optimizing defence planning, capability development and strategic decision-making. Reforms such as the creation of the Chief of Defence Staff (CDS) and the Department of Military Affairs (DMA) are highlighted as transformative steps toward fostering integration. The paper highlights the importance of coalescing defence policies with economic, technological and governance priorities, while leveraging dual-use technologies in emerging domains like cyber, AI and space. The paper also identifies key challenges that include tunneled bureaucratic vision that usurps coordination, sluggish defence indigenization due to reliance on imports and the non-involvement of country's academia and private-sector expertise. The absence of a documented

National Security Strategy (NSS) and fragmented governance structures exacerbate these challenges, leading to ad hoc planning and limited public-private collaboration. While recent progress in strengthening the Defence Industrial Base (DIB) and boosting private sector participation is acknowledged, gaps in long-term budgetary commitments and frameworks for technology transfer persist.

The paper also discusses India's response to hybrid and multi-domain threats, emphasizing the need for integrated approaches across civil and military institutions. However, gaps remain in institutionalizing academia-military partnerships and accelerating the adoption of emerging technologies. Proposed measures such as the establishment of the Indian Defence University (IDU) and expanding public-private partnerships have yet to gain momentum.Though, the paper highlights the potential of Civil Military Fusion to bridge India's strategic and developmental goals, but misses out on the exact role of Defence Industrial Base and their contribution towards building Digital Infrastructure in remote borders areas that can synergise both security and economic imperatives in these areas.

(e) **Shankar, P. R. (2023). Civil Military Fusion: A Model for India. CENJOWS Journal, (1), 52-67.** The paper discusses the need of civil-military fusion for India's rise to power, contrasting the US and Chinese models. While the US model is disaggregated and driven by the services, China's approach is centrally planned and aims for a "whole-of-nation" approach. The lack of a specific model for India has affected our ability to harness potential of Civil – Military initiatives and there is need for a unique Indian model. The importance of breaking down bureaucratic barriers and

fostering collaboration between different sectors for successful implementation is a prerequisite to develop our border regions. A clustered approach for India, focusing on key sectors like defence, space, and energy as well as emerging technologies like AI and robotics needs to be explored. There is an urgent need to further research the challenges and opportunities that civil-military fusion presents in India, focusing on specific issues like integrating the existing military-industrial complex with new technologies and capabilities that can directly benefit infrastructure development in border areas.

(f) **Dixit, S. (2023). Military-Civil Fusion in China and Lessons for India. Synergy Journal, 2(1), 88-105.** This excellent paper analyses China's Military-Civil Fusion (MCF) strategy, highlighting China's focus on integrating military and civilian resources and potential to enhance comprehensive national power. The paper emphasizes the pivotal role of Military - Civil Fusion (MCF) in boosting economic growth, technological advancement, efficient governance and enhanced military capabilities. China's well-structured approach underpinned by a clear vision and robust organisational framework, demonstrates how aligning military and civilian efforts can address complex socio-economic challenges. The paper identifies that China's MCF strategy prioritizes dual-use infrastructure, disruptive technologies like AI and space and strong partnerships among military institutions, academia, and private enterprises. The driver of this success is China's centralized governance model, exemplified by the Central Commission for Military-Civil Fusion Development. China's has dedicated financial support worth $73 billion towards MCF initiatives that has bolstered

effective execution of this strategy. The author also highlights contrasting Indian approach to civil military fusion, which is in infancy and is not supported by cohesive government policies. While India has made progress through reforms like the establishment of the Chief of Defence Staff (CDS) and the Department of Military Affairs (DMA), but large number of challenges exists. These include fragmented governance, lack of formalized academia-industry-military collaboration, and inadequate focus on dual-use infrastructure. The absence of a comprehensive national CMF strategy limits India's ability to align defence and developmental objectives. The paper is silent on under-utilization of defense industrial base and the need for public-private partnerships to drive innovation in border areas and how these initiatives can boost economy of border regions while significantly enhance military capabilities. The paper also misses out on strategies to build dual use infrastructure, CMF focused funds and adoption of Whole of Nation Approach for enhancing physical and economic security of border regions.

(g) **Thapa, A. (2024). Civil-Military Fusion in the Indian context. Centre for Airpower Studies (CAPS) in Focus.** Col. M.B. Singh examines the integration of military and civilian logistics to create a cost-effective, technologically advanced and sustainable and effective logistics ecosystem. The paper emphasises the criticality of Civil-Military Fusion (CMF) in enhancing national security and operational readiness while optimizing resources for infrastructure development. Some key aspects of CMF accentuated in the paper include the development of dual-use infrastructure, such as roads, tunnels, airfields and pipelines to meet both civilian and military requirements. The paper underscores the alignment of defence needs

with national policies like the PM *Gatishakti* initiative and the National Logistics Policy (NLP) to ensure faultless integration and proficient utilization of resources. Additionally, it advocates for leveraging digital technologies to unify military and civilian logistics systems thus enabling better interoperability and supply chain management. The paper also identifies several challenges including fragmented governance structures, delays in critical border infrastructure projects and limited financial viability for military-specific investments. The lack of a unified digital interface and inadequate private sector involvement are also prominent hurdles. However, the paper is silent on strategies to build Unified Governance Framework that can design a formal mechanism that incorporates military logistics to include existing communication infrastructure in Border area into national infrastructure planning, ensuring holistic economic growth in these areas.

(h) **Chinoy, S. R. (2023). Civil-Military Fusion for *Atmanirbhar Bharat*. ORF Publication.** This is an excellent paper by Ambassador Sujan R Chinoy that examines the role of Civil-Military Fusion (CMF) in strengthening India's national security and achieving strategic autonomy. It signifies CMF as a structure for fusing military and civilian resources to enhance operational efficiency, defence modernization and self-reliance. The author identifies key objectives, including fostering jointness among the armed forces, paramilitary and civilian agencies for promotion of self-reliance through *Atmanirbhar Bharat*, developing dual-use technologies and implementing theater commands for streamlined operations. The paper stresses on the critical aspect of coordination between armed forces, Defence Research and Development Organisation (DRDO), defence PSUs, academia

and private industries in building a robust defence ecosystem. It emphasizes leveraging disruptive technologies like AI, drones and cyber to enhance military preparedness. In addition, it advocates for synergy in border management through better training, logistics and resource-sharing between armed forces and border agencies like the Border Security Force (BSF) and Indo Tibetian Border Police (ITBP). However, the paper is silent on strategy for development of organizational structures for joint decision-making and integration of resources, methods to boost Defence-Industry-Academia Collaboration for dual-use technologies to enhance military potential while boosting economic growth through resource optimisation.

(i) **Event Report (2022, June 14). Panel discussion on Civil-Military Fusion in India. MP-IDSA Auditorium, New Delhi**. This was an thought provoking panel discussion chaired by Ambassador Sujan R. Chinoy, the Director General, MP-IDSA with discussants of the stature of Lt. Gen Raj Shukla, Lt Gen. C.P. Mohanty, Shri Sanjay Mitra, former Defence Secretary and AVM Anil Golani (Retd). The panel explored the critical role of integrating civilian and military resources to enhance national power during war and peacetime. Highlighting global examples, such as the U.S. Army Futures Command, Israel's reservist ecosystem, China's military-academic complex and Turkey's drone advancements, the panel illustrated successful CMF models. In contrast, India’s efforts such as the creation of the CDS-DMA remain suboptimal due to silos between institutions, inadequate funding for military-focused startups and limited trust between civil and military leadership. The discussion brought to focus some key challenges like the lack of collaboration between academia, private industries and the military,

insufficient integration of military and civil training programs and limited awareness of military operations in the civilian domain. Financial constraints and policy barriers further hinder India's ability to emulate global benchmarks. The discussion emphasized the need for tailored CMF strategies suited to India's unique context, including policy reforms to incentivize private-sector involvement in defence, fostering public-private partnerships, and introducing a revolving door mechanism for talent circulation. However, the discussion remained silent on development of dual use technologies, sharing of critical digital infrastructure in border areas and their impact on developing local economy while strengthening defence infrastructure.

(j) **Vasan (2023), Detailed Project Report on Project SAMBHAV**. This project report on Indian Army's flagship CMF project highlights a case study that demonstrate how collaborative projects between civil and military agencies have led to enhanced operational effectiveness of the Defence Forces in border regions, solidifying the argument for CMF as a strategy for reinforcing security through connectivity.

(k) **Rana (2020), China's Military-Civil Fusion Strategy and Implications for India (Issue Brief No. 268). New Delhi: CLAWS.** In this article Major General Rana highlights China's Military-Civil Fusion (MCF) strategy, elevated to a national priority under Xi Jinping. He highlights China's efforts to integrate economic, social and security strategies to build a world-class military. Transitioning from Civil-Military Integration (CMI), MCF emphasizes seamless collaboration between state, military and private sectors, supported by robust legal frameworks and organizational structures. Key features of his analysis include dual-use infrastructure, talent acquisition

programs and advancements in disruptive technologies such as artificial intelligence, quantum computing and unmanned systems. Strategic domains like space, maritime, cyber, and border regions are prioritized for innovation and dual-use capabilities often leveraging global partnerships and illicit technology acquisitions. He also emphasises on India's contrasting mindset in adoption of similar strategies to boost inclusive growth. Despite steps like the Chief of Defence Staff and "*Aatmanirbhar Bharat*" initiatives, India lags in disruptive technologies and dual-use infrastructure development, widening the capability gap with China. Research highlights the urgent need for India to develop a tailored civil-military fusion framework, enhance collaboration across sectors and invest in disruptive technologies to bolster national security and economic resilience. However, how these initiatives can be matured in fostering development in remote border areas with an objective of enhancing local economy and boosting defence capabilities has not been researched.

(l) **Gupta and Rao (2022), in their article "Connectivity Challenges in India's Border Regions,"** outline issues faced in Ladakh, where traditional development models have often overlooked the unique needs of border communities. However their findings are silent on use and development of dual use mobile towers that can meet requirements of Defence Forces and remote border villages of Ladakh.

(m) **Surabhi S. & Vig, K. (2020). Digital India: Opportunities and challenges. In Community Welfare Schemes in *Vikas-Sheel Bharat* (Vol. 2, pp. 1–10).** This excellent paper examines the transformative impact of the Digital India initiative, its role in promoting economic growth, improving governance and bridging the digital divide between rural and urban India. The

initiative aims to build a digitally empowered society through enhanced infrastructure, digital literacy and accessible public services. Key objectives highlighted in the paper include developing broadband and mobile connectivity, implementing e-governance and integrating digital technologies into agriculture, healthcare and education to spur entrepreneurship and socio-economic development. The paper also highlights pertinent challenges and barriers particularly in remote border areas with limited access to internet and digital resources. However, increased digitisation comes up with challenges of developing inclusive digital literacy programs, creation of financing models for border development infrastructure and addressing socio-cultural barriers to adoption. The paper is very well researched as far Digital India initiatives are concerned but is silent on requirement of cyber security and resilient digital systems for sustained utilisation in border areas.

(n) **Ghatak S. (2023). Civil-Military Fusion for National Security. United Services Institution (USI) Journal, Vol CL III, No 632, pp 306-314.** This article gives a very good insight into the potential of Civil-Military Fusion (CMF) to optimize the integration of civilian and military resources for achieving national security objectives. Lt Col Saumya Ghatak has drawn insight from the CMF models of the US and China and has studied the critical need for India to enhance its civil-military synergy through policy reforms, innovation, and structural integration. The paper emphasises the importance of building dual-purpose infrastructure, streamlining governance structures and enhancing education on defence related topics to improve awareness and trust between civil and military institutions. It advocates for integrating advanced technologies like AI, robotics, and cyber security into India’s defense

framework while leveraging public-private partnerships (PPPs) to boost investment in defense R&D and manufacturing. This excellent piece of research is however silent on potential of CMF to enhance national security and economic growth in remote border regions and how this can be addressed to improve governance, build digital infrastructure and promote CMF efforts in border areas.

Summary

The literature review highlights the research gaps that need to be explored to understand the role of digital infrastructure in Ladakh, emphasizing Civil-Military Fusion (CMF) as a key driver of security and economic development. While physical connectivity has improved, digital development remains fragmented and underutilized. India's lack of a structured CMF strategy contrasts with China’s integrated approach, which leverages AI, cyber security and dual-use infrastructure for national goals and advancement.

Despite initiatives like Digital India, Ladakh faces limited internet access, weak cyber security and poor mobile connectivity, affecting both military operational readiness and civilian economic activity. Public-Private Partnerships (PPPs) and AI-driven defence applications offer potential solutions, but governance challenges and policy gaps hamper progress.

A consistent CMF strategy is vital to bridge infrastructure gaps, augment security and drive regional economic growth. By integrating military expertise, private sector innovation and strategic policy reforms, India can create a secure, digitally connected and resilient border ecosystem.

CHAPTER 3

OVERVIEW OF LADAKH

"Ladakh is a symbol of India's pride. It is a land of brave patriots and unparalleled beauty, a region that demonstrates the strength of our unity and our will to protect our sovereignty."

- Prime Minister Shri Narendra Modi

Introduction: Ladakh – The Crown of India's Northern Frontier

Ladakh, often described as the "Land of High Passes," is a region of unparalleled beauty, cultural richness and immense strategic significance. As one of India's youngest Union Territories (UT), carved out of the erstwhile state of Jammu and Kashmir in October 2019, Ladakh represents a confluence of history, geography and modern geopolitics. Its unique characteristics make it a vital component of India's national security, cultural identity and developmental aspirations.

Geographical Context

Nestled in the northernmost part of India, Ladakh spans approximately 59,146 square kilometers, making it one of the largest yet most sparsely populated regions in the country[2]. Its landscape is dominated by towering mountains, barren plateaus and vast valleys bordered by some of the world's most iconic mountain ranges including the Karakoram in the north and the Zanskar in the south. The lowest pass to Ladakh is Zojila which is a 11,500 ft. It has an area of 4036 sq km and is situated between 34 to 35 degree North Latitude and 75 to 77 degree East West Longitude. The whole area is of high rocky mountains, desert arids, snow bound and devoid of natural vegetation. It occupies unique position because of its high altitude which ranges from 8000ft to

[2] https://en.wikipedia.org/wiki/List_of_districts_of_Ladakh

23000 ft above the mean sea level. The map of Ladakh[3] region is at **Figure 3.1.** The mountains are of sedimentary rocks and are in process of disintegration due to weathering.

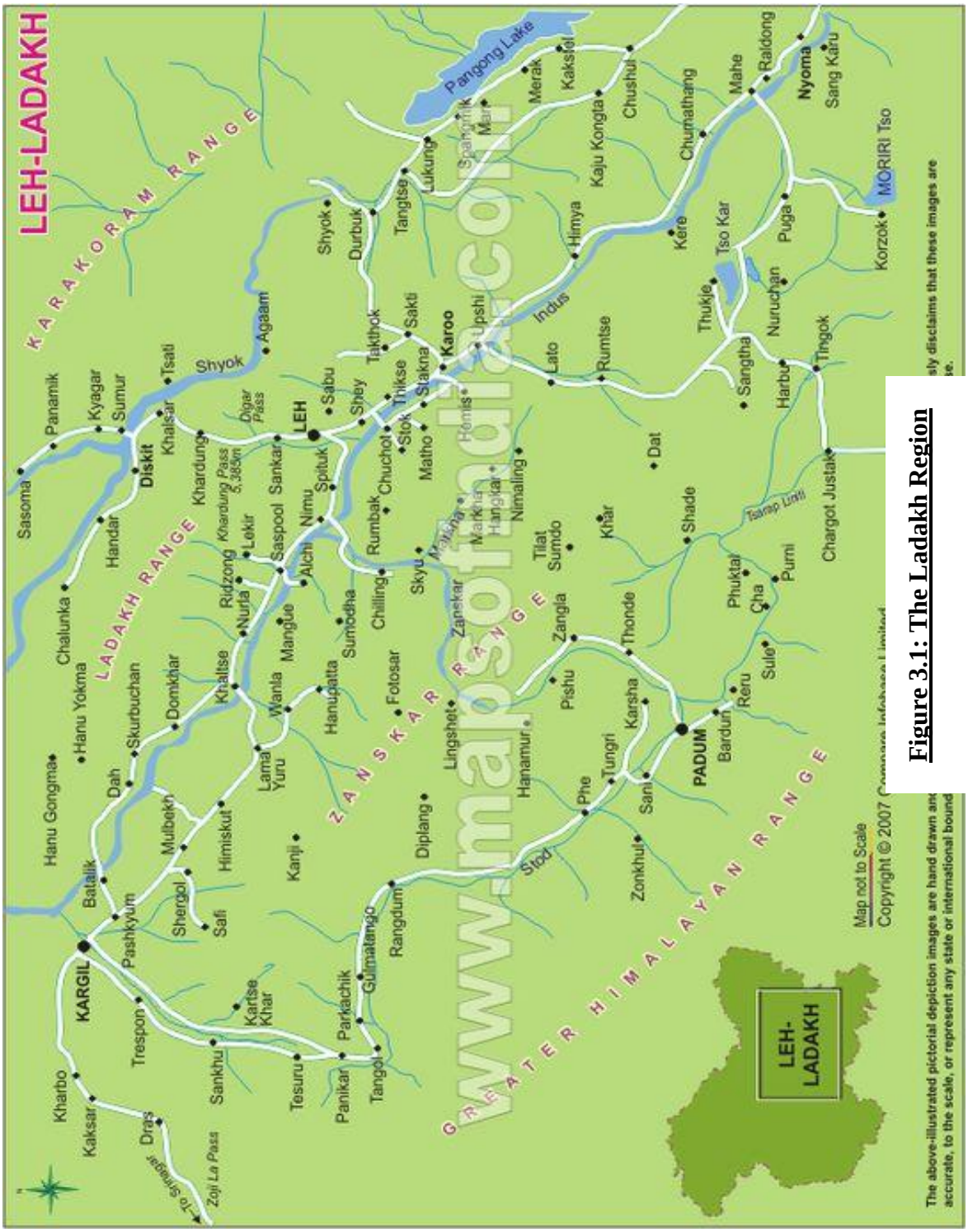

Figure 3.1: The Ladakh Region

[3] https://mapsofindia.com

The region's strategic location is underscored by its proximity to China's Tibet Autonomous Region to the east, Pakistan-administered Gilgit-Baltistan to the west and Afghanistan's Wakhan Corridor in the northwest. These geographical factors make Ladakh not only a land of incredible natural beauty but also a pivotal region in the geopolitics of South Asia. Sketch showing relevant places in Ladakh are given at **Figure 3.2**

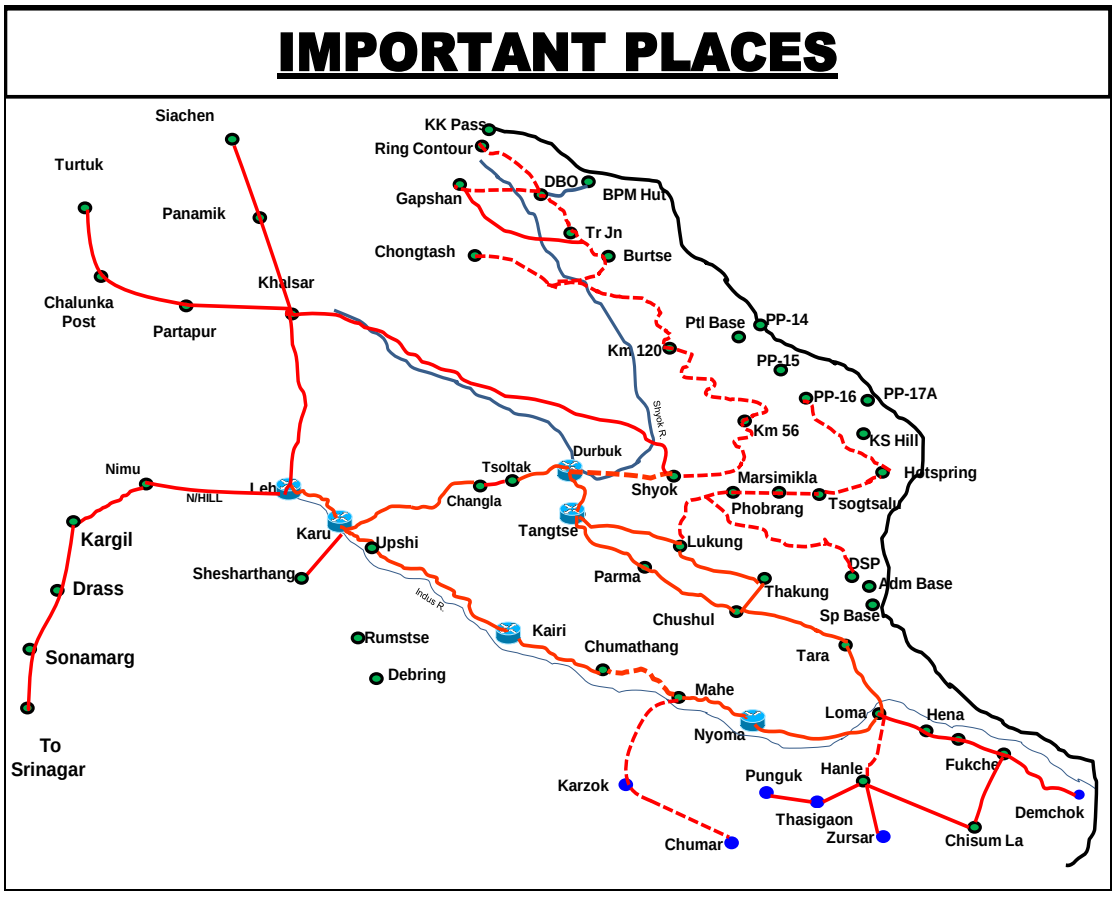

Figure 3.2: Important Places in Ladakh

Cultural and Demographic Significance

Ladakh is a melting pot of cultures, where Tibetan Buddhism and Shia Islam coexist in harmony. The Leh district is predominantly Buddhist, home to ancient monasteries like Hemis, Thiksey and Diskit, which reflect the deep spiritual roots of the region. The Kargil district, on the other hand, has a significant Shia Muslim population,

enriching Ladakh's pluralistic character. Smaller communities, including nomadic tribes like the Changpas, also contribute to the region's rich heritage.

Ladakh's cultural uniqueness is reflected in its traditional festivals such as Losar, Hemis Festival and Dosmoche, which attract visitors from around the world. Its handicrafts, including Pashmina wool products, Thangka paintings and traditional jewelry are highly valued for their authenticity and craftsmanship. Despite its remoteness, Ladakh has maintained its cultural identity, blending ancient traditions with modern influences. A deeper look at demographic variance of two main districts ie Leh and Kargil District is given as under:-

Leh District

Leh is the largest district in the country in terms of area. It is one of the coldest and most elevated inhabited regions of the world having 112 inhabited and 1 uninhabited villages. The biggest ethnic group is Buddhist having 66.40% of population followed by Muslims with 17.14% and Hindus with 14.28%. The main working force account for 33.07% to the total population where as marginal workers account for 16.50 % and non-workers 49.58%. The main occupation engaging the working force is cultivation (37.92%), agriculture labour (4.28%), household industry (1.24%) and other works (56.56%)[4]. Details of population by Sub Division, areas are given in the **Table 3.1**.

[4] https://leh.nic.in/about-district/demography/

S.NO	Sub Division	Number of		Population as per Census 2011	
		Villages	Panchayats		
1	Leh	21	19	~50,000	
2	Nubra	16	14	~27,000	
3	Khaltse	31	27	~17,000	
4	Nyoma	16	14	~13,000	
5	Kharu	19	15	~10,000	
6	Durbuk	10	9	~10,000	
	Total	113	98	1,33,000	
Decennelial Growth Rate (2001-2011)				13.87%	
Breakup of Population Census 2011				Male	72,306
				Female	60,926
Rural and Urban Breakdown of Population				Rural	87,329
				Urban	45,671
Religious Breakup					
1. Buddhist - 66.40% 2. Muslims - 17.14% 3. Hindus - 14.28% 4. Sikhs - 0.82% 5. Others - 1.36%					
Sex Ratio				690 Females per 1000 Males	

(Source : https://Leh.nic.in/demography/)

Table 3.1. : Sub Division Wise Population of Leh

Kargil District

Kargil district is extended over an area of 14036 sq. kms and comprises of 129 villages. As per Census-2011, population of the District was recorded as 1,40,802 souls. There was change of 18.02 % in the population compared to population as per 2001. The biggest ethnic group is of Muslims, followed by Buddhists and others. Details of population by areas is given in **Table 3.2** below[5].

S.NO	**Sub Division**	**Number of**		**Population as per Census 2011**	
		Villages	**Panchayats**		
1	Kargil	21	22	~50,000	
2	Drass	27	18	~27,000	
3	Shakar Chiktan	23	22	~17,000	
4	Sankoo	31	24	~13,000	
5	Zanskar	14	12	~10,000	
	Total	116	98	1,40,802	
Decennelial Growth Rate (2001-2011)				20.18%	
Breakup of Population Census 2011				Male	77,785
				Female	63,017
Rural and Urban Breakdown of Population				Rural	1,24,464
				Urban	16,338
Religious Breakup					
1. Buddhist - 14.29%					

[5] https://dseokargil.ladakh.gov.in/panchayat.html

2.	Muslims	-	76.87%
3.	Hindus	-	7.34%
4.	Sikhs	-	0.83%
5.	Others	-	0.67%
Sex Ratio			810 Females per 1000 Males

(Source : https://Kargil.nic.in/demography/)

Table 3.2 : Sub Division Wise Population of Kargil

Geopolitical Significance

Ladakh's location at the confluence of India, China and Pakistan places it at the heart of South Asia's geopolitical dynamics. The region serves as a buffer zone along contentious borders, particularly the Line of Actual Control (LAC) with China and the Line of Control (LoC) with Pakistan. Ladakh's eastern boundary is marked by the Aksai Chin region, which is under Chinese control but claimed by India. To the west, the region adjoins Pakistan-occupied Kashmir (PoK) and the strategically significant Gilgit-Baltistan region. Ladakh has been a focal point of India's territorial disputes, particularly with China. The region witnessed the Sino-Indian War of 1962, the Kargil conflict of 1999 and the recent Galwan Valley clashes in 2020. These events underscore Ladakh's role as a frontline in India's defense strategy and its importance in maintaining regional stability.

Strategic Importance

The rugged terrain of Ladakh makes it one of the most challenging yet strategically vital regions for India's military. The presence of the Siachen Glacier, the world's highest battlefield, highlights the extreme conditions under which Indian Armed Forces operate to secure the Northern Borders. Forward posts like Daulat Beg Oldie

(DBO), Demchok and Chushul play a crucial role in monitoring and countering adversarial activities along the LAC. The region's strategic significance is further enhanced by its proximity to the Karakoram Pass and the China-Pakistan Economic Corridor (CPEC). As China develops dual-use infrastructure in Tibet and Pakistan to strengthens its hold on Gilgit-Baltistan, Ladakh remains central to India's counter-strategy. Infrastructure development, including roads, tunnels, digital infrastructure and airstrips has been prioritized to ensure rapid troop mobilization and logistical support in this remote region.

Developmental Challenges and Opportunities

Ladakh's transformation into a Union Territory has brought renewed attention to its developmental needs. Despite its vast potential, the region faces significant challenges in infrastructure, healthcare, education and digital connectivity. Harsh winters and difficult terrain isolate many areas, limiting access to essential services and economic opportunities. Tourism is a major driver of Ladakh's economy, with its stunning landscapes such as Pangong Tso, Nubra Valley and Zanskar attracting adventure enthusiasts and cultural tourists alike. Additionally, the region holds immense potential for renewable energy, particularly solar and wind power, given its unique climatic conditions. Efforts are underway to balance development with environmental sustainability. Projects like the Zoji La tunnel and the construction of renewable energy hubs aim to enhance connectivity and economic growth while minimizing ecological impact. Promoting eco-tourism and protecting Ladakh's fragile ecosystem are essential for preserving its natural and cultural heritage. Ladakh's transition to a Union Territory symbolizes its integration into India's national mainstream. This change has brought governance closer to the people, allowing for more localized decision-making. However, it has also raised questions about preserving Ladakh's

unique cultural identity and ensuring equitable development across its diverse communities. The region's strategic, cultural and developmental dimensions make it an essential component of India's aspirations for national security and economic growth. Ladakh is not only a land of astonishing natural beauty but also a testament to the resilience and strength of its people, who continue to thrive amidst harsh conditions and geopolitical challenges.

CHAPTER 4

CIVIL MILITARY FUSION IN LADAKH

"Civil-military fusion bridges the gap between a nation's technological edge and its strategic priorities, ensuring both economic and security advancement."

- Xi Jinping

Civil Military Fusion: Concept

The concept of Civil-Military Fusion (CMF) signify the union of military and civilian resources and systems for maximising a nation's ability to state its comprehensive national power during war, peace and also in grey zone situations. The exchange of resources between civilian and military segments as well as industry and academia has been derisory in India. There is an urgent need for opening up hitherto fore protected areas such as high-end technology defence manufacturing, space and cyber technologies to the private sector which has enormous talent and resources. A revolving door mechanism between civil and military as practiced in the US will be highly advantageous for India and this would facilitate 'Make in India' and '*Aatmanirbhar Bharat'* in defence manufacturing[6]. In the primitive years of our Nation's Independence, the political maxims discouraged entrepreneurship enthusiasm, business development and capacity building. The development of industry was slave to license raj and babudom and culture of working in silos by civil bureaucracy, military, industry and academia was amply prevalent. It is a well known idea now that for capacity building, coalescing of business houses, academia and Armed Forces will be the key pillars of wealth creation for holistic development of societies and the nation as a whole. Qualitative aggregation of resources and

[6] https://www.idsa.in/idsa-event/panel-discussion-on-civil-military-fusion-in-india/

capacities from both the civil and military domains is the foundation stone of Civil Military Fusion. The stone walls that exist between the silos of civil and military institutions must be collapsed in order to allow seamless infusion of talent and capacities in the military, civil services, scientific community, academia, industries, domain experts, technologists and entrepreneurs. The complex security challenges that the nation faces especially on its Western and Northern borders demand complex security responses that can only be addresses through Whole of Nation approach.

Global Scan of Civil Military Fusion and Outcomes

United States of India (USA)

The United States has long pioneered the concept of Civil-Military Fusion, where collaboration between civilian sectors—like academia, industry and technology firms and the Armed Forces has driven deep advancements in national security and economic growth. Historically the feature of this fusion has been the Defense Advanced Research Projects Agency (DARPA), which has advanced revolutionary technologies (Internet) by leveraging civilian expertise and innovation for defence requirements and use. DARPA's investments have led to the development of the internet, GPS and stealth technology, all of which were initially military projects that transformed civilian life. This integration of civilian technological proficiency with military applications not only enhances defence capabilities but also invigorates the economy. The U.S. Department of Defense's (DoD) partnerships with Silicon Valley tech companies illustrate this fusion, as innovations in artificial intelligence, cyber security and unmanned systems are accelerated through collaborative efforts. Moreover, the concept of the "Third Offset Strategy"[7] encapsulates the U.S. approach to maintaining its strategic edge through technological superiority, fueled by civil-

[7] U.S. Department of Defense. (2014). *The Third Offset Strategy*. Retrieved from https://www.defense.gov

military partnerships. This strategy has spurred advancements in autonomy, robotics and big data analytics—fields where civilian innovation intersects with military needs. The dividends are evident not only in enhanced military readiness but also in economic gains. For instance, the commercialization of Global Positioning System (GPS) technology revolutionized industries from logistics to telecommunications, creating a multi-billion-dollar market.

Additionally, the U.S. military's commitment to fostering small business innovation through programs like the Small Business Innovation Research (SBIR)[8] grants showcases how civil-military fusion supports entrepreneurial ventures while fulfilling defence requirements. This approach ensures a steady pipeline of cutting-edge technology into defence applications while invigorating the national economy with new business growth and technological leadership. The dividends of this fusion are thus multi-fold: superior national defense capabilities, economic growth through technology transfer and sustained global technological leadership.

Off late the United States Army Futures Command (AFC) has been established as a public-private partnership[9]. The AFC is strategically located in the city of Austin, Texas which is considered to be America's innovation hub. The AFC has been a top recruiter of talented students, professionals and entrepreneurs by capitalising on the robust start-up ecosystem in Austin. The AFC is an example that signifies the complexities entrenched in the concept of CMF as it consists of many layers and nuances.

[8] Small Business Administration. (n.d.). Small Business Innovation Research (SBIR) program. Retrieved from https://www.sbir.gov

[9] Army Futures Command (2018) **Transforms the Army to Ensure War-Winning Future Readiness, retrieved from** https://www.army.mil/futures

China's Military Civil Fusion (MCF)

China has coined the term Military Civil Fusion (MCF) and has made it into a strategy that has become the basis of its national security and development, spearheading the flawless amalgamation of military and civilian resources to accentuate the economic growth, technology innovation and strategic capacities. China had previously relied on the Department of Civil Military Integration (CMI) Promotion of the Ministry of Industry and Information Technology to act as the administrative body over CMI work[10]. However it officially recognised MCF as the national security strategy in 2015. MCF in China aims to establish the link between the defence and civilian sectors, bridging all gaps and allowing the country to exploit vast resources to achieve a world-class military while simultaneously fostering economic growth not only in urban China but also in rural and remote border areas with India. The rewards of this strategy are particularly manifesting in China's border areas, where the fusion of economic and security development has transformed historically remote and underdeveloped regions into zones of strategic and economic significance.

The primary driver of China's MCF policy is the development and acquisition of dual-use technologies, such as artificial intelligence, big data, space exploration and robotics, which serve both civilian and military purposes[11]. The idea of creating a robust MCF through a military-academic complex where the state identifies and funds the brightest students and scholars to pursue doctoral research in the best institutions abroad and subsequently, this talent becomes the driving factor behind China's technological and scientific innovation in defence manufacturing. The construction of

[10] Dixit, S. (2023). Military-Civil Fusion in China and Lessons for India. Synergy Journal, 2(1), 88-105
[11] Chansoria, M. (2020). *China's Military-Civil Fusion Strategy and Implications for Global Security.* Observer Research Foundation. Retrieved from https://www.orfonline.org

infrastructure in border areas, including roads, railways, airports and logistics hubs, reflects this dual-use philosophy. Projects like the China-Pakistan Economic Corridor (CPEC), a flagship initiative of the Belt and Road Initiative, illustrate how MCF facilitates economic growth while enhancing military mobility and logistical capabilities along the country's Western Borders. For instance, the development of highways and railways in Xinjiang not only bolsters connectivity with Central Asia but also ensures the rapid deployment of troops and supplies in the event of conflict. These dual-use infrastructures have been crucial in securing China's borders while simultaneously opening up new trade routes, boosting tourism, and attracting investments to previously isolated regions. The economic dividends of MCF in border areas have been transformative. In regions like Tibet and Xinjiang, which traditionally faced significant socio-economic challenges, MCF policies have led to improved digital connectivity and increased trade[12]. For example, the development of high-speed rail networks, such as the Lhasa-Nyingchi Railway in Tibet, development of Optical Fiber based communication infrastructure right till the LAC linking all civilian towns and villages as also the forwards military deployments has enhanced not only the movement of forces with better coordination but has also stimulated the growth of local communities thus giving impetus to the local economy. The establishment of Special Economic Zones (SEZs) and MCF industrial zones in border provinces has further catalyzed economic growth by fostering innovation, creating jobs and attracting investments.

Moreover, China's MCF initiatives in border areas have played a critical role in addressing security challenges, particularly in Xinjiang and Tibet. These regions have long been considered hotspots for separatist movements and ethnic tensions. By

[12] Zhang, J., & Wang, X. (2015). *Developing China's border regions through Belt and Road Initiatives*. China International Studies, 50(4), 45-60

integrating military capabilities with economic initiatives, China has sought to stabilize these regions. MCF facilitates the deployment of advanced surveillance technologies, such as drones and facial recognition systems, while economic development initiatives aims to reduce poverty and unemployment, addressing the root causes of unrest. China's whole-of-nation approach to MCF is considered as all-embracing partnership between the military, local governments, academia and private enterprises that have ensured the success of this strategy. The MCF in China has transformed its border areas into hubs of economic activity and strategic significance. By integrating civilian innovation and military strength, China has not only enhanced its defence capabilities but also achieved substantial economic growth, particularly in its remote and challenging border regions. This model, though uniquely Chinese, offers valuable lessons for other nations like India to imbibe.

Israel's : Civil Military Fusion

Israel has implemented an successful Civil Military strategy by creating a reservist service in the Israel Defence Forces (IDF) that has shaped a revolving door ecosystem between civil and military domains. As a result, talented professionals and technocrats have oscillated between the civil and military domains creating a robust defence start-up ecosystem.

India : Civil Military Fusion

India's foundational metrics for developing Civil Military Fusion are undergoing brisk changes. In case India has to rise as a power of consequence, fully secured at its borders and marching towards becoming a 55 trillion dollar economy by 2047, the prerequisite of Civil Military Fusion is undisputed. The Chinese model as explained above is autocratic and top driven and will not suit our democratic fabric. The US model is too concentrated, advanced and based on the existing Military Industrial

complex edifice that were setup post World War II. However both models suitably adapted to Indian conditions can work in our environment. A strong political leadership prioritising CMF as a national security imperative and clear legal and policy frameworks defining roles, responsibilities and authorities of civilian and military actors would help in achieving good CMF in India.[13]

The desire is gaining ground and is becoming evident and is being articulated in the '*Atmanirbharta'* program and its predecessor 'Make in India'. However this desire needs to be followed in letter and spirit to arrive at concrete model that can serve the nations long term achievements. Accordingly, Civil Military Fusion needs a whole of the nation approach and the ability to stay the course for over a decade at least, so that the entire process becomes self-driven and irreversible as did our economic reforms of the nineties.[14] The establishment of the Chief of Defence Staff & Department of Military Affairs (CDS-DMA) has been path-breaking as it empowered the defence services to think, articulate, design and drive change in the national security system. Despite these changes, India's delivery in terms of CMF has been sub-optimal. The civilian domain of the Indian startup industry has undergone more growth as opposed to start-ups working in the military domain. Unless the startups in the military domain gain rapid acceleration, there is a risk of them petering out. Also common vision and convergence of tasks/action between civil and military will help in achieving national goals.

Civil Military Fusion for Development of Digital Infrastructure in Union Territory of Ladakh

The opportunities in Civil Military Fusion can be harnessed in many domains like development of Digital Infrastructure, Communications to include development of

[13] Thapa, A. (2024). Civil-Military Fusion in the Indian context. CAPS in Focus.
[14] Shankar, P. R. (2023). Civil Military Fusion: A Model for India. CENJOWS Journal, (1), 52-67

roads and bridges, transportation sector, health sector, power grid, humanitarian assistance and many more sectors can be listed. However, this research is focused towards analysing the development of digital infrastructure with a view to understand what impact it will bring towards improving the security apparatus in border areas as also in boosting of local economy. In today's digital ecosystem, telecommunication has become the foundation for businesses, governments, communities and families to seamlessly connect and share information. To this effect let us now analyse the current state of digital infrastructure in Ladakh. The details of overall tele-density of the UT of Ladakh compared with Pan India density is as shown below in **Table 4.1** below**.**

Parameters	Ladakh			All India		
	Total	Rural	Urban	Total	Rural	Urban
Subscriber base (Wireline+Wireless)(In mn)	0.54	0.29	0.25	117.9	520.30	651.61
Tele-density (Wireline+Wireless)(In %)	179.00	139.66	268.37	84.86	58.01	134.62
Wireless subscribers (In mn)	0.53	0.29	0.24	114.4	518.31	627.14
Wireless Tele-density (In %)	177.76	139.1	265.5	82.94	57.79	129.56
Wireline subscribers (In mn)	0.004	0.001	0.003	26.47	1.99	24.48
Wireline Tele-density (In %)	1.23	0.54	2.81	1.92	0.22	5.06

Source : TRAI Report on Ladakh

Table 4.1: Overall Telecom Density Scenario of Ladakh

According to TRAI report, the average tele-density of India as on 30th September 2024 stood at approx 84.86% with Ladakh having an average tele-density of approx 182.00 %.[15] Despite its high tele density of 182.00%, there are many sparsely populated remote and inaccessible regions in the UT that have limited or no

[15] **Telecom Regulatory Authority of India.** (2023, April 24). *Recommendations on improving telecom coverage and backhaul infrastructure in far-flung areas of Ladakh*. Retrieved from https://www.trai.gov.in

telecom coverage due to the challenging and mountainous terrain of the region, which makes it difficult to build and maintain telecommunications infrastructure. High density is possibly due to very high floating population attributed to tourism. However, a substantial digital divide still continues to exist in the UT. This digital divide is particularly pronounced in the remote and far-flung regions of the Ladakh UT.

There has been growing demand of people of Ladakh residing near the Line of Actual Control (LAC) for high-speed internet. The people, especially those residing along the Line of Actual Control, face hardship in pursuing online education and accessing digital banking. Many remote areas in the UT are without mobile towers. People living close to the LAC and the Line of Control (LoC) constantly face network issues. Mobile connectivity is strategically important for the locals as they are the first line of vigil who immediately inform the Armed Forces about any incursion by PLA troops along LAC in the region. As an outcome of the above, the government has initiated schemes like *USOF and Vibrant Village Programmes* bringing various stakeholders (Telecom Service Providers) to enhance the telecom connectivity in the remote and far-flung areas of the UT which will help in resolving the issues raised by the people.

On study of existing coverage of mobile availability in 229 villages of both Kargil and Leh districts of the UT, it was found that approximately 27 villages are devoid of any digital connectivity. A large number of Army, ITBP positions which at places were co-located with the remote villages and mostly isolated from civil population has no connectivity. Amongst TSPs, M/s RJIL(JIO) and M/s *Bharti* Airtel are offering 4G based coverage throughout all their operational sites in Ladakh, whereas M/s BSNL is offering 2G or 3G based services at all the operational sites in

the UT. M/s Vodafone India does not offer its services in this area. Data was obtained from two major TSPs ie JIO and Airtel to understand the coverage and the outcome was analysed under two categories:-

- ❖ Villages that have cellular mobile coverage due to presence of cellular tower(s) in those villages.
- ❖ Villages that have incidental coverage due to spill over of cellular signals from the adjoining villages

Based on the data obtained from TSPs, the details of villages in Ladakh which are having cellular coverage (including 4G and non-4G) is as tabulated below at **Table 4.2**

District	No of Villages	Villages with 4G Connectivity	Villages with Non 4 G Connectivity	Total Number of Villages with Mob Connectivity
Kargil	113	63	6	69
Leh	116	60	30	90
Total	229	123	36	159

Table 4.2: 4G & Non 4G Connectivity

The above table indicates that approx 70 Villages in Ladakh are without non 4 G mobile coverage. The graphical depiction is given in **Figure 4.1**.

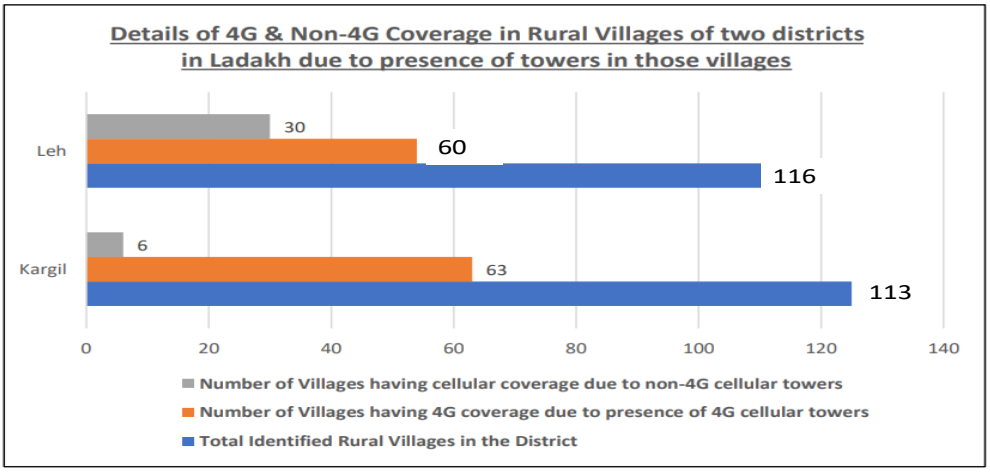

Figure 4.1 : 4G & Non 4G Connectivity

However deeper analysis of the data suggested that many villages were getting incidental coverage by being in near vicinity of the towers located in places covering other villages. It emerged that approximately 56 villages were having incidental coverage. The details are given in **Table 4.3** below.

District	No of Villages	Villages with incidental 4G Connectivity due to towers in nearby villages	Villages with Non 4 G Connectivity due to towers in nearby villages	Total Number of Villages with Incidental Mob Connectivity
Kargil	113	27	10	37
Leh	116	10	09	19
Total	229	37	19	56

Table 4.3 : 4G & Non 4G Incidental Connectivity

The graphical depiction is given in **Figure 4.2** below.

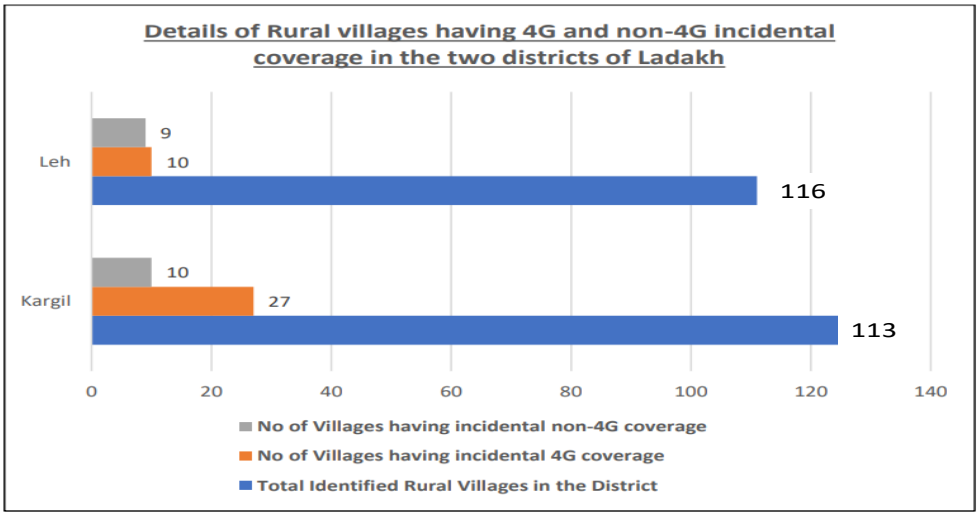

Figure 4.2 : 4G & Non 4G Incidental

Study of Gap Analysis

The study of above table clearly indicates that there are number of villages in two districts of Ladakh which are devoid of any connectivity. A comparative Table has been created from the data given in above Tables.

District	No of Villages	Villages with 4G Mobile Coverage	Villages with Non 4 G Mobile Coverage	Total Number of Villages with Mobile Connectivity	Total Number of Villages without Mobile Connectivity
Kargil	113	90	16	106	07
Leh	116	70	39	109	07
Total	229	160	55	215	14

Table 4.4: 4G & Non 4G Overall Connectivity

A graphical representation of the void is given as Under at **Figure 4.3**.

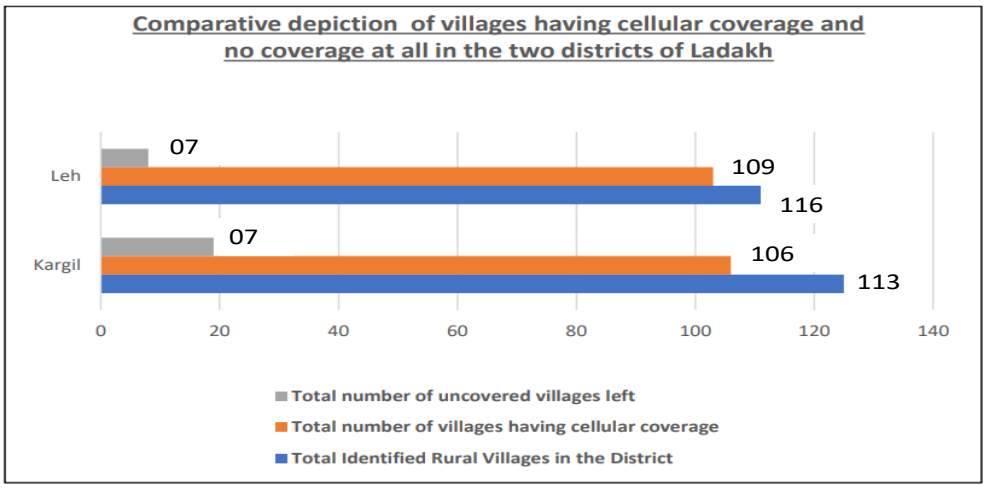

Figure 4.3 : 4G & Non 4G Overall Connectivity

The details of 14 uncovered villages are given at Appendix A.

The Government of India in its endeavours to promote infrastructure capacities through PM *GatiShakti* initiatives has launched *Vibrant Village Programs* to digitally connect all remote border villages along Northern Borders. Under these programs initiatives like Universal Service Obligation Fund Saturated (USOF) Villages has already been rolled out. Also an OFC-based *BharatNet* project has also been rolled out provide telecom and internet services to unconnected distant and far-flung villages along Northern Borders[16]. The details of the ongoing USOF efforts for both mobile coverage and internet connectivity based respectively, affecting the two districts of Ladakh are as mentioned below :-

- **USOF Schemes for Mobile Connectivity**

[16] **Telecom Regulatory Authority of India.** (2023, April 24). *Recommendations on improving telecom coverage and backhaul infrastructure in far-flung areas of Ladakh.* Retrieved from https://www.trai.gov.in

- **Mobile Connectivity in 354 Villages of Uncovered Border Areas** - The programme was planned to raise 354 mobile towers in 354 distinct villages in border regions of Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttar Pradesh, Bihar, Rajasthan, Gujarat, Uttarakhand and other important areas in order to provide mobile services. On April 28, 2020, a contract was signed by USOF with M/s Reliance Jio Infocomm Limited (the implementing agency). On 09 November 2021 with the amendment of the agreement, additional 55 villages were included in the list of villages for the installation of mobile towers. Out of the 14 unconnected villages in the two districts of Ladakh, 12 villages are already planned to be covered under this '354 Villages scheme'

- **Saturation of 4G Mobile Services in Uncovered Villages Across the Country** - On 27 July 2022, Central Government approved the USOF sponsored initiative to provide 4G mobile coverage to all unconnected villages in the nation. The project seeks to provide 4G mobile services in 24,680 untapped villages in challenging and isolated places (including the villages in UT of Ladakh). The project also incorporates a clause that allows for the addition of 20% more communities (approximately, additional 5000 villages) due to reasons like rehabilitation, new settlements, withdrawal of services by existing providers, etc. Additionally, 6,279 villages with only 2G or 3G access will also be upgraded to 4G. M/s *Bharat Sanchar Nigam Limited* (BSNL), utilizing the indigenously developed 4G technology stack, is carrying out the project execution. The project is being supported by

the Universal Service Obligation Fund. Eleven unconnected villages of Ladakh are being covered under this scheme. However, the progress on this scheme has been very slow and not much has been achieved.

- **USOF Scheme for connecting villages on Optical Fiber *BharatNet*** - To deliver high speed broadband access to all Gram Panchayats (about 2.5 lakh) in the country, *BharatNet*, one of the largest USOF sponsored rural telecom project in the world, is being deployed in phases. In the first phase over 1 Lakh Villages were connected on Bharat Net by December 2017. The scheme was further extended with approval of the Cabinet to add 1.25 Lakh more Gram Panchayats part of first phase to align with the vision of Digital India. The revised approach offers the best possible media mix (OFC, Radio, and Satellite) to link *Gram Panchayats* (GPs). In Phase II, connectivity of GPs was planned using different implementation model to include State-led Model, the Private Sector Model, and the CPSU Model, as well as Last Mile connectivity in GPs using Wi-Fi or any other compatible broadband technology. The present status as on date for satellite-based connectivity extended by M/s BBNL to *Gram Panchayats* in UT Ladakh are as tabulated below in **Table 4.5**.

Villages Connected on Satellite		
Planned	Completed	Operational
193	192	43

Table 4.5 : Overall Status of M/s BBNL Satellite

Out of the 14 uncovered villages in the districts of Leh and Kargil there are 7 villages that are considered to be covered under the '354 Villages scheme' and 05 villages are intended to be covered under 'Saturation of 4G Mobile' scheme of USOF. This leaves only 3 villages that will neither have any mobile coverage, nor are being planned to be covered in any of the two USOF schemes.

After having analysed the complete availability of Digital Infrastructure, mainly linked to availability of mobile connectivity in the two districts of Ladakh, it has emerged that most population centres in Ladakh has some kind of mobile connectivity and only three villages are isolated and devoid of any connectivity. With this kind of availability of mobile network in Ladakh, inherently the Armed Forces deployed in hinterland derive mobile connectivity by being in proximity of population centres. However, major challenges emerge as we get closer to the LAC in Eastern Ladakh and Line of Control (LC) in Western Ladakh. Though most of the Army locations are connected on the network owned by Army and the infrastructure developed inherently by them to main connectivity till the forwards posts. However, all the Defence locations are connected on landline and are dependent for mobile connectivity on civilian infrastructure. It is reasonable to assume that most of the mobile towers are located near to the villages and population centres as the TSPs deploy their infrastructure based on revenue they are able to generate for maintenance and thereafter expansion of their network. There is no dedicated deployment of mobile towers to make up for the needs of the forwards defence forces deployment. Also, over the years defence has also been sceptical in allowing their premises to private players to deploy their infrastructure as it would lead to compromise of security. Therefore the focus of defence has always been to develop its own infrastructure. To this effect, many projects have been realised over a period of time

to enhance voice, video and data connectivity on Army owned infrastructure in the UT. Though the government has been amenable to development of inherent Defence Communication infrastructure and accordingly has allotted funds for develop over a period of time.

It must be noted that in the UT of Ladakh, considerable development of digital infrastructure has taken place both by the civilian authorities as also by the Defence establishment. However, there has been no thought in coalescing of effort to develop a comprehensive plan to meet the requirements of both civilian and military establishments and entire development has taken place in silos. Therefore it is important to understand the defence owned digital infrastructure that can be leveraged to enhance digital connectivity in far flung area where either there is sparse civilian population or isolated defence deployments. There is huge opportunity of Civil Military Fusion to attain the common objective of enhanced digital connectivity to the entire Ladakh region agnostic to areas being close to LAC or LC. However for this to happen it is important to understand the Defence owned infrastructure as also the voids that exist in coverage of mobile network in the forward areas close to the LAC or LC. The data on Army locations and the alignments of Optical Fiber links being of confidential nature therefore only broad contours of availability and locations are being mentioned to avoid any compromise on security.

The Defence owned infrastructure in terms of OFC connectivity is given in **Figure 4.4**

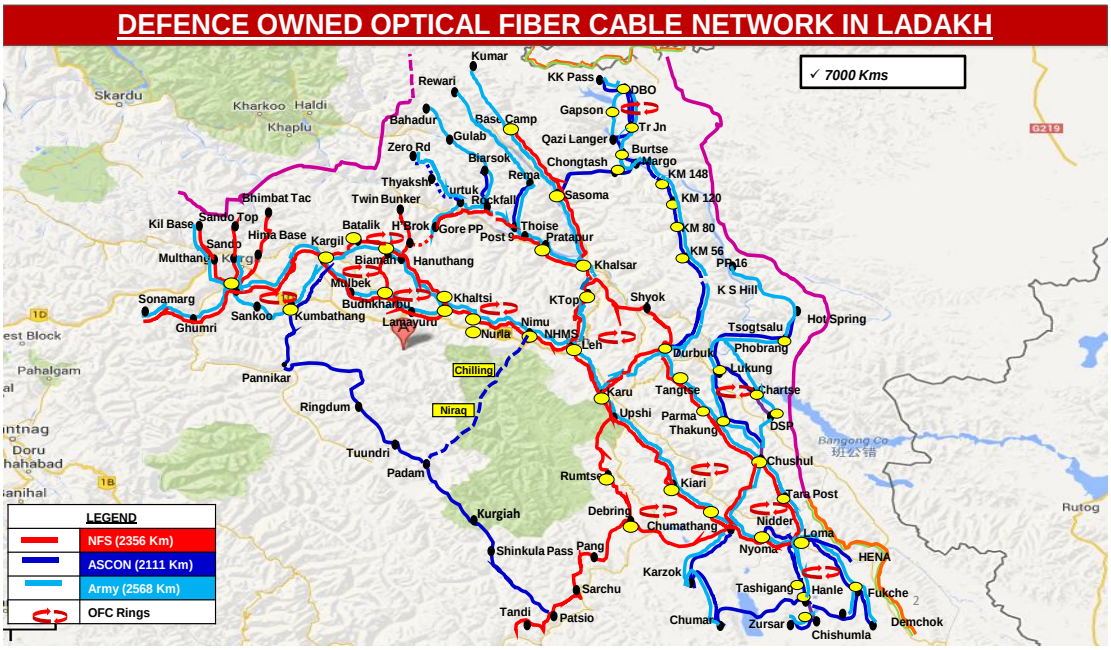

Figure 4.4 : Defence Owned OFC

It can be seen from the figure above that Defence has an OFC infrastructure of various kind laid all across the UT making a network of almost 7000 Kms. However most of the OFC has been of vintage and is being maintained at a very high OPEX. However in absence of any other network to service the vast frontier along LC and LAC this network is being continued with. The Network for Spectrum OFC as highlighted in the picture above is the latest OFC that has been commissioned in the UT connecting major hinterland and forward locations. However, there is no mobile network owned by the Army and therefore dependence on civilian infrastructure is paramount which is not available in forwards areas.

Civil Military Fusion Opportunity

Though the USOF and the 4G saturation programme of the Government is aimed at connecting major and minor population centers, the requirements of the Armed Forces has not been met and therefore the civilian authorities have been approached to realign the USOF sites or plan addition sites to meet the requirements of defence. The

unlit areas for mobile connectivity that are essential to needs of the Armed Forces in Ladakh are given as under in **Figure 4.5**

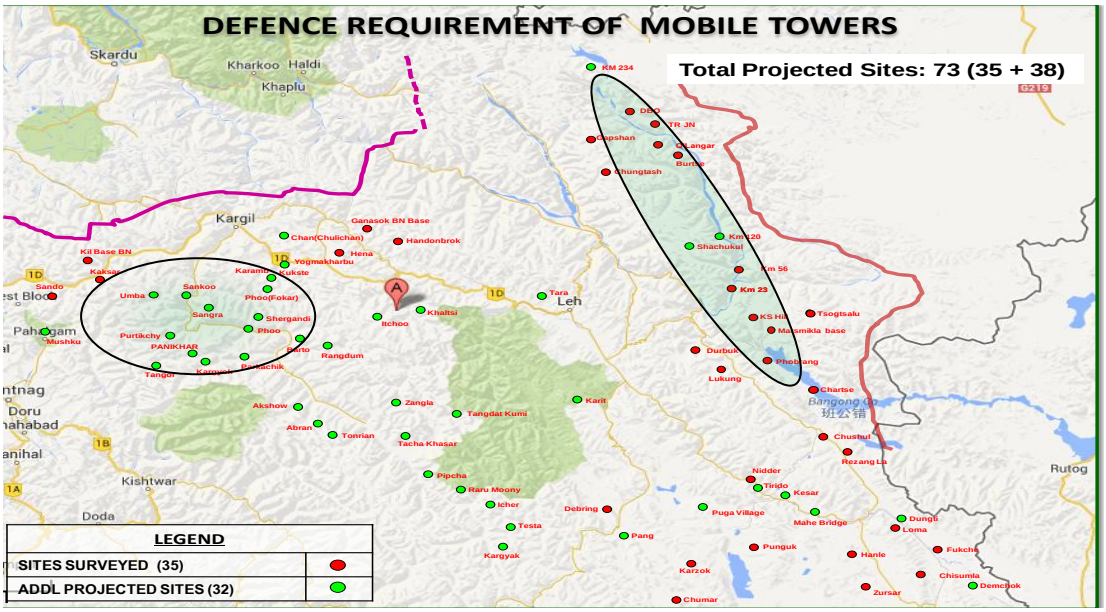

Figure 4.5 : Defence Requirement of Mobile Towers

It can be seen from the above picture that the Armed Forces has projected a requirement of 73 additional mobile towers giving mobile connectivity to the forward troops deployed near LAC and LC in Leh and Kargil Districts. Though most of the demands of the defence forces have been catered for by the authorities however the frontline areas as indicated by the red dots on the picture are devoid of satellite and OFC connectivity that can connect Base Transceiver Station to give mobile signals. However, most of these far flung locations are connected with Army owned OFC that gives land line connectivity. Here lies the opportunity of Civil Military Fusion to harness each other's resources by extending mobile connectivity to troops but also to the local residents as also to the thousands of tourists who flock the far flung areas almost close to the LAC and LoC. However, amalgamation of civil and military resources comes with large number of challenges as lot of security issues related to unnecessary disclosure of locations of military significance to the enemy as also flow

of data on common network can cause huge problems in its management and security repercussions. Another major challenge is for TSPs to develop these sites investing large sums of money without intended revenue collection stifles the initiative. Also the maintenance cost of human capital and equipment is also not commensurate to the investment. Therefore it is important to harness the resources of Defence to improve the functionality of infrastructure in far flung and remote areas near the border. Let us look at the challenges being faced by TSPs in development of infrastructure in Border Areas.

Challenges & Barriers to Development Of Digital Infrastructure through Civil Military Fusion

Key issues being encountered in progressing mobile network in remote and far-flung areas of Ladakh by the Telecom Service Providers are as given below:-

- **Inhospitable Terrain**. Kargil has precipitous, rugged and high landscape and Leh primarily consists of high plains and deep valleys. Frost bites and heavy snowfall are common happenings in Ladakh from November to March, making some of the areas specially near LAC and LC inaccessible in winters. This impedes the construction of new mobile towers rollout in remote areas. No synergy exist between Civil and Military establishments to address this issue.

- **Poor Availability of Power Supply**. The power supply arrangements and duration of availability of commercial power supply is not very encouraging for TSPs in the areas close to the borders. This leads to live BTSs being run on Diesel Generator sets. Major two TSPs, JIO and Airtel run most of the remote sites on Generator Sets. M/s BSNL also runs one-third of its BTS sites in Leh fully dependent on Army DG power and Army OFC. The

inadequate road network and harsh weather hinders the regular supply of diesel to these remote areas, resulting in long disruptions in operations of most of the towers in these areas.

- **Poor Return on Investment (RoI).** The villages in Ladakh are sparsely populated and in some of these villages, the inhabitants have two distinct settlements that they occupy during different seasons. Factors like low population density further augmented with element of transient settlements pose discouraging prospects towards RoI for operating TSPs and hence they channelize their efforts more on consolidation and further improvement of telecom infrastructure in revenue generating regions within Ladakh. Many of the previous and ongoing efforts, being undertaken to extend telecom coverage to these remote and far-flung areas are being rolled out and operated through USOF schemes of DoT.

- **Transmission Media Related**. The laying of underground cable in these areas is challenging, resulting in a lack of reliable transmission medium in the area.

- **Right of Way (RoW) Related Issues**. There are major challenges in obtaining ROW by the TSPs as most of the prospective routes are either too narrow for underground cable laying or are under Defect Liability Period (DLP) during which digging is not permitted. Local administration also charges high rates to TSPs which escalates the cost beyond business options for TSPs.

- **Clearance from Defence.** Most of the land in Ladakh is not Defence Land and clearance from the local bodies to install towers in the areas occupied by Armed Forces is very difficult to obtain.

- **<u>Operation of Civilian Infrastructure by Armed Forces</u>.** Even if the mobile towers are installed in the locations where Army, ITBP or any other defence agency is deployed, the contours of operating and maintaining of such infrastructure remain very unclear and impedes the TSPs from investing in such areas.

Opportunities for Civil Military Fusion for Development of Digital Infrastructure

Indian Army has taken the initiative in Ladakh and a number of new Mobile Towers have been established to provide Airtel 4G connectivity in the remote areas of Vibrant Villages of Hanle Valley and Loma with the consistent efforts of fusion with industry and local government to promote digital connectivity and improving the quality of life of not only the soldiers deployed in these areas but also the local communities in the remote areas of Changthang Region by giving boost to local economy and bringing in new opportunities for the region. New mobile tower has also been commissioned in the Siachen Glacier, the highest battlefield of the world by perfect fusion of Military resources and initiative and willingness of the TSPs like M/s *Bharti* Airtel. The details of news mobile towers being planned or made active to meet the requirements in far flung areas of Ladakh are given at Appendix B.

Case Study Project SAMBHAV: Civil Military Fusion Endeavour

A classic example of Civil Military Fusion can be analysed through the case study of development of Project SAMBHAV of the Indian Army which has turned out to be a success story in development of Digital Infrastructure Pan India and has been very effectively used in Ladakh although by the Defence personnel only. However, the development of the system is first of its kind in the country which has turned out to be an outstanding example of synergy between Defence, Private Industry and Academia.

A snap shot view of the endeavour is highlighted below to give credibility to the aim of this dissertation.

Evolution and Concept of SAMBHAV

The Armed Forces has been deficient of mobile telephony and rather have been burdened with use of insecure mobile communications that at times compromised operational security requirements. It was a felt need of the environment that operationally and administratively committed formations and units needed secure mobile communications. However, this was not possible as funds crunch did not allow development of a separate mobile system only for the defence forces. A large number of brainstorming sessions happened in Army HQs and as an outcome, an idea of developing a secure mobile communication system riding on the civil infrastructure available in the country through indigenous software and sanitized hardware evolved. This required getting the Defence, Industry and Academia on board exploiting their individual expertise to produce a state of the art communication system for the Armed Forces.[17] Thus began the journey of SAMBHAV through hundreds of collaborative meetings to finalise technology, hardware and software requirements.

Civil Military Fusion. The development and deployment of SAMBHAV provided significant insights into the importance of collaboration, resource utilization and adaptability. Civil-Military Fusion emerged as a crucial factor, highlighting the willingness of academia and Original Equipment Manufacturers (OEMs) to work in close coordination with the defence sector. This collaboration not only fosters innovation but also accelerates the development of solutions tailored to military needs. Equally important is the optimum utilization of civil infrastructure, as the Army has learned to leverage existing civil communication infrastructure effectively.

[17] 13. Vasan (2023), Detailed Project Report on SAMBHAV.

By exploiting pre-established systems, the Army can reduce costs and enhance operational capabilities without duplicating efforts.

The system is very effectively exploiting the Airtel and JIO mobile towers to deliver secure mobile services to the users of Defence Forces in far flung areas closer to LAC and LC wherever mob signals are present.

CHAPTER 5

IMPACT OF DIGITAL INFRASTRUCTURE ON SOCIO ECONOMIC DEVELOPMENT AND NATIONAL SECURITY

" The world is going through a significant transformation, driven by digital technology - we need a digital infrastructure that champions innovation and practice of inclusion."

- Satya Nadella, CEO of Microsoft

Digital infrastructure has emerged as a basis of modern development, impacting every aspect of governance, economy and national security. In India, the rapid development of digital networks, mobile connectivity and internet services has fueled economic growth, improved governance efficiency and improved national security. Digital infrastructure has emerged as a noteworthy infrastructure requirement, as compared to the traditional infrastructure necessities such as power, rail and roads. Economies across the globe are innovating and investing to make their digital infrastructure which comprises the physical resources necessary for the use of data, computerised devices, methods, systems and processes – more resilient, agile and futuristic. The digital infrastructure has become essential to the functioning of a society and the quality of life of its citizens. With nearly 886 million internet users in India, a host of native digital services, platforms, applications, content and solutions are expected to transform the digital ecosystem. India could potentially see a fivefold increase in economic value from digital transformation by 2026, representing an attractive opportunity for global and local businesses, startups and innovators to invest

in emerging technologies (like AI, Blockchain, or drones) in ways that are tailor-made to India's needs.[18]

With the Government of India gradually working towards goals of building Smart Cities it is essential for the nation to expand its digital infrastructure so as to efficiently use the edge technologies for economic progress. With increasing Smartphone penetration right till the most rural of the area, online activity has surged and a gigantic amount of data is being generated, it is therefore imperative to promote and build a framework for the development of strong digital infrastructure which will facilitate embracing of emerging technology areas such as 5G, IoT, artificial intelligence, machine learning, drones, robotics, and nano-based devices. Their applications in areas such as defence, agriculture, health, cyber security, smart cities and automation, with special focus on solving real-life problems will transform the destiny of the nation and will hasten its advance towards becoming *Viksit Bharat* by 2047.

However, in remote and strategically significant regions like Ladakh, digital infrastructure remains underdeveloped, presenting both challenges and opportunities for economic and security advancements. The impact of digital infrastructure on socio-economic development and national security in India, with particular focus on Ladakh has been explored. The role of government initiatives such as Digital India, *BharatNet* and telecom expansion projects addressing the security implications of robust digital connectivity, especially in border areas has been highlighted. Furthermore, the role of Civil-Military Fusion (CMF) in leveraging digital advancements for both development and defence has been discussed.

[18] Naman Agrawal, S. Mohit Rao and Himanshu Agrawal, The Role of Digital Infrastructure in Socio-economic Development, Apr 8,2021, Available at https://www.niti.gov.in/role-digital-infrastructure-socio-economic-development

The Role of Digital Infrastructure in Socio-Economic Development

A robust digital infrastructure enhances economic productivity, improves governance, promotes innovation and enhances public service delivery. Digital infrastructure essentially comprises the foundational technologies and systems that enable digital connectivity. The availability and quality of digital infrastructure determine a nation's ability to integrate technology into everyday life, driving progress in multiple sectors. Digital infrastructure is primarily categorized as:-

- Telecommunication Networks (fiber optics, mobile networks, satellite internet),
- Broadband and Internet Access,
- Data Centers and Cloud Computing Facilities,
- Digital Services (e-governance, digital payments, telemedicine, e-commerce).

Economic Growth and Digitalization in India

The expansion of digital infrastructure has been a key driver of economic growth, employment generation and financial inclusion in India**.** The integration of technology, telecommunications and financial services has created a more efficient, transparent and inclusive economy, fostering business expansion and improving accessibility to financial resources. As India's digital economy is projected to reach $1 trillion by 2030[19]**,** the rapid growth of 4G and 5G networks, fiber-optic connectivity, and digital platforms has played a pivotal role in transforming businesses and governance. This digital revolution has particularly benefited small and medium enterprises (SMEs), enabling them to expand their reach beyond local markets and improve operational efficiency through e-commerce, cloud computing and fintech solutions. The availability of high-speed internet and affordable mobile data has

[19] Ministry of Electronics and Information Technology (MeitY). (2021). India’s trillion-dollar digital economy: Advancing technology for growth. Government of India. Retrieved from https://www.meity.gov.in

allowed SMEs to leverage digital tools for marketing, payments and customer engagement, increasing their competitiveness in a rapidly evolving economy.

One of the most significant contributions of digitalization has been in the financial sector, where digital payments and banking services have revolutionized economic transactions. In 2023, UPI (Unified Payments Interface) transactions crossed ₹15 trillion ($180 billion)**,** showcasing the widespread adoption of cashless transactions and mobile banking.[20] The rise of platforms like Google Pay, Phone Pe, and Paytm has facilitated real-time payments, reducing reliance on cash and improving transaction security. Additionally, the government's *Jan Dhan-Aadhaar*-Mobile Trinity initiative has played a transformative role in financial inclusion by providing banking access to millions of unbanked individuals. Through direct benefit transfers (DBT), subsidies and welfare payments, *Jan Dhan-Aadhaar* Mobile Trinity has ensured transparent fund disbursement, eliminating intermediaries and reducing corruption. This system has particularly benefited farmers, rural workers and economically weaker sections, enabling them to receive government support directly into their bank accounts, fostering greater financial stability[21].

Beyond financial inclusion, digitalization has also contributed to employment generation and entrepreneurship. The emergence of the gig economy, fintech startups, and e-commerce platforms has provided new job opportunities, particularly in logistics, digital marketing, and IT services. Government programs such as Skill India and Digital India have further facilitated workforce development, equipping youth with digital skills necessary for emerging industries.[22] Moreover, the digital

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[20] **National Payments Corporation of India (NPCI).** (2023). *UPI transaction data report*. Retrieved from https://www.npci.org.in

[21] **Government of India.** (2023). *Jan Dhan-Aadhaar-Mobile (JAM) Trinity: Financial inclusion and direct benefit transfers*. Ministry of Finance. Retrieved from https://www.finmin.nic.in

[22] Skill India Mission. (2022). Digital skills for the future workforce. Retrieved from https://www.skillindia.gov.in

revolution has strengthened governance through e-governance platforms, smart cities initiatives and AI-driven analytics, enhancing efficiency, transparency and public service delivery.

Overall, India's digital infrastructure growth has created a healthy base for economic development, nurturing business innovation, improving financial accessibility and driving employment in various sectors. As the country continues to adopt 5G, AI, blockchain and cloud computing, digitalization will play an even greater role in shaping India's economic future, making it one of the worlds's leading digital economies.

Digital Infrastructure in Governance and Public Services

The growth of digital infrastructure has played a crucial role in employment generation and has created millions of job opportunities, particularly in IT sector, digital marketing, cyber security and financial services. The gig economy has started flourishing with freelance work and distance agnostic employment becoming more prevalent due to high-speed internet. To bridge the digital divide and prepare the workforce with future-ready skills, the government has launched initiatives such as Skill India and the National Digital Literacy Mission. These programs focus on up skilling youth, encouraging entrepreneurship and promoting digital literacy among rural population thereby nurturing inclusive economic growth[23]. The continued expansion of 5G networks, artificial intelligence (AI) and cloud computing is expected to further enhance job creation in the coming years, cementing India's position as a global leader in the digital economy.

India has made significant strides in e-governance, leveraging digital infrastructure to enhance transparency, efficiency, and accessibility in public services.

[23] **National Digital Literacy Mission (NDLM).** (2023). *Empowering citizens through digital literacy*. Retrieved from https://www.ndlm.in

Key initiatives include *Aadhaar*, the world's largest biometric identification system, which enables secure identity verification for over a billion citizens. Additionally, DigiLocker provides a secure, paperless storage solution for government-issued documents, reducing bureaucratic delays and improving accessibility. Other digital transformation projects, such as e-Courts and e-District, are streamlining judicial and administrative processes, ensuring faster case resolutions and improved service delivery. These initiatives reflect India's commitment to harnessing digital technologies for efficient governance and citizen empowerment.

Additionally, the healthcare sector has also witnessed a digital revolution with telemedicine and AI-driven innovations improving access to medical services. The e-*Sanjeevani* telemedicine platform has facilitated over 10 million consultations since January 2022, enabling patients in remote areas to connect with doctors online. Additionally, advancements in AI-driven diagnostics and electronic health records have enhanced efficiency, accuracy and accessibility in healthcare. These advancements demonstrate how digital infrastructure is transforming healthcare delivery, making essential services more inclusive and efficient.

Digital Infrastructure and National Security

The quick growth of digital networks and communication systems has made cyber security and digital defence critical components of India's national security strategy. As the country imbibes digital transition, it faces an increasing number of cyber threats, espionage attempts and information warfare challenges. With geopolitical situations, particularly with China and Pakistan, India's reliance on secure digital infrastructure, AI-driven surveillance and encrypted military communication**s** has become more significant than ever before. Digital infrastructure plays a crucial role in ensuring border security, intelligence gathering and military preparedness**,** particularly

in strategic region of Ladakh**,** where India has invested deeply in AI-driven surveillance, drone technology and secure military communication networks to safeguard territorial integrity.

Digital Infrastructure Development in Ladakh

The challenging terrain and harsh weather conditions in Ladakh make the traditional communications methods prone to disruptions for long time and are very unreliable. Maintaining secure and dependable communication networks is crucial for civilian and military functions. Therefore, fiber-optic and satellite-based communication networks are vital. The Indian Army's Project *Kranti* which aims to establish a secure, high-speed fiber-optic backbone for military installations as also the centre and state government's initiatives to connect all *Gram Panchayats* in Ladakh on optical fiber cable will boost development of Digital Infrastructure**.** In addition**,** satellite-based communication systems**,** powered by ISRO's GSAT military satellites and the recent trials of Starlink and OneWeb satellite internet services in Ladakh indicate the potential for enhanced digital connectivity in border regions of Ladakh**.**

The aspect of Digital Infrastructure availability was analysed in the previous chapter and it emerged from the analysis that 14 Villages in Ladakh are devoid of any kind of Digital Connectivity whereas a large number of gaps exists in areas close to the borders where military deployments exists. The total number of mobile tower existing and those planned to be installed in near future in Ladakh is summarized in **Table 5.1** below:-

Service Provider	**Existing Towers**	**Planned in 2024-25**
BSNL	167	146 / 241* (Planned)
Airtel	244	41 / 54*
Jio	231	3 / 9*

Total	642	190 / 304*

Table 5.1 : Summary of Telecom Towers

It can be seen from the table that 642 telecom towers exist in the region, covering a vast expanse of inhibited and uninhibited areas in the most rugged terrain. Many areas lack reliable 4G or broadband connectivity, affecting economic and educational opportunities. If we look at the internet penetration, it becomes evident that population centres like Leh and Kargil and surrounding areas are well covered but rural areas do not have the requisite services. Details are summarized in **Table 5.2** below:-

Region	**Internet Penetration (%)**	**Avg. Speed (Mbps)**	**Main Provider**
Leh District	85%	25 Mbps	Jio, Airtel
Kargil District	78%	18 Mbps	BSNL, Airtel
Nubra Valley	55%	12 Mbps	BSNL, Jio
Changthang	35%	8 Mbps	BSNL (Satellite)
Pangong	20%	6 Mbps	BSNL (Satellite)
Hanle Valley	10%	4 Mbps	ISRO (GSAT)

Table 5.2 : Internet Penetration in Ladakh

Impact of Digital Infrastructure on the Economy of Ladakh

The expansion of digital infrastructure including mobile networks, broadband internet and digital services has begun to impact Ladakh's economy very significantly. The impact of digital infrastructure on economy can be observed in several key areas like tourism, boosting of local businesses, Agriculture and sustainable livelihood, health and medicine. Lets study the impact on these key areas.

- **Boosting Tourism Industry.** Tourism is the backbone of Ladakh's economy, contributing 50-60% of the region's revenue. Digital infrastructure has played a crucial role in expanding this sector by Online Bookings & Digital Marketing**.** Platforms like Airbnb, MakeMyTrip and Booking.com have increased tourist inflow by enabling seamless online reservations. Improved Navigation & Connectivity through mobile coverage and GPS services has helped tourists explore Ladakh more safely. Out of the 5,25,374 tourists who visited Leh in year 2023, approx 70% used digital platforms to plan their trips[24]. Growth of home stays, guesthouses and eco-tourism ventures in remote villages like Turtuk and Hanle increased by 15 to 20%.

- **Digital Payments**: The introduction of UPI, Paytm and QR-code-based transactions has made payments easier, reducing dependency on cash in remote areas of Ladakh. Breakdown of Digital Transactions in Ladakh (2023) are as under:-

  - 40% UPI Payments (Google Pay, PhonePe, Paytm),
  - 25% Debit/Credit Card Transactions,
  - 20% Cash-Based Transactions,
  - 15% Internet Banking & NEFT/RTGS and
  - The transportation department in Ladakh has collected revenue via Sarathi Portal to a tune ₹3.25 Crore in 2023 and has registered 43,947 Vehicles via VAHAN Portal and issued 11,316 Permits[25]. The data clearly indicated the facilitation of e-governance through digital infrastructure.

[24] Swadesh Darshan 2.0, Available at https://leh.nic.in/swadesh-darshan-leh/
[25] E- governance Publication by UT Administration Ladakh (2023), Available at https://cdnbbsr.s3waas.gov.in

- **Social Media Influence**. High-speed internet allows local businesses to use Instagram, Facebook, and YouTube for promotion, attracting more visitors.
- **Empowering Local Businesses & Handicrafts.** Ladakh is known for its Pashmina wool, Thangka paintings and apricot-based products. Digital connectivity has enabled e-commerce opportunities for Ladakhi artisans to sell their products globally, facilitated by net banking and digital payments, reducing dependence on cash. Digital infrastructure has also helped promotion of online platforms like Amazon and Flipkart, where local businesses can advertise and network with urban markets. Ladakh experienced 35% increase in online orders and had been the front runner state in use of online platforms.
- **Agriculture & Sustainable Livelihoods.** Agriculture in Ladakh is a secondary economic activity, primarily due to the region's cold desert conditions, high altitude and limited arable land which restrict large-scale farming. However, the integration of digital infrastructure has begun to transform the agricultural sector, enhancing productivity and market access for farmers. Satellite technology and remote sensing now provide real-time weather forecasts, helping farmers make informed decisions about planting and irrigation. Additionally, digital platforms have enabled e-commerce opportunities, allowing Ladakhi farmers to sell organic produce such as apricots, barley, and seabuckthorn products directly to consumers across India. Online marketplaces and government-backed initiatives like the National Agriculture Market and local digital trade platforms have expanded the reach of Ladakh's organic farming sector. The economic impact of digital integration in agriculture has been substantial. Market access for apricots,

barley, and seabuckthorn products has expanded, with exports increasing by nearly 20% in recent years. Farmers utilizing digital trading platforms and direct online selling have reported an income increase of 15-30%, as they can now bypass intermediaries and access higher-value markets.[26] Government programs like the *Pradhan Mantri Kisan Samman Nidhi* and Direct Benefit Transfers (DBT) have also contributed to financial stability, ensuring timely subsidies and support. While challenges such as harsh climate conditions and digital illiteracy among farmers remain, the ongoing expansion of 5G, satellite internet, and agri-tech startups promises a more sustainable and profitable future for agriculture in Ladakh.

- **Education & Skill Development.** The integration of Information and Communication Technology (ICT) in education is playing a transformative role in overcoming geographical, infrastructural, and resource challenges in Ladakh**.** ICT offers e-learning platforms, digital classrooms, virtual lessons, and mobile-based education**,** ensuring that students in far-flung areas receive quality education. Initiatives lik**e** *SWAYAM, DIKSHA* and video conferencing tools help bridge the educational divide by enabling online learning, interactive sessions, and digital literacy programs for teachers**.** The government's investment in ICT infrastructure and teacher training programs has further improved access to education. ICT is enhancing learning outcomes, reducing dropout rates, and fostering skill development**,** making digital education a vital tool for Ladakh's socio-economic progress

- **Telemedicine & Digital Healthcare Economy.** Ladakh's remote villages lack specialized healthcare making digital infrastructure vital for

[26] E governance Publication by UT Administration Ladakh (2023), Available at https://cdnbbsr.s3waas.gov.in

improved access. Telemedicine platforms like e-*Sanjeevani* enable online consultations. As per a study pilot study conducted in Ladakh in 2021-22, Super-specialty medical teleconsultations were provided to healthcare providers in UT of Ladakh by specialists in the Department of Telemedicine Postgraduate Institute of Medical Education and Research, Chandigarh[27]. Doctor-to-Doctor teleconsultations were initiated by treating doctors at healthcare facilities in UT Ladakh on the e-*Sanjeevani* platform. This kind of utilisation of Digital Infrastructure significantly reduced the travel cost for medical treatment. These advancements bridge the healthcare gap, though continued investment in connectivity and medical infrastructure remains essential

National Security & Defense Driven Economic Development

Ladakh is strategically a high-security zone which necessitates robust digital connectivity for border security, surveillance and military logistics. The expansion of fiber optics, AI-powered surveillance and satellite internet has not only enhanced defence capabilities but also created jobs in defence technology and cyber security. Additionally, dual-use infrastructure, such as improved roads, communication networks and digital services, benefits both military operations and civilian communities. These advancements have led to increased defence-related technology investments in Ladakh, promoting economic growth in border villages by supporting local businesses and connectivity-driven development.

Digital infrastructure has significantly transformed Ladakh's economy, driving growth in tourism, e-commerce, financial inclusion, healthcare and education. However, challenges such as harsh terrain, limited private investment and cyber

[27] Jain (2022), Super-specialty Medical Teleconsultations to Remote Areas of Ladakh, India via E-Sanjeevani under Hub-and-Spoke Model: A Pilot Study, Available at https://telehealthandmedicinetoday.com/index.php/journal/article/view/471

security risks continue to hinder progress. To fully realize its digital potential, Ladakh must strengthen public-private partnerships, introduce government incentives for startups, enhance cyber security frameworks and accelerate 5G/ 6G and satellite internet deployment**.** With strategic planning and sustained investment**,** Ladakh can emerge as a model for digital-driven economic growth in high-altitude regions**,** fostering long-term development and connectivity

CHAPTER 6

DATA ANALYSIS AND INTERPRETATION

Having described the nuances of research design for the subject study in Chapter 1, this chapter attempts to analyse the data collected from the sample to test the validity and reliability of the instrument i.e. the questionnaire and to test the hypothesis using various statistical tools. The analysis includes the data originating from the survey questionnaire as well as interviews and Focused Group Discussion, which will be presented in narrative, graphical and tabular form. The analytical results form the basis of findings which are summarized. The conclusions drawn will be discussed, indicating how the research objectives have been met.

The research hypothesis for the study was formulated as follows:-

- **Hypothesis (H1).** Civil-Military Fusion significantly enhances the development of digital infrastructure in remote border areas of India, thereby strengthening national security and promoting inclusive economic growth in the region.
- **Hypothesis (H0).** Civil-Military Fusion does not significantly enhance the development of digital infrastructure in remote border areas of India, nor does it strengthen national security or promote inclusive economic growth in the region.

Data Collection

Primary Data. A Pilot Questionnaire was first designed and circulated to Military Officers of all three services, Officers of BSNL, Residents of Ladakh and some experts. Based on the responses received on the Pilot Questionnaire and interviews / discussions held with the experts, the Questionnaire was further fine-tuned to make it more logical, consistent, unbiased and assertive. The data was finally collected in

form of researcher administered questionnaire to the respondents to the sample selected from the population for quantitative data analysis. Questionnaire consisted of the following: -

- 21 closed ended questions (on a five-point Likert Scale, varying from Strongly Disagree to Strongly Agree).
- Questions to capture the awareness levels of the respondents on the following:-
  - Concept of Civil-Military Fusion for digital infrastructure development
  - Civil-military collaborations for digital infrastructure development in Ladakh, and on
  - Understanding the role of military in developing digital infrastructure in Ladakh.
  - Question on demographic variables (Name, Age group and occupation group).

The questionnaire was circulated in electronic (digital) form. The questionnaire was analysed based on valid responses received from **358 respondents** that included Government Officials (Civilian), Military Personnel, Private Sector Employees, Residents of Ladakh and Others.

- **Secondary Data**. Secondary data was collected from Open Sources / including online and research articles containing facts and figures on the Civil-Military Fusion and its effect on development of the digital infrastructure in remote border areas of India was also collected and suitably incorporated to enhance the findings.
- **Focussed Group Discussion/ Interviews**. Group and individual interviews were conducted in physical and online mode with senior military officers at

policy making level, senior government officials posted in the UT of Ladakh, President and Group CTO Mobility of JIO, Regional Business Head of Airtel, Senior Manager of BSNL and Chief Signal Officers of Northern Command and 14 Corps and Senior Officers in Directorate of Signals in Delhi. A separate questionnaire was framed to conduct a Focussed Group Discussion/ Interviews with all stake holders relevant for Civil Military Fusion efforts for development of Digital Infrastructure.

Questionnaire Design. Questionnaire consisting of 21 statements (Likert items) were prepared for perception measurement concerning the various facets of the constructs as under:-

- C1 : Current Digital Infrastructure.
- C2 : Civil-Military Collaboration.
- C3 : Benefits of Civil-Military Fusion.
- C4 : Challenges and Concerns to CMF.
- C5. : Policy and Implementation for CMF.

Questionnaires are placed at Appendix 'C' & Appendix 'D'

Likert Scaling. Responses have been evaluated on a Likert scale with "Strongly Disagree", "Disagree", "Neutral", "Agree" & "Strongly Agree" corresponding to numeric values 1 to 5 respectively. The responses against demographic variables and on understanding the awareness levels were also suitably converted to ordinal data for descriptive analysis.

Data Cleansing, Organising and Coding. This was a very important step before analysing the data. Of the total 358 responses received (including incomplete responses), the data was cleaned and organised (thereby getting valid 357 responses) in the following way;-

- Respondent No 127 didn't answer on any question and was hence removed.
- 7 respondents left one question each with blank response . These were filled with average responses, as it was less than 5% of the respondents.
- All Likert Scale questions were correctly coded. There wasn't any reverse coded question.
- Responses against all demographic variables were correctly coded and entered.
- The resultant 357 valid cases (respondents) were analysed using various statistical tools as described below.

Details of Findings. The data analysis has been done under the following major heads using the Jamovi Software:-

- Descriptive analysis.
- Factor Analysis and Check for Adequacy.
- Check for Reliability and Normality.
- Expert interviews

Descriptive Data Analysis

Total Sample.

- Descriptive analysis of the collected data was carried out using analyse option in which case summaries were arrived at for all the responses for questions based on five constructs.

- **Interpretation**. It was seen that the means for most of the individual questions were more than 3.5 for constructs C1, C2, C3 and C5 (less questions C1Q1, C1Q4 and C2Q4), hence there is strong agreement of respondents towards constructs as the constructs were measuring agreement of the research hypothesis (H1). As regards to the sufficiency/ adequacy of the digital infrastructure in Ladakh region, the respondents disagreed. Further, respondents also feel that adequate mechanisms are Not in place to facilitate civil-military coordination for infrastructure projects in Ladakh (Question C2Q4). For the construct C4, which captures the Challenges and Concerns to CMF, the questions were negatively loaded. However, mean score more than 3.5 for all four questions indicates that all respondents feel that there are serious concerns with respect to civil military infrastructure in the region. All important questions are also analysed individually in subsequent paragraphs. The table for descriptive analysis of the questions is attached at under in Table 6.1.

Descriptives

	C1Q1	C1Q2	C1Q3	C1Q4	C1Q5	C2Q1	C2Q2	C2Q3	C2Q4	C3Q1	C3Q2	C3Q3	C3Q4	C4Q1	C4Q2	C4Q3	C4Q4
N	357	357	357	357	357	357	357	357	357	357	357	357	357	357	357	357	357
Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	2.423	3.866	4.356	2.238	4.448	4.426	4.434	4.294	2.955	4.305	4.384	4.280	4.401	3.585	4.036	3.689	3.922
Standard deviation	0.8727	0.7745	0.9023	0.9037	0.7463	0.7848	0.7414	0.7073	0.9169	0.7339	0.7080	0.7344	0.6398	0.9608	0.7543	0.8521	0.8991
Minimum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1
Maximum	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Shapiro-Wilk W	0.8427	0.7731	0.6604	0.8371	0.6806	0.6727	0.6779	0.7248	0.8635	0.7046	0.6853	0.7360	0.7075	0.8283	0.8163	0.8239	0.7970
Shapiro-Wilk p	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001

Table 6.1: Descriptive Analysis, Source: Primary Data

Descriptive Analysis of Questions. The questions pertaining to demographic data as well as each construct were subjected to descriptive analysis. The outcome from the statistical analysis was compiled in graphical form and inferences were drawn as discussed in succeeding paras:-

(a) **Age Group**. Majority of the respondents were between the age of 35 to 54 years. The age wise details of the respondents were as under (**refer Table 6.2)**.

Frequency	Percent	Valid Percent
25-34	60	17%
35-44	130	36%
45-54	146	41%
55 and above	21	6%

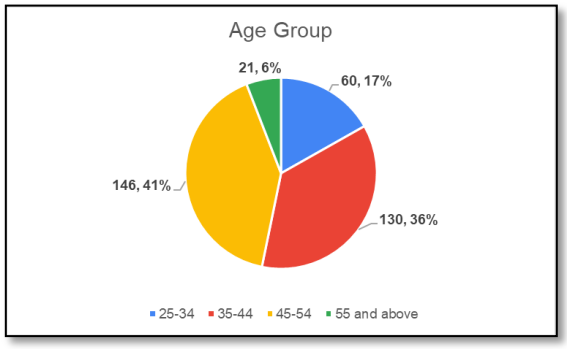


Table 6.2 : Age Group of the Respondents, Source: Primary Survey

(b) **Occupation**. Majority of the respondents (87%) were Military Personnel. The details of the respondents as per the occupation is as under (**refer Table 6.3**).

Occupation	Count	Percentage
Military Personnel	313	87.43%
Government Official (Civilian)	18	5.03%
Private Sector Employee	12	3.35%
Resident of Ladakh	7	1.96%
Other	8	2.23%
Grand Total	358	100.00%

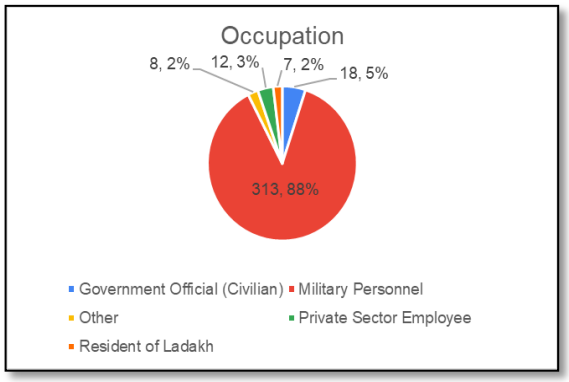


Table 6.3 : Occupation of the Respondents, Source: Primary Survey

(c) Bases on the question "How aware are you of the concept of Civil-Military Fusion for digital infrastructure development?", **the responses received clearly demonstrates that there is adequate awareness (almost 83%) amongst the respondents** on the issue. The details of the same are depicted as a chart in **Figure 6.1**.

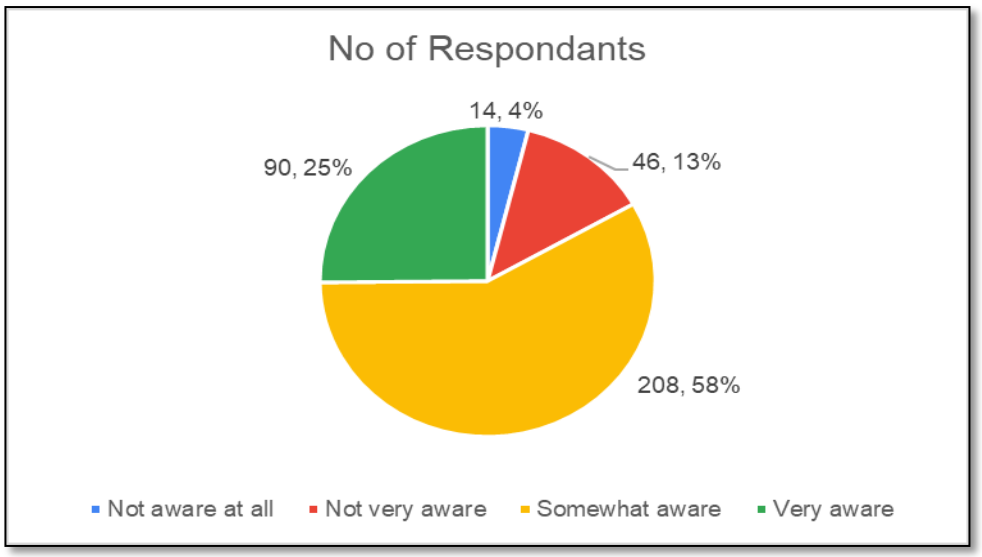


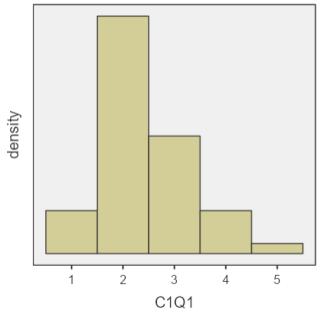
Figure 6.1 : Number of Respondents, Source : Primary Survey

(d) **Question Wise Descriptive Analysis.**

(i) **C1Q1**: The current digital infrastructure in Ladakh is adequate for local needs.

Frequencies of C1Q1

C1Q1	Counts	% of Total	Cumulative %
1	34	9.52 %	9.52 %
2	188	52.66 %	62.18 %
3	93	26.05 %	88.24 %
4	34	9.52 %	97.76 %
5	8	2.24 %	100.00 %

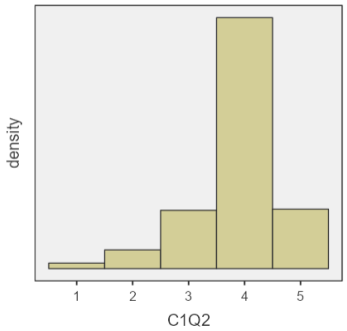


Analysis : Approximately 60% of the respondents either strongly disagree or disagree that current digital infrastructure in Ladakh is adequate for local needs. This clearly brings out the need of adequate infrastructure in the area.

(ii) **C1Q2**: Internet connectivity in Ladakh Region has improved significantly in recent years

Frequencies of C1Q2

C1Q2	Counts	% of Total	Cumulative %
1	5	1.40 %	1.40 %
2	17	4.76 %	6.16 %



Frequencies of C1Q2

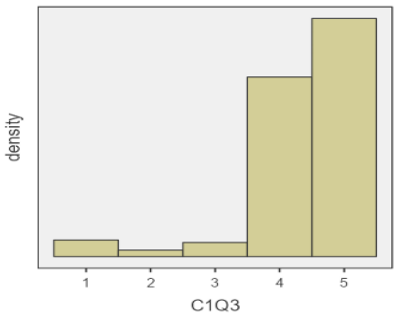
C1Q2	Counts	% of Total	Cumulative %
3	53	14.85 %	21.01 %
4	228	63.87 %	84.87 %
5	54	15.13 %	100.00 %

Analysis : Approximately 79% of the respondents agree or strongly agree, that internet connectivity has improved significantly in Ladakh. Digital infrastructure will give impetus to economic growth in remote border areas of Ladakh.

(iii) **C1Q3**: Digital infrastructure will give impetus to economic growth in remote border areas of Ladakh

Frequencies of C1Q3

C1Q3	Counts	% of Total	Cumulative %
1	13	3.64 %	3.64 %
2	5	1.40 %	5.04 %
3	11	3.08 %	8.12 %
4	141	39.50 %	47.62 %
5	187	52.38 %	100.00 %

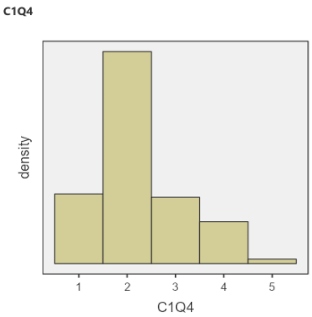


Analysis : Approximately 92 % of the respondents agree or strongly agree, that digital infrastructure will give impetus to economic growth in remote border areas of Ladakh.

(iv) **C1Q4**: Existing communication facilities are sufficient for the operational needs of the military

Frequencies of C1Q4

C1Q4	Counts	% of Total	Cumulative %
1	63	17.65 %	17.65 %
2	192	53.78 %	71.43 %
3	60	16.81 %	88.24 %
4	38	10.64 %	98.88 %
5	4	1.12 %	100.00 %

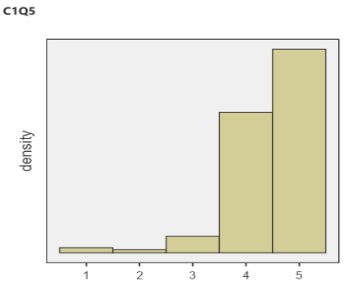


Analysis : Approximately 70 % of the respondents disagree or strongly disagree, that existing communication facilities are sufficient for the operational needs of the military

(v) **C1Q5**: High-speed internet connectivity in remote villages of Ladakh is a necessity to uplift economy of the region

Frequencies of C1Q5

C1Q5	Counts	% of Total	Cumulative %
1	5	1.40 %	1.40 %
2	3	0.84 %	2.24 %
3	16	4.48 %	6.72 %
4	136	38.10 %	44.82 %
5	197	55.18 %	100.00 %

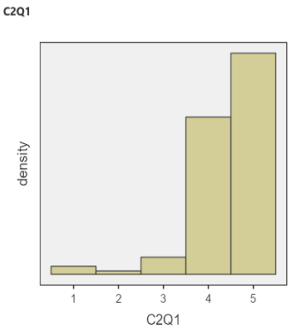


Analysis : Approximately 93 % of the respondents agree or strongly agree, that High-speed internet connectivity in remote villages of Ladakh is a necessity to uplift economy of the region.

(vi) **C2Q1**: Civil-military collaboration is essential for developing digital infrastructure in border areas.

Frequencies of C2Q1

C2Q1	Counts	% of Total	Cumulative %
1	7	1.96 %	1.96 %
2	3	0.84 %	2.80 %
3	15	4.20 %	7.00 %
4	138	38.66 %	45.66 %
5	194	54.34 %	100.00 %

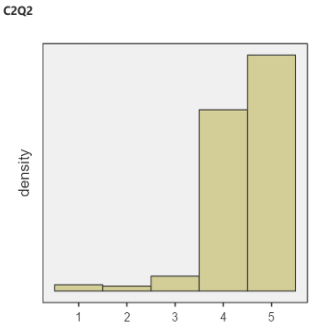


Analysis : Approximately 93 % of the respondents agree or strongly agree, that Civil-military collaboration is essential for developing digital infrastructure in border areas..

(vii) **C2Q2**: Civil-military partnerships can promote efficient resource utilization in remote areas of Ladakh

Frequencies of C2Q2

C2Q2	Counts	% of Total	Cumulative %
1	5	1.40 %	1.40 %
2	4	1.12 %	2.52 %
3	12	3.36 %	5.88 %
4	146	40.90 %	46.78 %
5	190	53.22 %	100.00 %

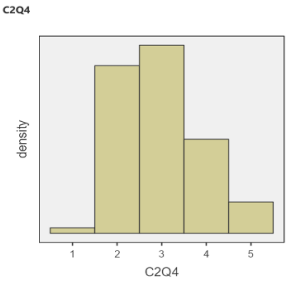


Analysis : Approximately 93 % of the respondents agree or strongly agree, that Civil-military partnerships can promote efficient resource utilization in remote areas of Ladakh.

(viii) **C2Q4**: There are adequate mechanisms in place to facilitate civil-military coordination for infrastructure projects in Ladakh.

Frequencies of C2Q4

C2Q4	Counts	% of Total	Cumulative %
1	4	1.12 %	1.12 %
2	123	34.45 %	35.57 %
3	138	38.66 %	74.23 %
4	69	19.33 %	93.56 %
5	23	6.44 %	100.00 %

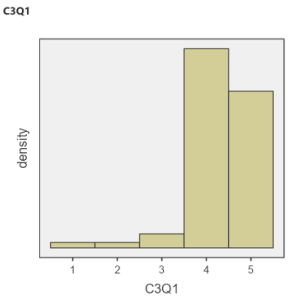


Analysis : Approximately 36 % of the respondents strongly disagree and 39% remained neutral to availability adequate mechanisms in place to facilitate civil-military coordination for infrastructure projects in Ladakh. **It clearly indicates that concept of CMF is still in nascent stages.**

(ix) **C3Q1**: Coordinated efforts between civil and military stakeholders in developing digital infrastructure can enhance defence capabilities.

Frequencies of C3Q1

C3Q1	Counts	% of Total	Cumulative %
1	5	1.40 %	1.40 %
2	5	1.40 %	2.80 %
3	13	3.64 %	6.44 %
4	187	52.38 %	58.82 %
5	147	41.18 %	100.00 %

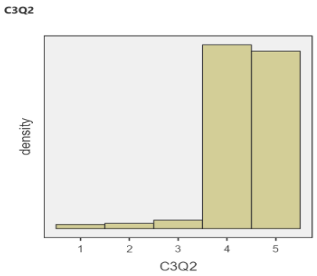


Analysis : Approximately 93 % of the respondents agree and strongly agree that: coordinated efforts between civil and military stakeholders in developing digital infrastructure can enhance defence capabilities in border regions of Ladakh.

(x) **C3Q2**: Improved digital infrastructure will enhance economic opportunities for local communities.

Frequencies of C3Q2

C3Q2	Counts	% of Total	Cumulative %
1	4	1.12 %	1.12 %
2	5	1.40 %	2.52 %
3	8	2.24 %	4.76 %
4	173	48.46 %	53.22 %
5	167	46.78 %	100.00 %

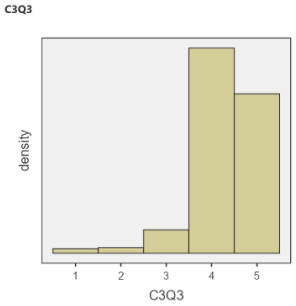


Analysis : Approximately 95 % of the respondents agree and strongly agree that: Improved digital infrastructure will enhance economic opportunities for local communities.

(x) **C3Q3**: Civil-military fusion will attract private investment in the region & can promote development.

Frequencies of C3Q3

C3Q3	Counts	% of Total	Cumulative %
1	4	1.12 %	1.12 %
2	5	1.40 %	2.52 %
3	21	5.88 %	8.40 %
4	184	51.54 %	59.94 %
5	143	40.06 %	100.00 %

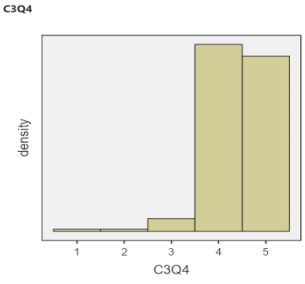


Analysis : Approximately 92 % of the respondents agree and strongly agree that: Civil-military fusion will attract private investment in the region & can promote development.

(xi) **C3Q4.** The development of digital infrastructure will improve public service delivery in remote areas.

Frequencies of C3Q4

C3Q4	Counts	% of Total	Cumulative %
1	2	0.56 %	0.56 %
2	2	0.56 %	1.12 %
3	12	3.36 %	4.48 %
4	176	49.30 %	53.78 %
5	165	46.22 %	100.00 %

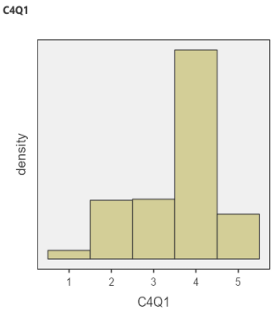


Analysis : Approximately 96 % of the respondents agree and strongly agree that The development of digital infrastructure will improve public service delivery in remote areas.

(xii) **C4Q1.** Data security concerns may arise from civil-military collaborations.

Frequencies of C4Q1

C4Q1	Counts	% of Total	Cumulative %
1	8	2.24 %	2.24 %
2	55	15.41 %	17.65 %
3	56	15.69 %	33.33 %
4	196	54.90 %	88.24 %
5	42	11.76 %	100.00 %

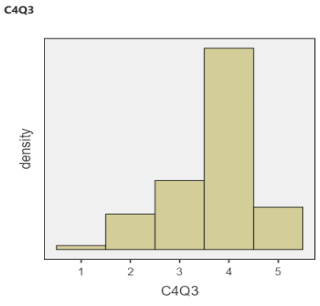


Analysis. Approximately 67 % of the respondents agree and strongly agree that data security concerns may arise from civil-military collaborations.

(xiii) **C4Q3.** The lack of trust between civilian and military stakeholders is a significant challenge

Frequencies of C4Q3

C4Q3	Counts	% of Total	Cumulative %
1	4	1.12 %	1.12 %
2	36	10.08 %	11.20 %
3	70	19.61 %	30.81 %
4	204	57.14 %	87.96 %
5	43	12.04 %	100.00 %

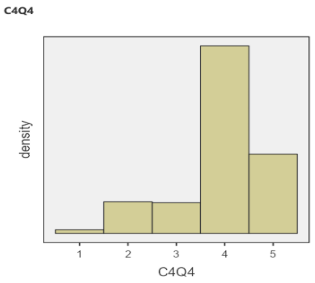


Analysis. Approximately 69 % of the respondents agree and strongly agree that the lack of trust between civilian and military stakeholders is a significant challenge

(xiv) **C4Q4.** High costs of infrastructure development in remote areas are a major barrier.

Frequencies of C4Q4

C4Q4	Counts	% of Total	Cumulative %
1	4	1.12 %	1.12 %
2	34	9.52 %	10.64 %
3	33	9.24 %	19.89 %
4	201	56.30 %	76.19 %
5	85	23.81 %	100.00 %

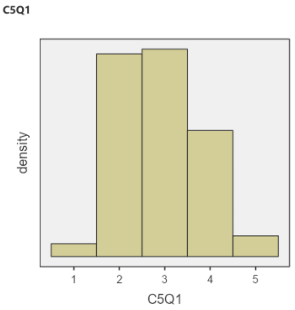


Analysis. Approximately 80 % of the respondents agree and strongly agree that High costs of infrastructure development in remote areas are a major barrier.

(xv) **C5Q1.** Government policies adequately support civil-military fusion for infrastructure development.

Frequencies of C5Q1

C5Q1	Counts	% of Total	Cumulative %
1	8	2.24 %	2.24 %
2	127	35.57 %	37.82 %
3	130	36.41 %	74.23 %
4	79	22.13 %	96.36 %
5	13	3.64 %	100.00 %

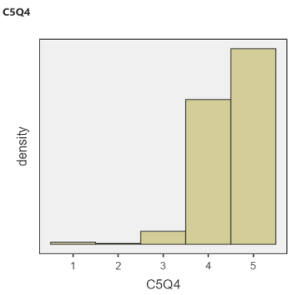


Analysis. Approximately 38 % of the respondents strongly disagree that Government policies adequately support civil-military fusion for infrastructure development. It is also evident from the responses that 36% respondents are unaware of any initiative of Government in promoting CMF in Ladakh.

(xv) **C5Q4.** There should be a clear policy framework to guide civil-military collaboration in digital infrastructure projects

Frequencies of C5Q4

C5Q4	Counts	% of Total	Cumulative %
1	2	0.56 %	0.56 %
2	1	0.28 %	0.84 %
3	13	3.64 %	4.48 %
4	145	40.62 %	45.10 %
5	196	54.90 %	100.00 %



Analysis. Approximately 95 % of the respondents strongly agree that there should be a clear policy framework to guide civil-military collaboration in digital infrastructure projects.

Inferential Analysis

Overall Validity (Sampling Adequacy and Test of Significance). The factorability of 21 Likert items was examined. The Kaiser-Meyer-Olkin test for sampling adequacy for the 357 respondents of final survey had a value of **0.872** which is appropriate for a survey, much above the **acceptable 0.6**. The **Bartlett's Test of Sphericity** was highly significant (X^2 (2631) = 210, p=.0001, which is <0.05). **Refer Table 6.4** below. With these indicators **factor analysis** was considered suitable for all 21 questions for the test of validity.

KMO Measure of Sampling Adequacy

	MSA
Overall	0.8717
C1Q1	0.6646
C1Q4	0.6407
C1Q5	0.9372
C2Q1	0.8123
C2Q2	0.8300
C2Q3	0.9337

Bartlett's Test of Sphericity

χ^2	df	p
2631	210	< .0001

C2Q4	0.7288
C3Q1	0.9238
C3Q2	0.9154
C3Q3	0.9292
C3Q4	0.9178
C4Q2	0.7835
C4Q3	0.6474
C4Q4	0.7950
C5Q1	0.6750
C5Q2	0.8863
C5Q3	0.9055
C5Q4	0.9165
C1Q2	0.6985
C1Q3	0.8462
C4Q1	0.5320

Table 6.4 : KMP Bartlett's Test – Overall Validity of Survey

Overall Reliability Test. Total 21 questions were analysed as part of test of reliability. The result obtained was satisfactory as regards to test of reliability. The ideal **Chronbach's Alpha** value should be more than **0.6** and the value obtained was **0.7837** which shows quite a higher reliable scale for the questionnaire. Refer **Table 6.5.**

Scale Reliability Statistics

	Cronbach's α
scale	0.7837

Note. items 'C1Q1', 'C1Q4', and 'C5Q1' correlate negatively with the total scale and probably should be reversed

Table 6.5 : Reliability Statistics – Overall Reliability Final Survey

Overall Normality Test. Histograms and Normal curves for constructs are given below in **Figure 6.2**:-

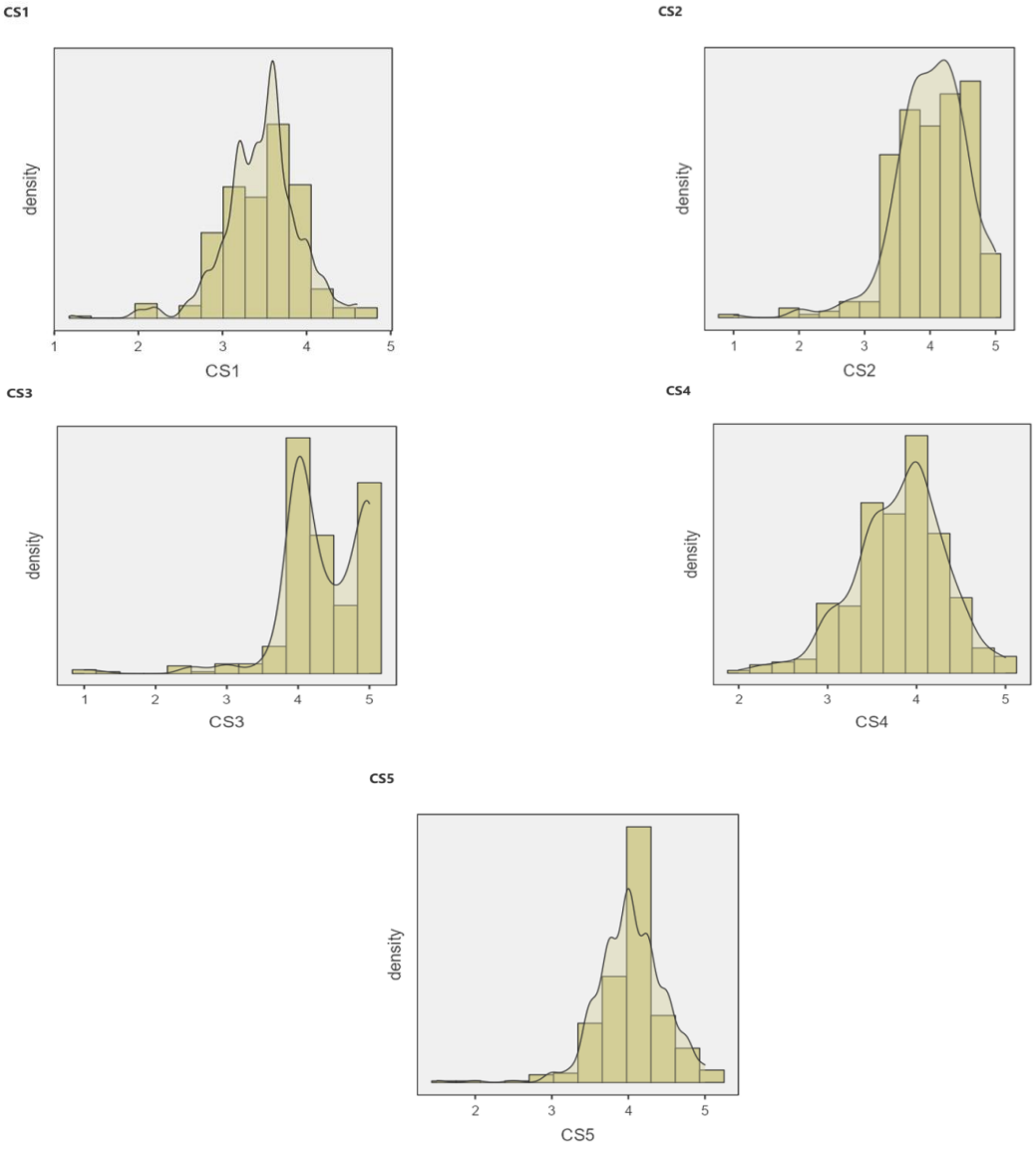


Figure 6.2 : Overall Normality Test

Descriptives

	CS1	CS2	CS3	CS4	CS5
N	357	357	357	357	357
Missing	0	0	0	0	0
Mean	3.466	4.027	4.342	3.808	4.034
Median	3.600	4.000	4.250	3.750	4.000
Standard deviation	0.4483	0.5594	0.6030	0.5169	0.4425
Minimum	1.200	1.000	1.000	2.000	1.500
Maximum	4.600	5.000	5.000	5.000	5.000
Shapiro-Wilk W	0.9485	0.9313	0.8069	0.9671	0.9307
Shapiro-Wilk p	< .0001	< .0001	< .0001	< .0001	< .0001

Table 6.6 : Overall Normality Test

The Shapiro Wilk test for normality was performed to ascertain the normality of sample (**Table 6.6**). The test was not statistically significant ($p<0.001$) hence the sample was not shown to be normally distributed. However, the graphs above show that the data is close to Normal distribution, apart from few outliers. The Construct C1, C4 & C5 is closest to Normal Distribution and Construct C2 & C3 the least, with some skewness in the data.

Qualitative Analysis. Perceptions and cognitive attributes of a complex issue like Civil Military Fusion for Development of Digital Infrastructure requires understanding of perceptions and cognitive attributes. The observational and exploratory approach with pragmatic view was adopted to assimilate various articles, webinars, books, and reports. Data obtained through Focused Group Discussions and Interview data obtained through personal interviews provided the primary inputs for qualitative interpretivism based on inductive reasoning. The details of qualitative analysis for the appropriate data set are covered in succeeding paragraphs.

Interview Guide. Since it was essential to get broader, yet in depth knowledge of the subject, interviews from subject matter experts, who have been dealing with policy issues on CMF was adopted as main tool to gather data on the overall perceptions and insights of the area of research. Structured personal interviews method was undertaken to get the qualitative inputs. Interview guide was prepared in consultation with the research guide based on conceptual and theoretical framework, which evolved out of review of literature as well as responses to pilot survey. Four distinct categories (Military Person on ground, Policy Maker at Army Headquarters, Private Industry Players and Civilian Public Servants) were identified and interviews and follow ups were undertaken as mentioned below: -

- Chief Signal Officer of Northern Command and Chief Signal Officer of 14 Corps.
- Interview with President and Group CTO of JIO and Regional Business Head of *Bharti* Airtel.
- Officers from Directorate General of Signals (Army Headquarters).
- Officer from staff of DCOAS (Information System & Coordination).

Organising and Content Analysis of the Data. Structured questionnaire was sent by email to the Interviewees and telephonic follow up was done to clarify and ascertain contextual understanding. Final transcripts were sent to the interviewee for his/ her approval and consent. Email responses of selected and high-ranking interviewees duly rectified to keep the anonymity of subject matter experts is attached as Appendix E.

Each response was then studied and restudied to determine conceptual similarities and divergence with own understanding as well as within different subject matter experts.

Themes. Main themes that emerged out of data obtained from interviews and pertaining to the identified research objectives and sub objectives are as under :-

- Theme 1: Challenges in Implementing Civil-Military Collaboration (CMC)
- Theme 2: Military Resources Available for Civilian Connectivity
- Theme 3: Security Concerns in Shared Infrastructure
- Theme 4: Role of Government Policies and Funding Programs
- Theme 5: Private Sector Involvement and Expectations from Military

Coding Strategy and Content Analysis. Based on the identified themes the interview data sets were coded for words and phrases. Themes were divided in appropriate sub themes and the primary codes were then grouped in clear sub theme based verticals to determine the congruence and divergences. Sub themes and codes incorporated in the content analysis for qualitative study of the interview data are as following: -

- **Theme 1: Challenges in Implementing Civil-Military Collaboration (CMC)**
    - **Sub Theme 1. Lack of Political Will and Bureaucratic Hurdles** – Several respondents highlighted slow approvals, red tape, and lack of a unified policy approach as major obstacles.
    - **Sub Theme 2. Geopolitical and Security Constraints** – Border sensitivity limits civilian access to military infrastructure.

- **Sub Theme3. Environmental and Geographic Barriers** – Harsh terrain, extreme climate, and high altitude make infrastructure development challenging.
- **Sub Theme 4. Economic Viability for Private Players** – Low population density and high costs deter telecom service providers (TSPs) from investing.

- **Theme 2: Military Resources Available for Civilian Connectivity**
  - **Sub Theme 1. Optical Fiber Cable (OFC) Network** – The Army's extensive OFC network is a valuable asset for extending civilian connectivity.
  - **Sub Theme 2. Power and Shelter Infrastructure** – Military bases provide essential power backup and shelter for telecom installations.
  - **Sub Theme 3. Communication Towers and Civil Structures** – Existing military-owned towers can reduce infrastructure costs.
- **Theme 3: Security Concerns in Shared Infrastructure.**
  - **Sub Theme 1. Cyber security Risks –**Risks from hacking, data breaches and cyber espionage.
  - **Sub Theme 2. Physical Security Risks** – Unauthorized access to military infrastructure could compromise national security.
  - **Sub Theme 3. Interception and Social Media Risks** – Monitoring and intelligence gathering through unsecured communication channels.
- **Theme 4: Role of Government Policies and Funding Programs**

- **Sub Theme 1. Effectiveness of Vibrant Village Program & USOF** – Delays in fund allocation and lack of clarity on implementation. More Inter-ministerial coordination
- **Sub Theme 2. Need for Policy Reforms** – Faster execution of government projects and clearer policies for private sector involvement.
- **Sub Theme 3. Financial Incentives for Private Players** – Subsidies, tax exemptions, and regulatory support to attract investment.

- **Theme 5: Private Sector Involvement and Expectations from Military**
  - **Sub Theme . Logistical Support from Military** – TSPs require assistance with transporting equipment in remote areas.
  - **Sub Theme 2**. **Shared Access to Infrastructure** – Military's OFC (specially availability of dark fibers), power and shelter infrastructure can lower private investment costs.
  - **Sub Theme 3. Need for Service-Level Agreements (SLAs)** – Defining roles, responsibilities and accountability for infrastructure sharing.

Content Analysis. The content was thematically analysed using manual method and open-source software of word cloud. The summary of word cloud as per the six interviews conducted as part of Focussed Group Discussion is given at **Figure 6.3**:-

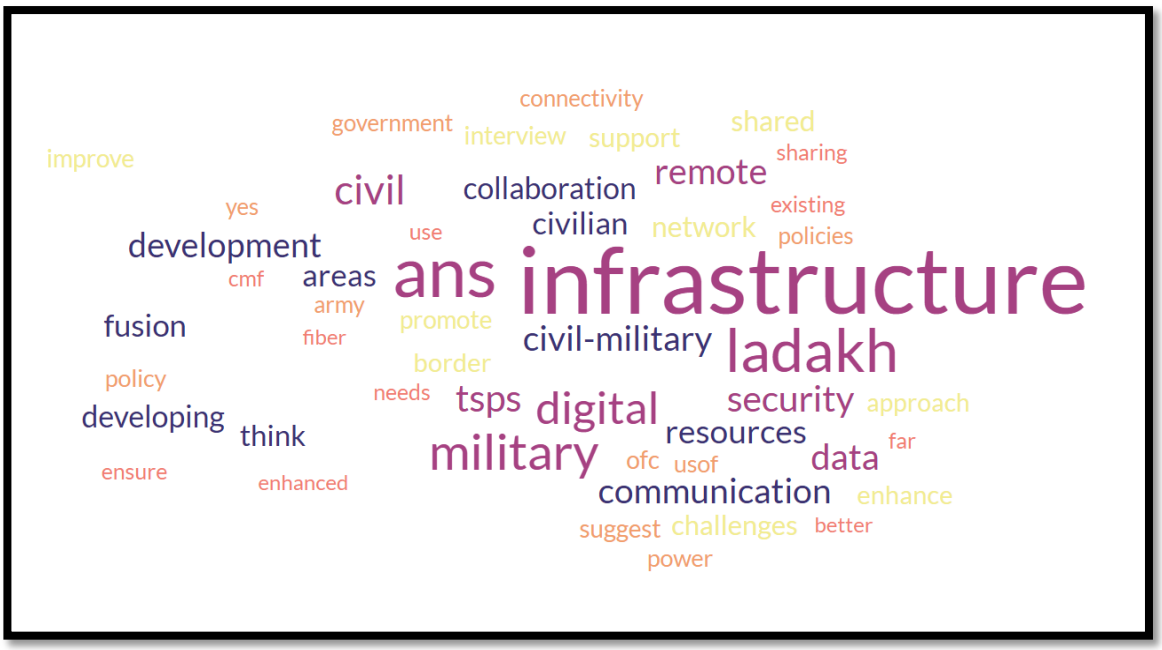


Figure 6.3: Word Cloud : Content Analysis

Challenges in developing Infrastructure were the most discussed theme, emphasizing the policy and security constraints. Military's Optical Fiber Network (OFC) was frequently cited as the most valuable asset for expanding civilian connectivity. Cyber security risks and policy gaps were common concerns, reinforcing the need for stronger governance and regulatory measures. Private sector involvement was limited due to financial constraints and lack of incentives.

The analysis of the Data obtained through questionnaire and interviews indicates that the Hypothesis "Civil-Military Fusion will significantly enhances the development of digital infrastructure in remote border areas of India, thereby strengthening national security and promoting inclusive economic growth in the region" can be accepted.

Findings

The analysis of civil-military fusion for development of digital infrastructure in Ladakh brings out several findings. Challenges such as bureaucratic hurdles, lack of political will, harsh terrain, and economic unviability for Telecom Service Providers

(TSPs) hinder progress. Resources of the Defence Forces including Optical Fiber Cable (OFC) networks, power supply and shelter infrastructure, can notably enhance civilian connectivity, provided security concerns—such as cyber threats, data breaches and unauthorized access are efficiently managed. Government policies like the Vibrant Village Program and USOF offer potential funding but suffer from slow implementation and lack of clarity. Private sector participation remains restricted due to high capex and regulatory barriers, necessitating financial incentives, tax reliefs and smooth approval processes. A joint civil-military task force, service-level agreements (SLAs) and strong security measures are essential to ensuring sustainable and secure digital infrastructure development in remote border regions of Ladakh.

CHAPTER 6

FINDINGS, RECOMMENDATIONS AND CONCLUSION

General

This research was aimed at studying the aspects relating to leveraging Civil Military Fusion for development of Digital Infrastructure in Ladakh. The study was based on extensive study of current infrastructure availability through an Literature Survey; responses received from subject matter experts, academicians, local residents of Ladakh, Policy Makers in Government; through a questionnaire and was followed by interviews and focused discussion. This chapter brings out summary of findings and recommendations based on the findings.

Findings Based on Data Analysis

The findings of the study based on the data analysis (as carried out in the previous chapter) have been summarised as under: -

Ser No	Findings
(a)	60% of the respondents feel that current digital infrastructure in Ladakh is inadequate for local needs. This clearly brings out the need of adequate infrastructure in the area
(b)	79% of the respondents feel that internet connectivity has improved significantly in Ladakh. Digital infrastructure will give impetus to economic growth in remote border areas of Ladakh
(c)	82 % of the respondents feel that digital infrastructure will give impetus to economic growth in remote border areas of Ladakh.
(d)	70 % of the respondents feel that existing communication facilities are not

	sufficient for the operational needs of the military
(e)	93 % of the respondents feel that High-speed internet connectivity in remote villages of Ladakh is a necessity to uplift economy of the region.
(f)	93 % of the respondents feel that Civil-military collaboration is essential for developing digital infrastructure in border areas.
(g)	93 % of the feel that Civil-military partnerships can promote efficient resource utilization in remote areas of Ladakh.
(h)	36 % of the respondents felt that there are inadequate mechanisms in place to facilitate civil-military coordination for infrastructure projects in Ladakh. A large number of respondents were neutral to the concept of CMF processes indicating concept of CMF is still in nascent stages.
(i)	93 % of the respondents feel that coordinated efforts between civil and military stakeholders in developing digital infrastructure can enhance defence capabilities in border regions of Ladakh
(j)	95 % of the respondents feel that improved digital infrastructure will enhance economic opportunities for local communities.
(k)	92 % of the respondents feel that Civil-military fusion will attract private investment in the region & can promote development.
(j)	96 % of the respondents agreed that the development of digital infrastructure will improve public service delivery in remote areas.
(m)	67 % of the respondents feel that data security concerns may arise from civil-military collaborations.
(n)	69 % of the respondents feel that the lack of trust between civilian and military stakeholders is a significant challenge
(o)	80 % of the respondents feel that High costs of infrastructure development

	in remote areas are a major barrier
(p)	38 % of the respondents felt that Government policies inadequately support civil-military fusion for infrastructure development. 36% respondents are unaware of any initiative of Government in promoting CMF in Ladakh
(q)	95 % of the respondents feel that there should be a clear policy framework to guide civil-military collaboration in digital infrastructure projects

Some other Key Findings are as under:-

- Limited mobile towers, harsh terrain and poor power supply restrict telecom expansion to remote border areas.
- The tele-density (182%) in urban areas of Ladakh is very high but remote villages near the LAC and LoC lack connectivity. Internet penetration varies widely: Leh (85%), Kargil (78%), Changthang (35%), Pangong (20%), Hanle (10%).
- Out of 229 villages in Ladakh, 93 villages have 4G connectivity, 36 villages have non-4G (2G/3G) connectivity, 70 villages lack mobile coverage, though 56 of these have incidental coverage from nearby towers. Key mobile network providers are Reliance Jio and Bharti Airtel which offer 4G services, while BSNL provides 2G/3G in some areas. The USOF initiative aims to install 354 more mobile towers in border areas, yet implementation is slow due to bureaucratic delays. Army on its own initiative has been able to activate more than 73 Sites to connect to remote locations. In addition 32 more sites have been approved as part of 4G Saturation project. Approximately 14 villages in Ladakh remain without mobile coverage, out of these, 12 villages are planned

to be covered under the "354 Villages Scheme", while 11 villages are planned under the 4G Saturation Scheme. However, Only 3 villages remain completely unconnected, but many forward military positions lack mobile connectivity, forcing reliance on Army landline networks.

- The power supply arrangements and duration of availability of commercial power supply is the main discouraging factor for TSPs in areas close to the borders as it leads to prolonged downtime of the system which leads to poor Return on Investment and user satisfaction.
- BharatNet project plans to connect Gram Panchayats via OFC, satellite, and wireless technologies. 193 villages were planned for satellite-based internet, with 192 completed, but only 43 are operational. The progress of the project remains slow.
- The Indian Army has 7,000 km of Optical Fiber Cable (OFC) but maintains it at a high operational cost and does not share its resources for civilian connectivity. Most of the far flung locations are connected with Army owned OFC that gives land line connectivity. The opportunity of Civil Military Fusion lies in harnessing each other's resources by extending Army owned OFC for connecting last mile civilian mobile communication equipment to extend wireless connectivity to troops and also to the local residents as also to the thousands of tourists who flock the far flung areas close to the LAC and LC
- No dedicated Army mobile network exists, leading to heavy reliance on civilian telecom infrastructure which is limited to pockets of habitation.
- There is limited collaboration between the military and civilian telecom providers, leading to duplicated efforts and inefficiencies.

- The digital infrastructure in Ladakh will significantly boost the region's economy, particularly in tourism, local businesses, agriculture and financial inclusion. Digital platforms like Airbnb, MakeMyTrip, and online payment systems has increased tourist inflow, with 70% of the 5.25 lakh visitors in 2023 using digital tools for bookings and transactions. Local businesses, especially handicrafts and Pashmina wool producers, have expanded their reach through e-commerce, leading to a 35% rise in online orders. In agriculture, digital connectivity has enabled weather forecasting, e-markets, and direct sales, increasing farmer incomes by 15-30%. The integration of digital banking and fintech solutions has also enhanced financial inclusion, reducing dependency on cash. However, further expansion to unconnected areas will boost local economy to higher levels.

Recommendations

Some of the key recommendations for leveraging Civil-Military Fusion for development of Digital Infrastructure in Ladakh are summarised below:-

- CMF must be institutionalized as part of India’s National Security Strategy to align defence, research, industry and civilian sectors for technological and economic growth. A dedicated CMF organization should be established to absorb, exploit and sustain modern military and dual-use technologies.
- Establish a Joint Civil-Military Digital Task Force in Ladakh – Create a coordinated policy body with representatives from the military, government and private sector to streamline approvals, funding, and project execution.
- Leverage Military-Owned Optical Fiber Cable (OFC) Networks – Army’s more than 7000 Km, Project Kranti, OFC network project in Ladakh can be exploited to extend connectivity in border areas with guarded access ensuring

network segmentation/ partition and cyber security. Utilize this network, power supply and communication infrastructure for dual-use purposes. Military must relax some security restrictions while civilian agencies must take responsibility for maintenance.

- Expand Government Funding and Incentives – Strengthen USOF and Vibrant Village Programs by providing financial subsidies, tax relief and risk-sharing models to encourage telecom providers (TSPs) to invest in border areas of Ladakh. Army's existing infrastructure can be leveraged to reduce CAPEX and some kind of arrangements through MoU can put in place to reduce OPEX for the TSPs. The Indian Army must open up to assist in deploying equipment, maintaining infrastructure and helping in operational continuity during extreme weather conditions or during hostile situations due to enemy actions.
- Improve Infrastructure Deployment in Border Areas – Install 32 additional mobile towers in forward locations to enhance military and civilian connectivity, using satellite-based and 5G technologies where fiber deployment is impractical. This can be accelerated by leveraging existing military infrastructure in remote areas.
- Enhance Coordination between Military and Civil Authorities – Implement a centralized approval process for land access, Right of Way (RoW) clearances, and infrastructure setup to minimize delays in establishment of towers and other communication infrastructure. Bureaucratic delays in infrastructure development must be cut down by eliminating red tape and ensuring fast-tracked approvals.

- Strengthen Cyber security Measures – Implement zero-trust architecture, encryption, network segmentation and regular audits to safeguard shared military-civilian digital networks. Implement transport and application-level security for data protection and use niche technologies like network slicing, VLANing and dark fiber for ultra-secure military communicationswhile sharing resources for civilian communications.
- Develop Military-Civilian Service-Level Agreements (SLAs) – Define clear roles, responsibilities, and security protocols for infrastructure sharing between the Armed Forces and private telecom operators.
- Encourages Private Sector Participation – Provide long-term commitment, financial incentives and reduce bureaucratic hurdles to attract TSPs and start-ups to invest in Ladakh's digital infrastructure. A good step would be to exempt tax, provide subsidies and share infrastructure cost for telecom operators willing to expand into remote border areas.
- Integrate Emerging Technologies – Promote the use of AI-powered surveillance, drone-based connectivity and block chain-driven cyber security to enhance both border security and civilian connectivity.
- Promote Civil-Military Innovation Hubs – Establish research centers and public-private partnerships (PPP) to drive technological innovations tailored for high-altitude and remote connectivity solutions.

Conclusion

The development of digital infrastructure in Ladakh presents both a strategic opportunity and a logistical challenge. Given the region's harsh terrain, extreme climate and geopolitical significance, expanding digital connectivity requires seamless collaboration between the military, civilian authorities, telecom providers,

and private investors. Civil-Military Fusion offers the most viable solution, leveraging military-owned assets like Optical Fiber Cable (OFC) networks, power supply and communication towers to bridge connectivity gaps while ensuring national security and operational readiness.

A unified governance approach is essential for the efficient execution of digital projects. The formation of a Central Civil-Military Coordination Body would ensure structured decision-making, faster project approvals, and synchronized efforts across stakeholders. Currently, delays in permissions and regulatory approvals hamper infrastructure expansion, discouraging private investment. A single-window clearance system would streamline processes, enabling telecom service providers (TSPs) to deploy mobile towers, expand OFC networks, and enhance broadband access with minimal delays. Additionally, the government must ensure that funding from programs like the Universal Service Obligation Fund (USOF) and Vibrant Village Program is efficiently allocated and utilized, with a focus on not just connectivity but also digital literacy, e-governance, and local economic development.

Security concerns remain a critical barrier to effective CMF. While the military has expressed concerns over sharing communication networks, implementing multi-layered cyber security protocols such as network segmentation, encrypted communications and strict access controls can mitigate risks. The adoption of network slicing, VLANs and dark fiber will allow secure military communications to coexist with civilian services without jeopardizing national security.

Financial sustainability is another key factor in the successful deployment of digital infrastructure in Ladakh. Due to low population density and challenging terrain, TSPs often struggle to justify investment costs. Government incentives including tax exemptions, infrastructure cost subsidies should be provided to

encourage expansion of digital space. Public-Private Partnerships (PPPs) should be actively promoted, ensuring that private companies have a stake in infrastructure development while benefiting from military support in logistics, power supply and site security. A well-integrated communication network will improve real-time response to natural disasters, facilitate remote medical assistance and strengthen emergency response mechanisms. By ensuring continuous connectivity in high-risk areas, civil-military cooperation can play a crucial role in both national security and humanitarian assistance. A structured, well-coordinated and security-conscious Civil-Military Fusion strategy can reform digital infrastructure in Ladakh and dividends of digital expansion through joint use of military and civilian resources can strengthen national security and also could hasten socio-economic development, transforming Ladakh into a future-ready digital economy.

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Appendix A**.**

District Wise Details of **14 Uncovered Villages with no Mobile Coverage**			
Ser No	District	Population	Name of Village
1.	Kargil	624	Derchik
2.	Kargil	1287	Garkon
3	Kargil	958	Kaksar
4	Kargil	349	Kuktse
5	Kargil	316	Kochick
6	Kargil	605	Ating
7	Kargil	358	Ranaqshah
8	Leh	99	Umla
9	Leh	202	Teri
10	Leh	167	Tarchit
11	Leh	361	Samad Rakchan
12	Leh	103	Thanga Chathang
13	Leh	142	Khemakhungiu
14	Leh	325	Kanji

Appendix B.

New Airtel Towers in 2024-25.

S No	Site Name	Remarks
1.	Ganasok	Active
2.	Handangbrok	Active
3.	Achinathang	Active
4.	Munthung	Active
5.	GT Top	Active
6.	Post 43	Active
8.	Bara Pathar	Active
7.	Bimbat Tac	Active
9.	Oril	Self fabricated tower
10.	Vijay Hill	Planned for Next Yr
11.	Gore PP	Active
12.	Post 9	Active
13.	Kumar	Planned for 2025, Reliance Jio 5G active
14.	Gulab	Planned for 2025, Active (Jio)
15.	DBO	Active
16.	Burtse	Active
17.	KM 148	Active
18.	KM 120	Active
19	KM 56	Active
20.	Tsogtsalu	Active
21.	KS Hill	Active
22.	Naglung Lungmpa	Active
23.	Phobrang	Active
24.	Charste	Active
25.	Chongtash	Active, Self fabricated tower
26.	KM 234	Active, Self fabricated tower
27.	Murgo	Planned for Next Yr
28.	Track Jn	
29.	Qazi Langer	
30.	Chusul	Active
31.	Loma	Active
32.	Hanle	Active
33.	Hanle	Active
34.	Tasi Gang	Active
35.	Punguk 1	Active
36.	Punguk 2	Active
37.	Nyoma BRO	Active
38.	Dungti	Active
39.	Mandir Base	Active
40.	Thakung Post	Active
41.	Hena	Active

42.	Fukche	Active
43.	Chisumle	Active
44.	Mahe	Active
45.	Karzok	Active
46.	Chumar	Active
47.	Tara Post	Active
48.	Kailash	Planned for next yr
49.	Zursar	
50.	Punguk	Planned for next yr
51.	Rango	
52.	Hanle	
53.	Hanle	
54.	Merak	

Appendix C

RESEARCH QUESTIONNAIRE

LEVERAGING CIVIL-MILITARY FUSION FOR THE DEVELOPMENT OF DIGITAL INFRASTRUCTURE IN LADAKH

It is an online survey as part of the Research Paper being submitted to Panjab University for the Advanced Professional Programme in Public Administration (APPPA) conducted by the Indian Institute of Public Administration (IIPA).

This questionnaire is designed to gather perceptions on the role of civil-military collaboration in developing digital infrastructure in remote border areas, particularly Ladakh. Responses will be measured on a Likert scale:
1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Q No1. What is your age group?

- 25-34
- 35-44
- 45-54
- 55 and above

Q No 2. What is your occupation?

- Government Official (Civilian)
- Military Personnel
- Resident of Ladakh
- Private Sector Employee
- Other

Q No 4. How aware are you of the concept of Civil-Military Fusion for digital infrastructure development?

- Very aware
- Somewhat aware
- Not very aware
- Not aware at all

Q No	**QUESTION**	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Current Digital Infrastructure						
5.	The current digital infrastructure in Ladakh is adequate for local needs.	1	2	3	4	5
6.	Internet connectivity in Ladakh Region has improved significantly in recent years.					
7.	Digital infrastructure will give impetus to economic growth in remote border areas of Ladakh					
8.	Existing communication facilities are sufficient for the operational needs of the military.					
9.	High-speed internet contectivity in remote villages of Ladakh is a necessity to uplift economy of the region.					
Civil-Military Collaboration						
10.	Civil-military collaboration is essential for developing digital infrastructure in border areas.					
11.	Civil-military partnerships can promote efficient resource utilization in remote areas of Ladakh.					
12.	Civil Military collaborations can reduce the digital divide in border regions.					
13.	There are adequate mechanisms in place to facilitate civil-military coordination for infrastructure projects in					

	Ladakh.					
14.	Coordinated efforts between civil and military stakeholders in developing digital infrastructure can enhance defense strategies					
Benefits of Civil-Military Fusion						
15.	Improved digital infrastructure will enhance economic opportunities for local communities.					
16.	Civil-military fusion will attract private investment in the region's development.					
17.	The development of digital infrastructure will improve public service delivery in remote areas.					
18.	In your opinion, what role should the military play in developing digital infrastructure in Ladakh	Provide technical expertise	Share existing infrastructure	Ensure secure communication systems		
Challenges and Concerns						
19.	Data security concerns may arise from civil-military collaborations.					
20.	Civil-military coordination is often slowed down by bureaucratic hurdles.					
21.	The lack of trust between civilian and military stakeholders is a significant challenge.					

22.	High costs of infrastructure development in remote areas are a major barrier					
Policy and Implementation						
23.	Government policies adequately support civil-military fusion for infrastructure development.					
24.	More funds should be allocated for digital infrastructure in remote border areas.					
25.	The involvement of local communities is critical for the success of these projects.					
26.	There should be a clear policy framework to guide civil-military collaboration in digital infrastructure projects					

Appendix D

LEVERAGING CIVIL-MILITARY FUSION FOR THE DEVELOPMENT OF DIGITAL INFRASTRUCTURE IN LADAKH

The Interview Questions are for survey as part of the Research Paper being submitted to Panjab University for the Advanced Professional Programme in Public Administration (APPPA) conducted by the Indian Institute of Public Administration (IIPA).

These questions are designed to gather perceptions on the role of civil-military collaboration in developing digital infrastructure in remote border areas, particularly Ladakh.

Q No 1. In your opinion, what are the most significant challenges in implementing civil-military collaboration for digital infrastructure development in remote border areas like Ladakh?

Q No 2. What resources of Military's existing infrastructure can be leveraged to enhance civilian connectivity in Ladakh?

Q No 3. What steps can policymakers take to ensure successful civil-military collaboration?

Q no 4. What recommendations would you make to improve the effectiveness of Civil-Military Fusion efforts in developing digital infrastructure in Ladakh?

Q No 5. Do you think enhanced communication infrastructure as an outcome of Civil Military Collaboration will promote better disaster management in Ladakh?

Q No 6. What are the threats to Data Security if digital infrastructure in Ladakh is shared for Military and Civilian use?

Q no 7. What safe guards can you suggest to improve security of data on shared Infrastructure?

Q no 8. Do you think Government policies adequately support civil-military fusion for infrastructure development in Ladakh?

Q No 9. Do you think there are conflicts of interest between civilian and military stakeholders as far CMF is concerned? If yes, what mitigation measures you can suggest to promote development of digital infrastructure in Border Areas?

Q No 10. How can Vibrant Village program and USOF aid in enhancing Civil Military Fusion in Ladakh?

Q No 11. What are the challenges faced by TSPs in developing Digital Infrastructure in Ladakh?

Q No 12. What are the expectations of TSPs from Military resources for developing Digital Infrastructure in remote areas of Ladakh?

Appendix E

INTERVIEW TRANSCRIPT – INTERVIEW 1

Q1. In your opinion, what are the most significant challenges in implementing civil-military collaboration for digital infrastructure development in remote border areas like Ladakh?

Ans**.** The single biggest roadblock is the 'will to make it work'. Unless there is a singularity of aim to achieve the same, it is difficult to accomplish the same as most of the factors are against it. None of the factors, namely, geographical and climatic barriers, high cost and financial risks, and regulatory and governance issues, cannot be overcome if there is a unified national approach and each stakeholder rises above their respective domain and only thinks about nation-building.

Q2. What resources of Military's existing infrastructure can be leveraged to enhance civilian connectivity in Ladakh?

Ans. The extensive fiber network and passive communication infrastructure that the Military has been able to build and maintain is the biggest offering to enhance civilian connectivity in Ladakh and other border regions. While Military will have to relax some of its stringent security concerns, civil agencies have to step up and take ownership of the infrastructure around the year to maintain the high uptime as is necessitated for critical communication requirements.

Q3. What steps can policy makers take to ensure successful civil-military collaboration?

Ans. The first and foremost is that any infrastructure project being undertaken by either military or civil agency should be centrally controlled. While it may initially be resisted, heavily by both the sides, it is an essential step lacking which efforts are

divided and multiple times duplicated. The net result is sub-optimum utilisation of resources.

Q4. What recommendations would you make to improve the effectiveness of Civil-Military Fusion efforts in developing digital infrastructure in Ladakh?

1. Formation of a central committee comprising of all the stakeholders, which will steer all the communication projects centrally and monitored at a suitably high level. 2. Division of responsibility and apropos introducing accountability. For eg communication along major roads and highways with civil agencies and to the arteries and branches with the Indian Army. 3. Cross-employment of personnel in communication-related departments. 4. Establishment of strict Service Level Agreements which are appropriate for any 'critical communication infrastructure'. 5. Inculcating a spirit of unified approach in infrastructure building rather than a perceived sense of one-upmanship.

Q5 Do you think enhanced communication infrastructure as an outcome of Civil Military Collaboration will promote better disaster management in Ladakh as also enhance operational capabilities of Defence Forces ?

Ans. Absolutely. Any infrastructure development being undertaken with a unified approach will fetch far better results than what could be achieved using an isolated and fragmented approach. As with any system, the best time to achieve any integration is from the inception stage rather than trying to achieve one, once the independent infrastructure has been established. The dividends of a unified approach will be a game changer as far as disaster management and operational capabilities are concerned.

Q6. What are the threats to Data Security if digital infrastructure in Ladakh is shared for Military and Civilian use?

In today's age, there are enough technologies available that will safeguard the data despite the sharing of communication infrastructure with civil agencies. While owning an independent communication infrastructure only addresses physical-level security, network-level, transport level, and application level security are still available to secure the data. This does not mean that physical-level security will not be available upon sharing the physical communication infrastructure- there are enough safeguards available for this too. Thus, by adopting a layered approach to secure data, the military data can be suitably secured even in the share infrastructure scenario.

Q7. What safe guards can you suggest to improve security of data on shared Infrastructure?

Ans. Layered security, viz., physical, network, transport and application-level security, will ensure enough safeguarding of data. Also, techniques like network slicing, logical partitioning; VLANs and dark fiber (for ultra-critical data) are some of the ways in which it can be ensured that military data does not get intermixed with non-military data.

Q8. Do you think Government policies adequately support civil-military fusion for infrastructure development in Ladakh?

Ans. As of now, the policies are not sufficient to support civil-military fusion. Whatever policies exist lack implementation. However, it is being seen that there is an earnest endeavor to address this void. Of late, the Indian Army has taken out a number of policy decisions that support the sharing of optical fiber and passive communication infrastructure with Telecom Service Providers. This has already started showing results as new communication infrastructure has come up at places that had been devoid of the same for the longest time. The momentum needs to be

maintained now, and trust needs to be established between agencies for more such mutual collaborations.

Q9. Do you think there are conflicts of interest between civilian and military stakeholders as far CMF is concerned? If yes, what mitigation measures you can suggest to promote development of digital infrastructure in Border Areas?

Ans. While conflict of interest is an issue, the more relevant issue is lack of trust and sense of ownership of respective communication infrastructure, which gives a control over the same. Also, the important aspect to highlight is the varied requirements. CMF is possible only for such aspects where the requirements overlap. For example, the optical fiber from Leh to Pangong Lake is where both military and civil interests overlap but an optical fiber to Kiari will not be of much interest to civil agencies for lack of civil population and lack of revenue generation from such a location. For places like these, the government should incentivise the civil agencies by giving them subsidies to establish communication infrastructure using CMF.

Q10. How can Vibrant Village program and USOF aid in enhancing Civil Military Fusion in Ladakh?

Ans. USOF (now named *Bharat Nidhi*) is an essential pillar for the Vibrant Village Program, under which government-funded communication infrastructure is being established at remote and inhospitable locations. As the military has presence over most of these locations, such infrastructure should be established jointly in consultation with local military authorities so that it is beneficial for both the military as well as the local population, which has been devoid of communication for a long time. The military can play a big role in assisting the establishment of infrastructure and subsequently its maintenance, which is a bigger challenge considering the terrain friction and its resulting difficulty in carrying out timely repairs. It is here that the

military can step in and provide necessary assistance during inclement weather and along inhospitable terrain.

Q11. What are the challenges faced by TSPs in developing Digital Infrastructure in Ladakh?

Ans. Among the many challenges related to geographic terrain, temperature, limited window of operations, altitude, difficulty in upkeep, closure of roads in winters, and lack of natural resources, the biggest challenge is that TSPs don't find a good business case for establishing the communication infrastructure. The estimated revenue is far less than what is needed to establish and maintain the infrastructure. Thus, CMF plays a critical role wherein sharing of resources can cut down major expenditure for TSPs. Further incentives can be given by Governement in the form of subsidy so that the venture becomes financially viable for TSPs.

Q12. What are the expectations of TSPs from Military resources for developing Digital Infrastructure in remote areas of Ladakh?

Ans. TSPs ask primarily for optical fiber, which provides the backbone to their terminal equipment. Besides this, the need for fuel, manning of equipment during inclement weather and passive communication infrastructure such as shelter and power are also at times sought by TSPs.

INTERVIEW TRANSCRIPT – INTERVIEW 2

Q1. In your opinion, what are the most significant challenges in implementing civil-military collaboration for digital infrastructure development in remote border areas like Ladakh?

Ans. Geopolitical Sensitivity along Geographical and Environmental Challenges are some of the key aspects which pose as challenges along with Security Constraints. Implementation of Civil -Military Collaboration needs a lot of Engagement and most importantly political will.

Q2. What resources of Military's existing infrastructure can be leveraged to enhance civilian connectivity in Ladakh?

Ans. Reach & Will are two significant aspects which Military has an upper edge. Military and Private Players (Telcos) can work together and bring a lot of change in the region.

Q3. What steps can policy makers take to ensure successful civil-military collaboration?

Ans. Cutting Bureaucratic Red Tape. Fast approvals. Well coordinated approach and most importantly not to view the Private players as mere money making machine. The Policy makes needs to incentivise any private player who is ready to support the enhancement and development of the region, there are has to be a diff approach / rules of engagement visa-vis any other state or region.

Q4. What recommendations would you make to improve the effectiveness of Civil-Military Fusion efforts in developing digital infrastructure in Ladakh?

Ans. No comments offered.

Q5. **Do you think enhanced communication infrastructure as an outcome of Civi Military Collaboration will promote better disaster management in Ladakh as also enhance operational capabilities of Defence Forces ?**

Ans. Integrated approach with clear responsibilities. Leveraging technology to the fullest (Invite Private players to study and recommend. Establish state of the art communication which is the key backbone of any developmental plan. Skill local community.

Q6. What are the threats to Data Security if digital infrastructure in Ladakh is shared for Military and Civilian use?

Ans. While there are risks primarily from cyber world, insider threats, and the vulnerabilities of shared physical and network systems. These risks must can be managed carefully through strong cybersecurity measures, segregation of networks, clear access controls, and physical security. We need to implement best practices to maximize the collab while minimizing the risk to national security and civilian data integrity.

Q7. What safe guards can you suggest to improve security of data on shared Infrastructure?

Ans. All Cyber Security Critical layers. (Data Segmentation, IAM, PAM, Zero Trust, Monitoring etc)

Q8. Do you think Government policies adequately support civil-military fusion for infrastructure development in Ladakh?

Ans. Not fully.

Q9. Do you think there are conflicts of interest between civilian and military stakeholders as far CMF is concerned? If yes, what mitigation measures you can suggest to promote development of digital infrastructure in Border Areas?

Ans. Different priorities and goals is one key aspect. We need to work in tangent to overcome this big hurdle. There has to be a joint task force / team to ensure there is no hurdles.

Q10. How can Vibrant Village program and USOF aid in enhancing Civil Military Fusion in Ladakh?

Ans. Government needs to utilize the funds and give ease to implement the USOF at its full strength.The USOF need to expand its approach beyond communication only, it has to add the last mile of education, health and sill development.

Q11. What are the challenges faced by TSPs in developing Digital Infrastructure in Ladakh?

Ans. As mentioned above, The Government has to Subsidise and Incentives in terms of tax exemptions, subsidised infrastructure costs, and reduce regulatory barriers for projects in remote regions. Government needs to Leverage Satellite and Wireless Technologies along with other innovative ideas on accessibility of power for these imp infrastructures.

Q12. What are the expectations of TSPs from Military resources for developing Digital Infrastructure in remote areas of Ladakh?

Ans. As mentioned above, The Government has to Subsidise and Incentives in terms of tax exemptions, subsidised infrastructure costs, and reduce regulatory barriers for projects in remote regions. Government needs to Leverage Satellite and Wireless Technologies along with other innovative ideas on accessibility of power for these imp infrastructures.

INTERVIEW TRANSCRIPT – INTERVIEW 3

Q1. In your opinion, what are the most significant challenges in implementing civil-military collaboration for digital infrastructure development in remote border areas like Ladakh?

Ans. Support on permissions to build the right infrastructure and to provide / support connectivity.

Q2. What resources of Military's existing infrastructure can be leveraged to enhance civilian connectivity in Ladakh?

Ans. Optical fiber, civil structures, Power supply

Q3. What steps can policy makers take to ensure successful civil-military collaboration?

Ans. Single window and time bound clearance

Q4. What recommendations would you make to improve the effectiveness of Civil-Military Fusion efforts in developing digital infrastructure in Ladakh?

Ans. Enable us to conduct the survey and submit a full blueprint and then support for permissions to build

Q5. **Do you think enhanced communication infrastructure as an outcome of Civil Military Collaboration will promote better disaster management in Ladakh as also enhance operational capabilities of Defence Forces ?**

Ans. Absolutely, one , it will act as an alternate to what army has already built, two, it will be a state of art comms at par with global standards

Q6. What are the threats to Data Security if digital infrastructure in Ladakh is shared for Military and Civilian use?

Ans. If right security infrastructure and process safeguards are built, this system will be as security proof as the best possible globally

Q7. What safe guards can you suggest to improve security of data on shared Infrastructure?

Ans. Multilayer checks, auto executed for access and use of data

Q8. Do you think Government policies adequately support civil-military fusion for infrastructure development in Ladakh?

Ans. Yes.

Q9. Do you think there are conflicts of interest between civilian and military stakeholders as far CMF is concerned? If yes, what mitigation measures you can suggest to promote development of digital infrastructure in Border Areas?

Ans. The CAPEX intensive nature of communications infrastructure specially if difficult terrain at times makes it cost prohibitive to scale and density. If there is reasonable subsidy to create this, it will help immensely,

Q10. How can Vibrant Village program and USOF aid in enhancing Civil Military Fusion in Ladakh?

Ans. Both can provide financial benefits to create digital infra

Q11. What are the challenges faced by TSPs in developing Digital Infrastructure in Ladakh?

Ans. Permissions, movement of material, manpower

Q12. What are the expectations of TSPs from Military resources for developing Digital Infrastructure in remote areas of Ladakh?

Ans. Support with permissions to build and necessary existing infra re power, fiber and civil structure