

Bharat 6G Alliance Whitepaper

AI and Network Evolution to 5G Advanced and 6G

Native AI, Infrastructure Implications, and Global-India Perspectives



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Executive Summary

The shift from 5G Advanced to 6G is set to revolutionize telecom networks, transitioning from traditional systems to AI-native frameworks that are deeply integrated across every layer of the network. In 6G, AI will no longer be a tool for optimization but the very backbone of network design enabling networks to be autonomous, intelligent, and self-healing.

This white paper delves into the significance of AI-driven networks and their transformative role in the evolution of 5G Advanced to 6G. From self-optimizing systems to AI-powered orchestration, the paper explores how AI-native architecture will provide real-time adaptability, reduce operational complexity, and elevate service delivery.

For India, AI-native 6G represents a leap toward technological sovereignty, positioning the nation to lead in both AI research and network infrastructure development. The country's vast demographic diversity and unique socio-economic landscape provide a perfect opportunity to develop affordable, scalable AI solutions tailored for both urban and rural needs. India's active role in AI model development for telecom will be critical to the creation of global standards and IP that are accessible and equitable.

Globally, AI-integrated 6G will enable cutting-edge applications like immersive virtual environments, precision healthcare, and autonomous transportation, positioning telecom as the central nervous system for all sectors. However, with great innovation comes complex challenges ranging from data privacy, ethics in AI, to security concerns, requiring both local and international collaboration.

Key insights and findings:

- AI is the key enabler of next-generation networks, fundamentally reshaping how networks operate, scale, and interact with users.
- AI-native 6G promises to unlock unprecedented levels of automation, enabling self-optimizing, self-healing and self-protecting networks.
- Lead in standards to have AI related IPR opportunity creation across the value chain.
- India has a unique opportunity to spearhead the creation of indigenous, efficient AI models that are aligned with its diverse, cost-sensitive needs driving AI-led innovation for emerging economies.

- To capitalize on this opportunity, India must focus on building sovereign AI technologies, creating a robust data ecosystem, and investing in open-source collaborations.
- Collaborative research between telecom, AI, government, and academia is paramount to avoid fragmented efforts and to address ethical, security, and regulatory issues surrounding AI deployment.
- India's leadership in AI-based telecom innovation can influence global standardization bodies and ensure that global standards are inclusive and reflective of the needs of the Global South.
- The role of data governance, AI ethics, and network security must be prioritized to mitigate risks as we move towards a fully autonomous, data-driven ecosystem.

This white paper lays out a strategic roadmap for India's leadership in the AI-native 6G future, ensuring that the country not only participates in but shapes the global telecom ecosystem. By focusing on indigenous innovation, AI-driven infrastructure, and collaboration, India has the potential to redefine the global 6G narrative and ensure that AI-enhanced telecom remains equitable, accessible, and scalable.

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1 Introduction: Bharat6G Alliance and AI Initiatives

The **Bharat6G Alliance (B6GA)** was established to realize the ambitious *Bharat 6G Vision*, which aims to position India as a global frontrunner in the next-generation telecommunication technologies by 2030. As shown in *Figure 1*, Bharat 6G vision focuses on designing and deploying intelligent and secure 6G networks that provide ubiquitous connectivity for a high-quality life, with a strong emphasis on affordability, sustainability, and ubiquity. The B6GA serves as an industry-led, government-facilitated platform that brings together public and private companies, academia, research institutions, and standards development organizations to foster collaborative innovation.

India pursues 6G not just as a technological advancement, but as a profound strategic initiative to drive economic growth, enable deep digital inclusion, and position the nation as a global leader in telecommunications. Rooted in a vision of using advanced connectivity for societal benefit, B6GA aims to shape both national progress and global impact.

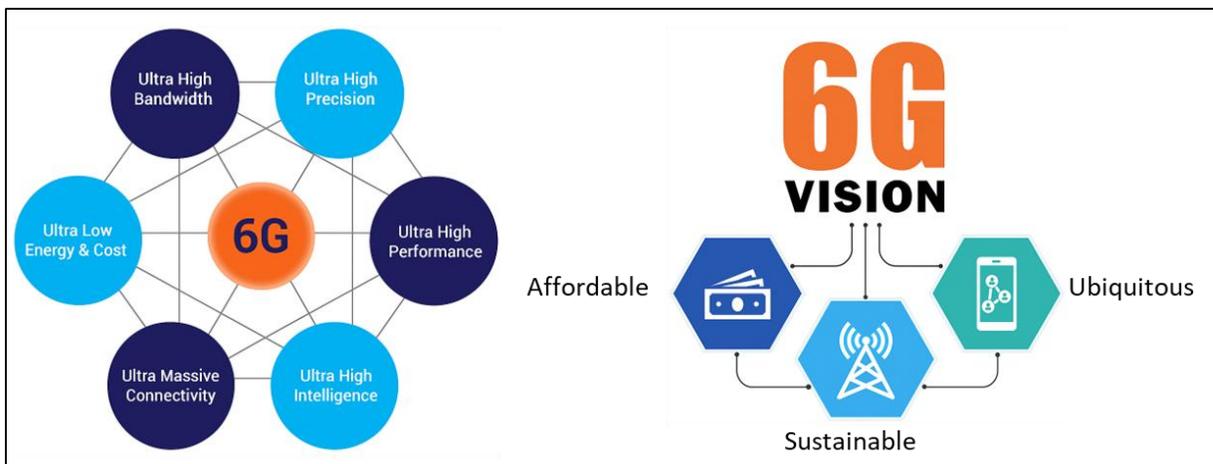


Figure 1: Bharat 6G Vision.

1.1 5G Advanced and 6G: An AI-native evolution

As the global telecom industry progresses from 5G advanced (5G-A) to 6G, one of the key shift is the integration of Artificial Intelligence (AI) and Machine Learning (ML) into the very fabric of networks. 5G-A extends current systems through advanced spectrum use, intelligent antennas, non-terrestrial integration, and edge computing, enabling immersive applications such as extended reality (XR), holographic communication, and autonomous systems. However, 6G

marks a transformative leap envisioned as an ***AI-native network*** where intelligence is embedded across all layers, from spectrum and resource management to security, orchestration, and semantic communication. In this paradigm, AI serves as the nervous system of 6G network, enabling them to sense, decide, and act autonomously in real-time. The 6G network enables immersive, intelligent, and seamless connectivity. This isn't just about faster speeds; it's about creating a deeply integrated digital fabric that extends human capabilities and enables unprecedented interactions between the physical and virtual worlds. The ever-growing number of users, the expanding diversity of data types, and the emergence of entirely new use cases are all critical forces driving the initiative to develop these advanced 6G technologies. 6G network architecture is envisioned to feature advanced design, intelligent management, and unified control protocols that seamlessly operate across optical, wireless, and satellite domains.

AI and ML are indispensable tools to the development of 6G networks. This is because a 6G network must constantly and rapidly balance competing demands: ensuring excellent user experience, maintaining robust security, and operating within the fundamental limits of physics. Consequently, data will gain immense value, not just from its creation and consumption, but significantly from its inherent information content. The ultimate quality of this data will directly determine the worth of this advanced, intelligent communication ecosystem.

1.1.1 India's AI Momentum in Support of 6G

India has identified AI as a strategic enabler for inclusive growth and digital self-reliance. According to the *Stanford AI Index 2024*, India ranks first in AI skill penetration and is among the top four globally in AI vibrancy. GitHub also places India first with a 24% global share of AI projects, reflecting the strength of its developer ecosystem. National initiatives such as:

- **National AI strategy – “AI for All” (2018)**, focused on healthcare, agriculture, education, mobility, and smart infrastructure.
- **National programme on AI (MeitY)**, structured around four pillars: National Center on AI, Data Management Office, AI skilling, and Responsible AI.
- **IndiaAI mission**, which drives compute capacity, innovation centers, datasets platforms, startup financing, and trusted AI frameworks.
- **BharatGen (2024)**, the world's first government-funded multimodal large language models (LLM) for Indian languages.

Together, these initiatives provide the foundational ecosystem for compute infrastructure, datasets, innovation hubs, and talent, supporting AI-driven 6G research and deployment.

1.1.2 Global AI and 6G Initiatives

India’s efforts align with a broader international momentum where AI is recognized as central to 6G evolution as given in *Table 1* below:

Table 1 - Global AI and 6G Initiatives

Country/Region	Flagship AI Initiative	6G Relevance	Institutional Drivers	Key Focus Areas
India	IndiaAI Mission, Bharat 6G Vision	AI for network intelligence, spectrum management, RIS, edge analytics	MeitY, DoT, TSDSI, B6GA	Compute infrastructure, public datasets, AI for telecom, foundational models, CNPN trials
European Union	Hexa-X / Hexa-X II, EU AI Act	Native AI in 6G architecture, orchestration, trust, energy-efficient networks	European Commission, ETSI, 6G-IA	AI-native protocols, zero-touch networks, ethics, and regulation
United States	CHIPS and Science Act, NextG Alliance (ATIS)	AI for Open RAN, intelligent edge, semantic communication	NSF, NTIA, DARPA, ATIS	Secure AI for telecom, AI-on-chip, autonomous spectrum systems
China	New Generation AI Plan, 6G R&D under MIIT	AI-defined core networks, pervasive intelligence, vertical use cases	MIIT, China Mobile, Huawei, CAICT	AI for 6G physical layer, surveillance, and industrial automation
South Korea	Korea AI Strategy 2030, 6G Vision	AI-embedded RIS, HAPS, XR, holography	MSIT, ETRI, SKT, Samsung	AI-chip co-design, mmWave / THz integration, immersive AI

Japan	Moonshot Goals, Beyond 5G Promotion Strategy	AI for control planes, NTN optimization, and societal-scale simulations	MIC, NICT, University of Tokyo	AI in disaster resilience, robotics, smart cities with 6G integration
Finland	6G Flagship (University of Oulu)	Pioneering AI-first 6G system architecture, edge intelligence	Academia in Finland, Nokia	AI-based sustainability, hybrid intelligence, testbeds

Strategic outlook:

In this global landscape, B6GA provides India with a platform to *contribute and shape the global standards and architectures*. By aligning AI initiatives with B6GA’s mission, India can ensure that its innovations, from foundational AI models to telecom-specific applications, directly influence the AI-native networks of the future. This combination of national AI leadership and international 6G collaboration, positions India to play a decisive role in shaping secure, inclusive, and intelligent connectivity for the world.

2 Telecom Landscape and 3GPP Roadmap to 5G Advanced and 6G

For decades, the **3rd Generation Partnership Project (3GPP)** has played a pivotal role in shaping the telecommunications landscape and redefining the potential of wireless connectivity. Through successive releases, 3GPP has progressively advanced 5G technology and laid the groundwork for the transition toward 6G as shown in *Figure 2*, which we briefly explain below.

- **Release 15 (2018):** Established the foundational 5G new radio (NR) specifications, enabling global commercial deployments. Key features included enhanced mobile broadband (eMBB), massive multi-input multi-output (MIMO), and flexible spectrum usage.
- **Release 16 (2020):** Expanded 5G applications by supporting industrial internet of things (IoT), vehicle-to-everything (V2X), integrated access and backhaul (IAB), unlicensed spectrum operation, and positioning. These advancements opened the door for use cases such as smart manufacturing and autonomous driving.

- **Release 17 (2020 – 2022):** Extended 5G into new domains by introducing non-terrestrial networks (NTN) for satellite-based connectivity, reduced capability (RedCap) devices for cost-efficient IoT, multicast and broadcast services (MBS), and operation up to 71 GHz. Enhancements in MIMO, dynamic spectrum sharing (DSS), network energy saving, positioning enhancements, and ultra-reliable low-latency communications (URLLC) further broaden the global applicability of 5G.
- **Release 18 (2022 – 2024):** Marked the beginning of 5G-A, enhancing MIMO, DSS, coverage, URLLC, and user equipment (UE) power saving, high accuracy and sidelink positioning. It introduced AI/ML for air interface optimization, sidelink improvements for device-to-device communication, mobility upgrades, and expanded NTN features.
- **Release 19 (2023 – 2025):** Enhanced 5G-A with deeper AI/ML integration, Ambient IoT (AIoT), RedCap enhancements, and explorations of full-duplex operation, energy-saving measures, and advanced NTN.
- **Release 20 (2025 onwards):** Serves as a stepping stone toward 6G evolution, advancing AI/ML in the air interface, enhancing AIoT, integrated sensing and communication (ISAC), and advanced MIMO (Phase 6). It also sets the stage for 6G with redesigned physical layers, AI/ML-enabled sensing, and next-generation architectures to meet future connectivity demands.

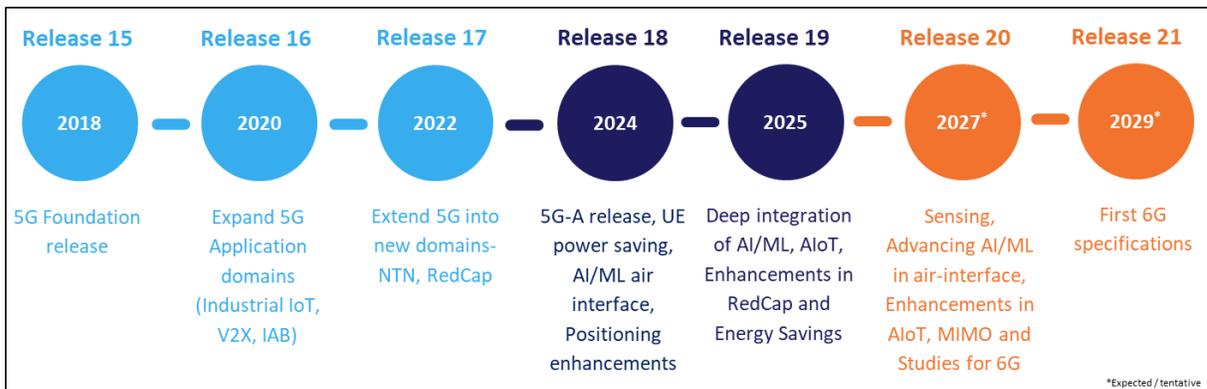


Figure 2: 3GPP timelines from 5G to 6G specs

Parallel to these technical specifications, 3GPP will define service requirements, performance targets, system architecture, and enabling technologies for 6G. A major emphasis is on applying AI/ML to mobility management, including radio resource management (RRM) prediction and forecasting events like handovers and radio link failures. The NR air interface will receive particular focus, especially in areas such as CSI feedback, supported by enhanced UE data collection capabilities, ensuring that AI/ML is deeply embedded into the fabric of next-generation networks.

As this roadmap illustrates, the evolution from 5G-A to 6G is no longer about incremental improvements alone, but it is about embedding intelligence as a native capability of the network itself. Next, we discuss the *AI/ML landscape in India and globally*, where we examine how national missions and global initiatives are aligning to make AI the cornerstone of 6G.

3 AI/ML Landscape for 6G: Expanded Details on India and Global Efforts

As outlined in the 3GPP roadmap in *Figure 2*, the evolution from 5G-A to 6G is defined by the progressive integration of intelligence into the network fabric. The IMT-2030 guidelines reaffirm this by identifying AI/ML as a key technology for 6G, where networks will not only support AI-driven services but also be fundamentally powered by AI. In other words, 6G is envisioned as both a platform *for* AI and a system *enabled by* AI. Global efforts are now converging toward building AI-native 6G networks, and India has positioned itself as an active contributor to this global movement.

3.1 India's National AI Strategy and Telecom Sector Focus

The **Bharat 6G Mission** seeks to position India as a global supplier of advanced telecom technologies by 2030, with a strong focus on affordability, sustainability, and inclusivity. AI/ML is identified as a **central enabler** to realize this vision enabling intelligent RAN, autonomous core networks, and energy-efficient communications.

India's commitment is reinforced by:

- **Standardization contributions:** Through the Telecommunications Standards Development Society, India (TSDSI), Indian experts actively contribute to International Telecommunication Union (ITU) and 3GPP, ensuring domestic priorities such as intelligent orchestration, explainable AI, and digital sovereignty are embedded into global standards.
- **6G testbeds and research hubs:** The Department of Telecommunications (DoT) has funded 6G testbeds at Indian Institute of Technology(s) (IITs) and national research labs, with specific focus areas such as AI-native RAN and protocol design.
- **Center of Excellence's (CoEs):** Supported by the Ministry of Education, CoEs in AI at IIT Kanpur, IIT Delhi, IIT Ropar, and AIIMS Delhi are driving domain-specific innovation in health, agriculture, smart cities, and cyber-physical systems. The Wadhvani school of AI at IIT Kanpur is also advancing research on AI-native 6G standards and product development.

- **International engagement:** India recently hosted the ITU Focus Group on AI-native for telecommunication networks (FG-AINN). This forum is redefining global architecture by embedding AI at the core, while India's leadership is ensuring that practical, inclusive, and explainable solutions are part of the global agenda.
- **Startup ecosystem:** Programs like GENSIS and the IndiaAI Mission are funding AI/ML startups, particularly in Tier-2 and Tier-3 cities, to create indigenous solutions for telecom and beyond.

All these initiatives collectively reinforce India's ambition for technological sovereignty in AI/6G, ensuring that solutions are globally competitive and are tailored to the country's diverse socioeconomic needs.

3.2 Global Efforts for Driving AI in Telecom

India's roadmap aligns with the following regional and global efforts that are embedding AI into 6G development:

- **Europe:** Smart Networks and Services Joint Undertaking (SNS JU), through flagship projects like Hexa-X and Hexa-X-II, is advancing AI/ML integration from the physical layer to service orchestration. European Telecommunications Standards Institute (ETSI) is complementing this with work on explainable AI (XAI) and closed-loop management systems for self-adaptive networks.
- **United States:** The NextG Alliance has placed AI-native wireless networks at the heart of its 6G roadmap, supported by National Science Foundation (NSF), Department of Defense (DoD), and National Institute of Standards and Technology (NIST) programs. Initiatives like RINGS and a \$1.5B public wireless innovation fund are fueling research in AI-driven mobility, security, and orchestration.
- **China:** Through the IMT-2030 (6G) Promotion Group and the AI+ Program, China is accelerating AI-driven 6G research and development (R&D). A 2023 white paper outlined representative use cases for AI-telecom convergence, spanning ML model requirements, data formats, and specifications.
- **Japan:** The XG Mobile Promotion Forum (XGMF) and NICT are funding AI/ML-driven 6G R&D, with a strong emphasis on zero-touch orchestration and digital twins. Japan is also collaborating with Europe via SNS JU to align AI-native approaches.
- **Korea:** The Ministry of Science and ICT (MSIT) 6G R&D plan identifies ultra-intelligence as a key pillar, embedding AI across core and RAN. A 6G research center at Korea University is developing candidate technologies for intelligent wireless access, alongside international collaborations.

- **Brazil:** The Brasil6G national program focuses on AI/ML applications in areas such as coding techniques, beamforming, and mobility management in mmWave bands.

Across India and globally, through national missions like Bharat 6G, collaborative platforms such as Hexa-X, or strategic R&D funding in the US, China, Japan, and Korea, the direction is clear, 6G will be AI-native by design. In the next section, we examine how AI will move from assisting networks to defining them, and the transformative use cases this unlocks.

4 AI and Native AI

The integration of AI/ML into wireless communication marks a paradigm shift in how future networks are designed. Moving beyond conventional algorithm-based methods, 6G envisions AI-native architectures, where intelligence is just an add-on feature but embedded in the design of every layer of the network stack. This evolution enables real-time optimization, dynamic resource management, and a self-adaptive system capable of learning and acting autonomously.

4.1 From AI-Assisted to AI-Native Networks

The journey toward AI-native 6G can be understood as a continuum as shown in *Figure 3*:

- **AI-Assisted:** AI enhances specific operations (e.g., channel estimation, beam management) to improve efficiency.
- **AI-Integrated:** AI-based modules (e.g., mobility predictors, traffic classifiers) are added alongside legacy components to support network optimization.
- **AI-Native:** AI becomes the blueprint of the architecture itself, where data collection, training, inference, and updates are built into the system fabric, enabling networks that continuously evolve.

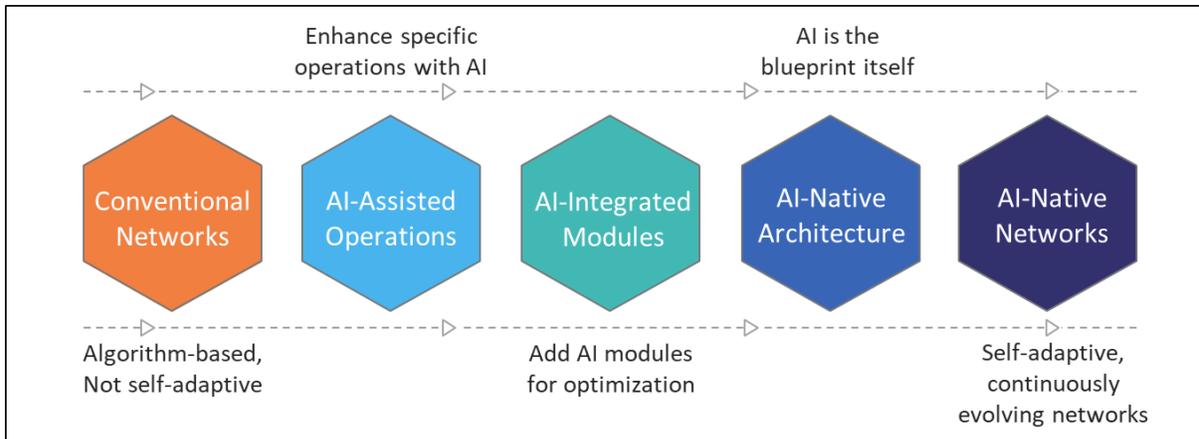


Figure 3: Building AI-native 6G networks

4.1.1 Benefits of AI-Native Design

Native AI unlocks following system-level advantages which are not possible with traditional architectures:

- **Energy efficiency:** AI-driven power control and beam management minimize energy consumption across RAN and core.
- **Ultra-low latency:** Predictive models anticipate mobility, handovers, and resource demands, reducing reaction times, which in turn improves the latency.
- **Dynamic optimization:** Networks adapt in real-time to shifting channel conditions, traffic loads, and user requirements.

4.1.2 Examples of AI-Native Solutions

- **AI at the Physical layer:** Neural models learn optimal signal constellations and pilot patterns for efficient spectrum use and energy-efficient operation.
- **End-to-end learning (autoencoders):** Joint optimization of transmitter and receiver via deep learning replaces multiple separate algorithms, improving throughput and robustness.
- **AI-Native RAN:** Mobility predictors optimize handovers before degradation occur; AI-enabled schedulers dynamically allocate spectrum for latency-critical applications.

- **Self-optimizing core:** AI agents continuously monitor key performance indicators (KPIs), retrain models, and update live deployments to sustain performance under evolving channel conditions and load requirements.

4.2 AI/ML Functional Framework

3GPP has already initiated work on an AI/ML functional framework for the NR air interface, studying how models interact with existing processes and standards, which is summarized in *Figure 4*. This contains:

- **Data collection** from live networks for training.
- **Model training and inference** pipelines for adaptive intelligence.
- **Performance monitoring** to benchmark AI against legacy algorithms.
- **Model updating** to ensure resilience against dynamic environments.

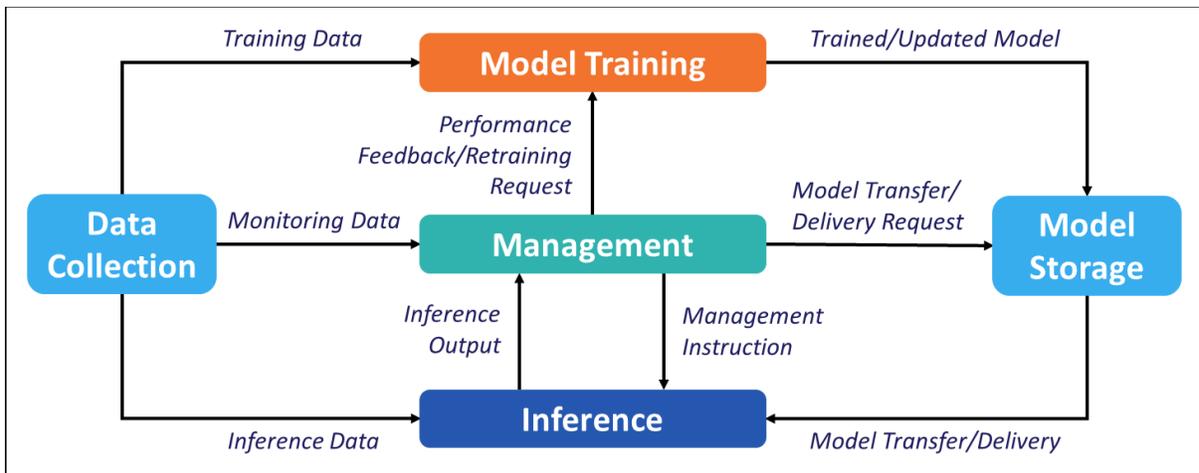


Figure 4: Functional Framework for AI/ML for NR Air interface

This transition from AI-assisted enhancements to AI-native, self-evolving systems represents the essence of 6G. It redefines networks as autonomous, learning-driven platforms that can sense, decide, and act in real time, paving the way for transformative use cases such as immersive XR, holographic communication, digital twins, and industrial automation.

To realize this vision, it is crucial to explore the AI/ML methodologies that will underpin these capabilities and define how intelligence is embedded across telecom networks.

5 AI/ML Methodologies in Telecom

The evolution toward AI-native networks requires rethinking how intelligence is developed, deployed, and embedded across every layer of telecom infrastructure. Several methodological paradigms are converging to power this transformation e.g., foundation models trained at scale and adapted to telecom-specific tasks, agentic AI enabling autonomous decision-making, and semantic communication focused on transmitting meaning rather than raw data. Together, these approaches define the building blocks for how 5G-A and 6G will sense, decide, and act in real time.

5.1 Foundation Models for Telecom

The term foundation model (FM), introduced by Stanford HAI in 2021, refers to large ML models trained on massive datasets and adaptable to a wide variety of tasks. These models, as shown in *Figure 5*, bring generalized knowledge, transfer learning, zero/few-shot capabilities, and self-supervised learning, making them ideal for the diverse and dynamic requirements of telecom.

In the network context, FMs act as a baseline that can be fine-tuned for specialized tasks, such as radio signal processing and operations automation, reducing the need for bespoke models for every problem. By capturing broad patterns across data modalities, they enable cross-domain intelligence that spans RAN, core, transport, and service layers.

Key characteristics of FMs include:

- **Scalability:** Trained on massive datasets with billions of parameters, enabling them to generalize across tasks.
- **Multi-Modality:** Ability to process and integrate different data types like text, images, audio, and time-series signals, into a unified reasoning framework.
- **Transferability:** Once pre-trained, they can be fine-tuned for specialized telecom tasks with relatively small domain-specific datasets.
- **Emergent capabilities:** Beyond supervised learning, FMs often demonstrate reasoning, summarization, and abstraction abilities not explicitly programmed.
- **Continuous adaptation:** Through fine-tuning and reinforcement learning, they can evolve alongside the dynamic conditions of telecom networks.

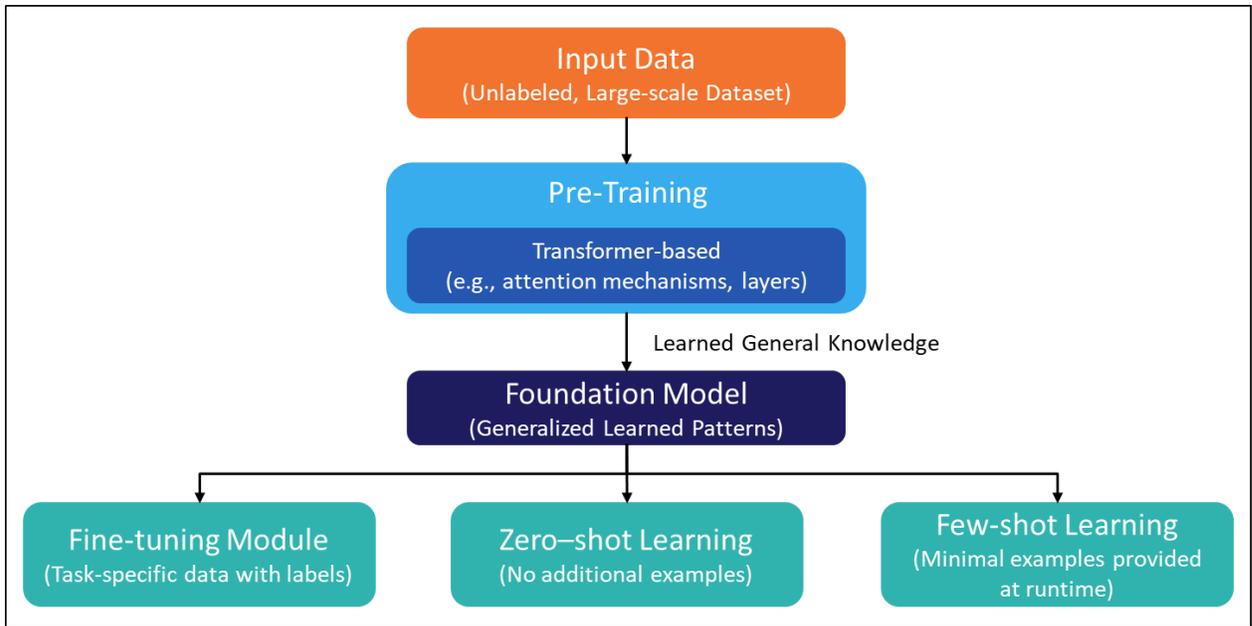


Figure 5: Foundation Models training and optimization adaptation

The various forms of FMs are shown in *Figure 6*, each optimized for different modalities:

- **Large language models (LLMs):** Trained primarily in text data, suited for semantic understanding, knowledge retrieval, and intent translation.
- **Vision-language models (VLMs):** These models integrate textual and visual representations, enabling reasoning across multi-modal data such as network telemetry visualizations and configuration logs.
- **Vision models (VMs):** Focused on image-like data representations, especially relevant in telecom where signals and channels can be represented as 2D/3D matrices.
- **Time-series models:** Specialized for sequential data analysis, crucial for predictive analytics, anomaly detection, and demand forecasting in telecom networks.

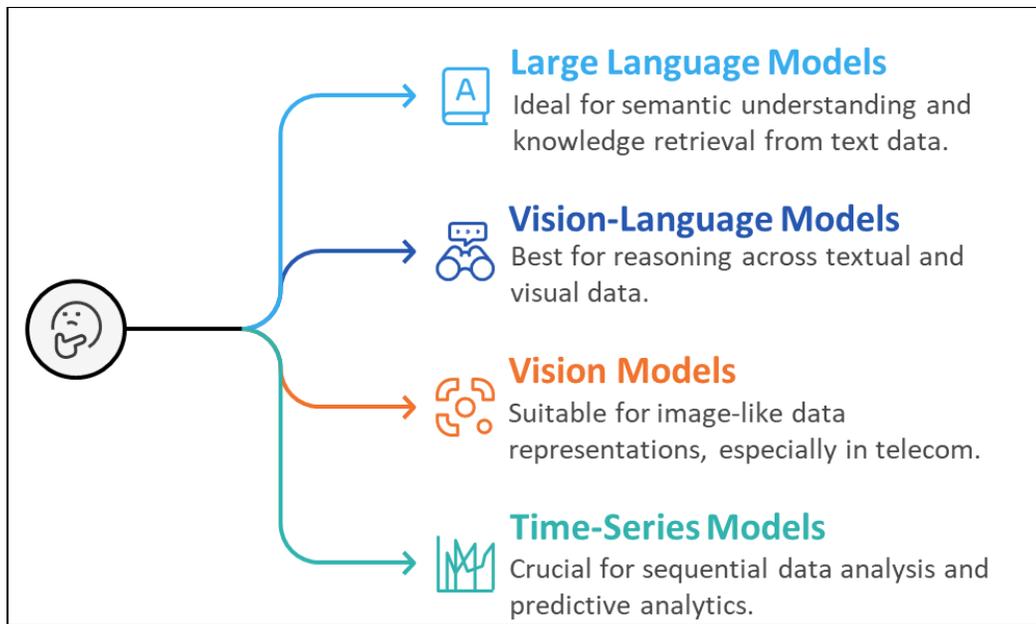


Figure 6: Forms of Foundation Model

5.1.1 Language Models (LLMs and SLMs) → From natural text to network intelligence

LLMs are built on transformer architectures trained on billions of tokens, giving them strong pattern recognition, reasoning, and generation capabilities. They can interpret natural language, generate structured text, and even produce code. When fine-tuned or adapted with domain-specific information, LLMs evolve from general-purpose engines into specialized telecom copilots.

In telecom networks, this opens multiple applications:

- **Standards intelligence:** LLMs indexed with retrieval-augmented generation (RAG) can act as 3GPP copilots, enabling semantic search and grounded Q&A across thousands of pages of specifications.
- **Intent-to-configuration:** They can parse human-readable intents (e.g., “Deploy an URLLC slice with 10 ms latency”) and translate them into machine-executable configurations across RAN, core, and transport.
- **Workflow & provisioning automation:** LLMs can convert service orders into orchestrated workflows, including validation and compliance checks.

- **Telemetry summarization:** By parsing unstructured logs and alarms, LLMs can summarize incidents, surface probable root causes, and recommend remediation actions.
- **Code & infra assistance:** For network engineers, LLMs serve as copilots for generating Terraform/Ansible templates or debugging CI/CD pipelines.

Thus, LLMs and domain-optimized small language models (SLMs) become bridges between human intent and machine execution, moving beyond chatbots into the core of network operations automation.

5.1.2 Vision Models → From image understanding to CSI optimization

Vision models, originally developed for image classification, object detection, and pattern recognition, leverage deep convolutional networks and more recently vision transformers (ViTs) to capture both local structures and global correlations. They excel at extracting features from high-dimensional data, recognizing spatial dependencies that might not be obvious to rule-based systems.

In telecom, radio channels can be represented as image-like tensors (e.g., 3D grids of time–frequency–antenna data). This makes vision models a natural fit for tasks such as channel state information (CSI) compression and feedback, which is crucial for achieving massive MIMO performance.

CSI Compression and feedback: Models such as CsiNet, TransNet, and SwinCFNet treat the CSI tensor as an image, learning compact representations that significantly reduce uplink reporting overhead while preserving high reconstruction fidelity. By capturing spatial–frequency correlations through convolutional and attention mechanisms, these models improve the quality of recovered CSI, enabling more accurate beamforming, resource scheduling, and ultimately, higher spectral efficiency.

This results in **leaner feedback, lower signaling burden, and improved RAN adaptability**, which is critical for 5G-A and 6G, where massive antenna arrays increase the feedback overhead and signaling complexity.

5.1.3 Time-series models → From temporal patterns to predictive network control

Time-series foundation models are designed to process sequential and temporal data, capturing patterns and dependencies across time. Built on architectures such as transformers, encoder-decoder models, and mixture-of-experts (MoE), these models excel at forecasting and anomaly detection in dynamic environments, as shown in *Figure 7*.

Telecom applications:

- **CSI & Link Prediction:** Forecast channel state information and link quality to mitigate feedback delays and enable proactive resource allocation.
- **Traffic & Mobility Forecasting:** Anticipate user movement and network load for optimal handovers, cell activation, and scheduling.
- **Operational Intelligence:** Predict energy consumption, detect early faults, and support proactive maintenance to improve network efficiency.

Representative Models:

- **Time GPT-1:** Transformer-based model trained on billions of sequential points for multi-domain temporal forecasting.
- **Times FM:** Patch-based decoder model for long-horizon forecasts, ideal for dynamic network planning.
- **Time MoE:** Activates a subset of experts per time step for efficiency without sacrificing accuracy.
- **Moirai:** Probabilistic encoder-only model supporting uncertainty-aware predictions.

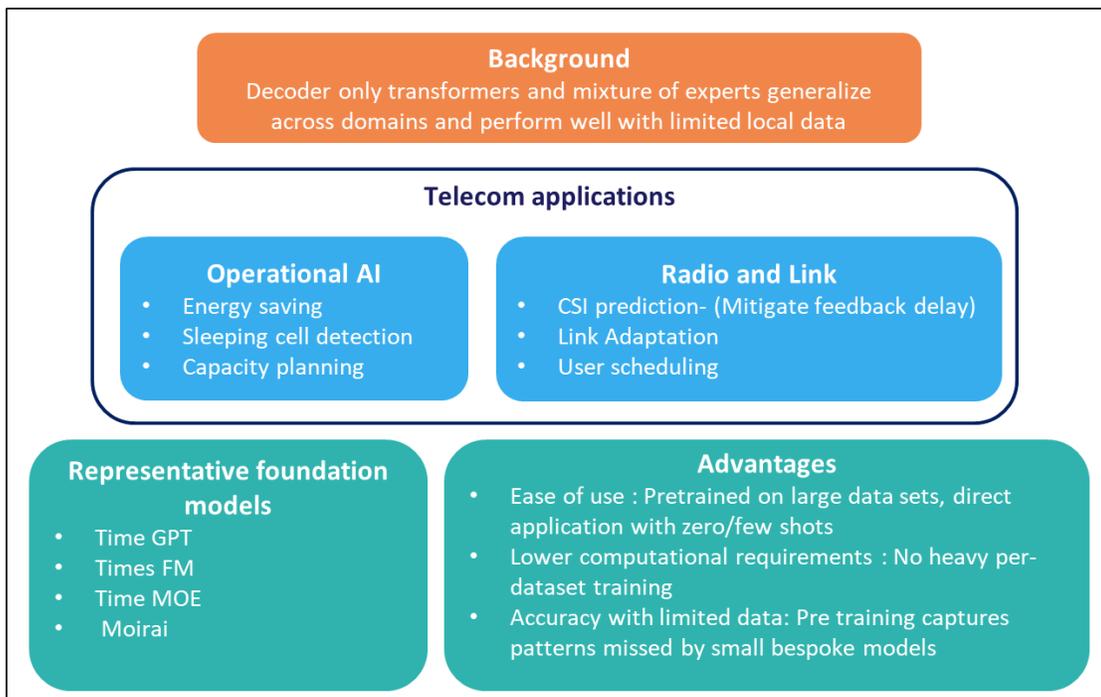


Figure 7: Time-series foundational models for 6G network8

5.2 Agentic AI: Intent-Driven, Closed-Loop Autonomy

As telecom networks evolve toward 5G-A and 6G architectures, the need for real-time, autonomous, and intent-driven operations has become paramount. Agentic AI, a new paradigm of intelligent and autonomous decision-making agents, is emerging as a critical enabler for this transformation. These agents can perceive the network environment, analyzing situations, making informed decisions, and executing actions independently.

In the context of telecom networks, Agentic AI enables autonomous decision-making across the network and its life cycle management, from planning and deployment to optimization and service assurance. They form the foundation of intent-driven, self-optimizing networks envisioned by the TM Forum's Autonomous Networks (AN) framework, particularly in achieving Level 3 and beyond. Here level 3 refers to conditional autonomous network operations. These networks exhibit adaptive behavior, closed-loop control, and proactive service assurance, as shown in *Figure 8*. Here, agents can monitor conditions, detect anomalies, simulate outcomes using digital twins, and take corrective or optimizing actions enabling the network to manage itself dynamically. Industry's best practices involve embedding these agents in a closed-loop architecture like the MAPE-K (Monitor, Analyze, Plan, Execute - Knowledge) framework, ensuring they act within governed policy boundaries and service level agreement (SLA) constraints. Whether it's rerouting traffic during a congestion event, activating additional cells in high-demand zones, or adjusting beamforming parameters on the fly, agentic AI enables proactive, adaptive operations that outpace traditional rule-based automation. Architecture of agentic AI in telecom networks typically includes four core layers:

- **Perception Layer** – collects real-time telemetry, event logs, alarms, and contextual data from the network.
- **Cognitive & Reasoning Layer** – applies AI/ML models (e.g., reinforcement learning, graph analytics, causality inference) to analyze situations and simulate decisions.
- **Policy & Intent Layer** – ensures decisions adhere to operational policies, regulatory rules, and service-level intents defined by the business.
- **Action & Execution Layer** – interfaces with orchestrators, controllers (e.g., SMO, RIC), and actuators to execute changes in the network environment.

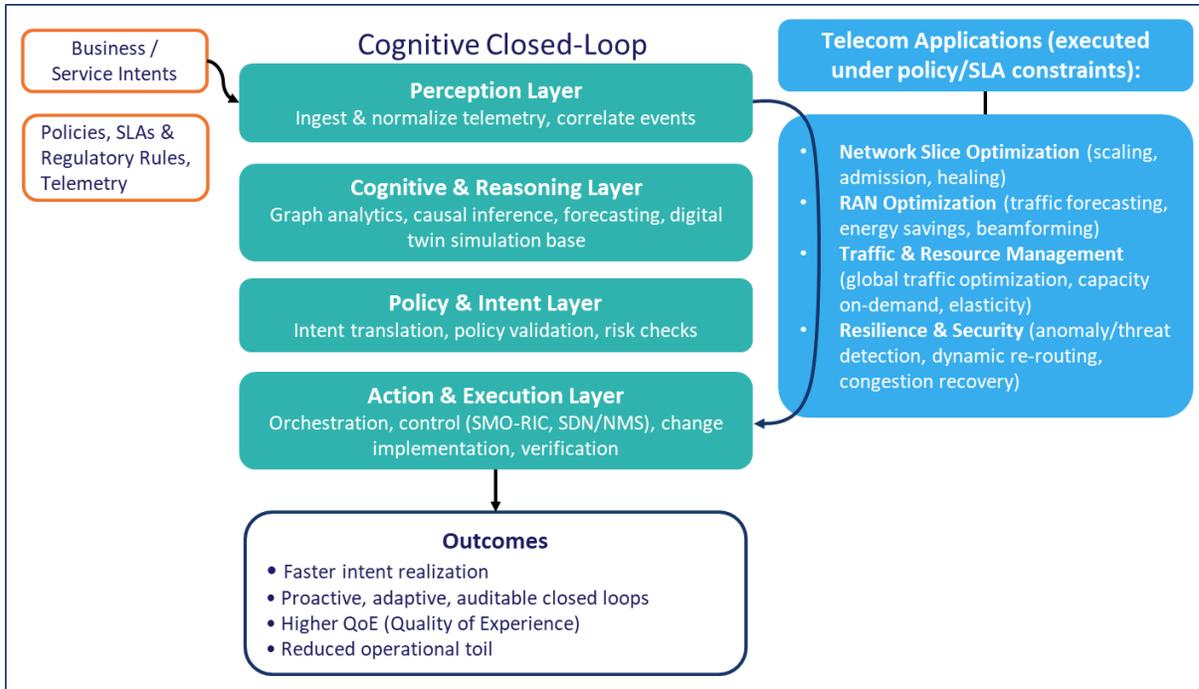


Figure 8: Agentic AI closed loop architecture applicability for 5G-A and 6G networks

5.3 Semantic Communication: Meaning over Bits

Semantic communication (SemCom) marks a pivotal evolution in wireless communication, shifting focus from transmitting raw bits to conveying the meaning and intent behind data. Traditional communication systems, guided by Shannon’s theory, are limited to syntactic accuracy, ensuring bits are transmitted correctly regardless of their relevance. This approach becomes inefficient in the context of modern applications such as XR, autonomous vehicles, and smart factories, where massive data volumes and low latency demand overwhelm bandwidth and energy resources. SemCom addresses these limitations by enabling intelligent transmission, where semantic encoders extract only task-relevant features, thus drastically reducing data traffic, improving bandwidth utilization, and enabling goal-driven communication. This paradigm is further empowered by integrating AI agents and LLMs, which enhance the system’s ability to infer meaning, reason contextually, and align shared knowledge bases between nodes.

To achieve semantic communication, several complementary techniques have been developed across various layers of the communication stack. A primary approach, as depicted in *Figure 9*, involves the use of deep learning-based joint source and channel coding (Deep JSCC), where neural networks are trained end-to-end to directly map source data into robust, compact semantic representations that are resilient to channel distortions. Additionally, knowledge graphs (KGs) are employed to capture the structured relationships and context of entities,

enabling both the transmitter and receiver to understand and reconstruct data using shared ontological frameworks. Semantic similarity models further ensure that the decoded output preserves the intended meaning, even if the exact original signal is not perfectly reconstructed.

Another crucial technique is the integration of LLMs and AI agents into semantic encoders and decoders. LLMs help quantify semantic importance, filter irrelevant information, and guide context-aware compression, particularly useful in text and multimodal communication. AI agents, on the other hand, contribute reasoning capabilities, allowing systems to make real-time decisions based on inferred goals or environmental context. Multi-modal semantic fusion, which aligns image, speech, and text data under a common semantic space, is another advanced technique critical for applications like XR or smart surveillance. Lastly, federated learning and distributed semantic model training help maintain performance while preserving privacy across edge devices. Together, these techniques form a robust toolkit for realizing efficient, intelligent, and resilient semantic communications in future 6G systems.

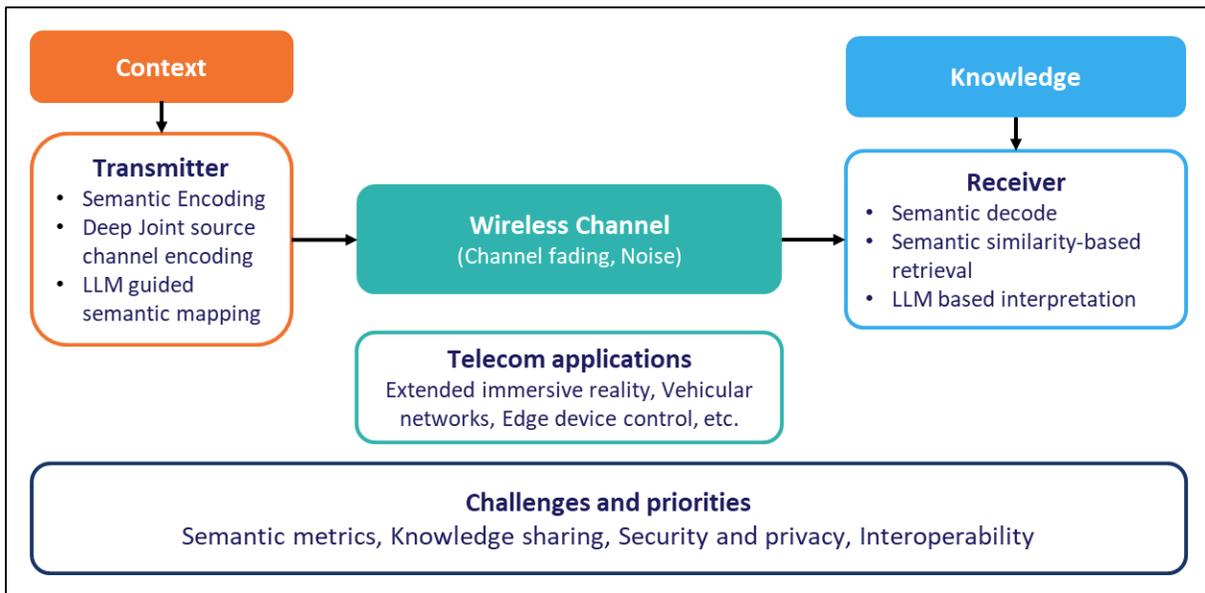


Figure 9: Semantic communication for 6G networks

SemCom can support emerging 6G services such as holographic telepresence and tactile internet by ensuring meaningful, timely information delivery with minimal overhead. However, transitioning to SemCom presents unique challenges. Lack of standardized semantic metrics complicates performance evaluation, and differences in knowledge bases between transmitter and receiver can lead to semantic misinterpretation. Security and privacy concerns are also heightened. Attackers may target semantic models or exploit background knowledge to infer sensitive content. Consequently, securing SemCom systems requires advanced techniques like semantic-aware encryption, knowledge inference control, and resilient AI models. Addressing

these challenges is crucial for deploying trustworthy and efficient semantic communication networks at the heart of 6G.

5.4 Approaches to Deploy AI/ML (Putting It All Together) Hybrid Topology (Central + Edge + Device):

Design principles.

Layered, modular, and hybrid: combine centralized intelligence with distributed autonomy to balance performance, trust, and operational control.

Reference deployment pattern as shown in *Figure 10* contains:

- **Central platforms:** model training, planning, and digital-twin simulation.
- **Edge inference:** low-latency, privacy-preserving decisions close to radios and users.
- **Orchestration-embedded AI:** microservice agents in Service Management and Orchestration (SMO) and the RAN Intelligent Controller (RIC) driving closed-loop automation (MAPE-K).
- **Federated learning:** site-level training without moving sensitive data to a central cloud.

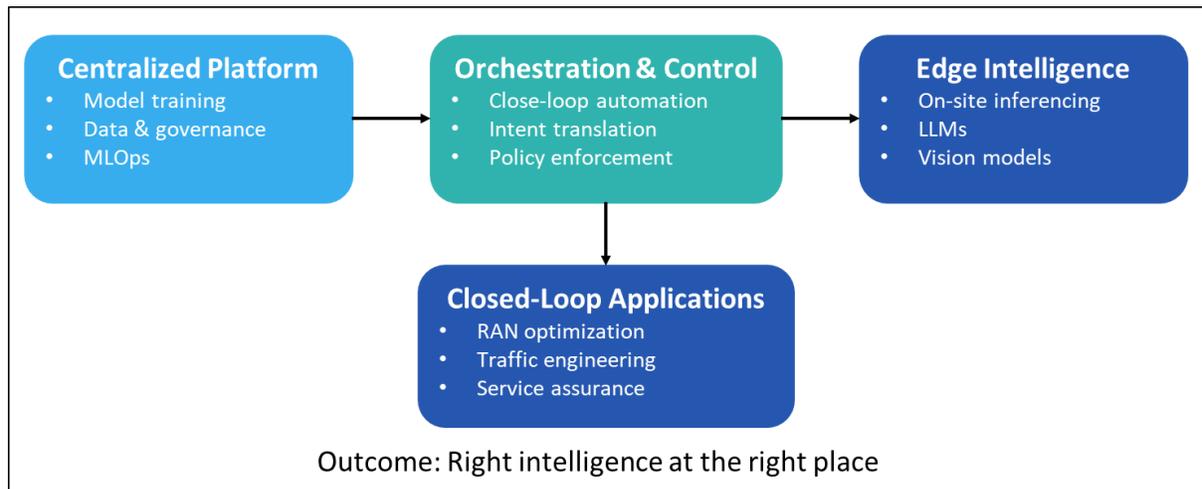


Figure 10: Approaches to deploy AI/ML in telecom

Roles of key AI modalities.

- **LLMs:** intent-to-configuration, diagnostics, remediation plans, and operator copilots.
- **Semantic communication models:** context-aware compression at the edge to reduce overhead in latency-sensitive scenarios.

- **Agentic AI:** autonomous decision-makers across RAN/transport/core that learn and optimize in governed control loops.
- **Vision–Language Models (VLMs):** field operations, site validation, visual inspection, and process automation.

Operations and governance

MLOps enables continuous monitoring of model performance and drift management to ensure accuracy as data, channel conditions/concepts evolve. Model updates are validated through A/B testing and shadow deployments, allowing safe experimentation without user disruption. Role-based access control restricts access to authorized personnel, with audit trails maintaining accountability. Automated policies and safety guardrails prevent harmful or noncompliant actions, while robust observability across data, models, and infrastructure enables rapid detection and resolution of issues. Together, these mechanisms ensure operational reliability, ethical governance, and regulatory compliance, fostering trustworthy and resilient AI systems throughout their lifecycle.

Outcome

To deploy the right intelligence in the right part of the network endowed with appropriate autonomy and intent awareness, ultimately unlocking unprecedented performance, efficiency, and innovation on the journey toward fully autonomous 6G

6 Potential AI/ML Implications for 6G Architecture

6.1 AI/ML Implications Across Network Layers

The integration of AI/ML into wireless communication is not only a performance upgrade, it also represents a paradigm shift in the very design of 6G architectures. Unlike conventional rule-based systems, 6G will be *AI-native*, with intelligence potentially infused into every protocol layer to enable real-time optimization, predictive resource management, and adaptive decision-making. This transition is particularly valuable in scenarios where mathematical modeling is intractable or closed-form solutions are unavailable, making AI/ML a natural fit for next-generation networks.

6.1.1 AI/ML at the Physical Layer (L1)

The physical layer translates information bits into radio waveforms and underpins critical functions such as channel coding, beamforming, channel estimation, and modulation. Traditional physical layer relies on mathematically designed algorithms, but as networks scale to massive antenna arrays, wide bandwidths, and higher frequencies, these models often struggle to maintain the expected performance. AI/ML provides robust, data-driven alternatives that adapt better to complex channel conditions, non-linearities, and hardware constraints.

Key applications include:

- **Channel state information (CSI) compression and prediction:** AI-based encoders/decoders reduce overhead from large antenna systems and mitigate channel aging in high-mobility environments.
- **Beam management:** ML models predict the best beam direction with fewer measurements, improving coverage and reducing latency.
- **Positioning in complex environments:** AI leverages multipath channel characteristics to deliver accurate localization in cluttered, NLoS factory or urban settings where conventional methods struggle.
- **Hardware impairment compensation:** From mitigating non-linearities in power amplifiers to correcting phase noise at higher frequencies, ML-based models help extend hardware efficiency and lifespan.

Together, these innovations enable more reliable, energy-efficient, and high-capacity 6G physical layer designs.

6.1.2 AI/ML at the Data Link and Network Layers (L2/L3)

At higher layers, AI/ML supports coordinated optimization across the MAC and network domains. Functions such as scheduling, mobility management, and congestion control benefit from predictive intelligence, allowing networks to proactively allocate resources and sustain QoS in dynamic environments. AI-driven traffic forecasting and anomaly detection also enhance security and reliability, ensuring seamless connectivity even under heavy load or unexpected demand shifts.

By embedding intelligence directly into protocol decision loops, L2/L3 evolves from reactive controllers into proactive, adaptive engines of efficiency.

6.1.3 AI/ML in the Core Network

The core network acts as the brain of the telecom system, and with the advent of 5G's service-based architecture, it has become increasingly modular and programmable. AI/ML strengthens this evolution by enabling analytics, automation, and intent-driven orchestration. The introduction of the Network Data Analytics Function (NWDAF) in 5G was the first step in providing a standardized way to collect, train, and deliver AI models for optimization.

In 6G architecture, it is expected and potential to use AI in the core extends far beyond analytics:

- **User-plane optimization:** detecting malicious traffic, dynamically adjusting QoS, and ensuring security with minimal latency.
- **Control-plane intelligence** – predicting signaling storms, improving mobility handovers, and managing energy-aware network slicing.
- **AI agents within orchestration** – embedding autonomous decision-making into Service Management & Orchestration.

6.1.4 Toward AI-Native Layered Architectures

The ITU's vision for 6G positions AI as both *for the network* (enhancing performance, efficiency, and reliability) and *within the network* (embedding AI agents and standardized frameworks for intelligence exposure). Together, this dual role enables protocol layers that are not only more capable but inherently autonomous, forming the foundation for self-optimizing 6G architectures.

6.2 AI/ML Implications on Telecom Infrastructure

The shift toward AI-native 6G architectures is not just about introducing new algorithms or models it requires a fundamental transformation of the underlying telecom infrastructure. Networks that can sense, decide, and act autonomously will place unprecedented demands on computing, storage, energy, and orchestration layers. To deliver on this vision, operators must rethink how infrastructure is designed, deployed, and scaled, ensuring it can support both the intelligence and agility required of future networks.

The GenAI-powered AI/ML systems are inherently resource-intensive, costly, and energy-demanding. In a developing country like India, with vast demographics and expansive geography, deploying AI requires strategic optimization to ensure affordability, energy efficiency, and scalable impact across diverse network environments

6.2.1 AI-enabled infrastructure hardware evolution

Building an AI-enabled network requires high-performance computing (HPC) infrastructure, AI accelerators, and distributed data centers located closer to the edge. Unlike classical telecom functions that rely on deterministic hardware pipelines, AI workloads are probabilistic and data-driven, requiring flexible, programmable compute architectures.

Telecom operators must progressively integrate AI accelerators such as graphics processing unit (GPU), tensor processing unit (TPU), neural processing unit (NPU), and field programmable gate array (FPGA) alongside general-purpose CPUs in their infrastructure stack. This mix enables dynamic training, inference, and model optimization across both centralized and edge environments. For India, with its vast geographic diversity, an adaptive compute layer, combining centralized AI clouds with tower-level edge compute nodes, can significantly enhance efficiency while minimizing backhaul costs.

6.2.2 Networking Impacts of AI Workloads

AI workloads are data-intensive and latency-sensitive, placing new demands on network design and capacity. The surge in model training, inference traffic, and cross-site synchronization between data centers creates new east-west traffic patterns, where large volumes of data move between servers and data centers rather than just in and out of them. Telecom networks must therefore evolve from static connectivity to AI-optimized, intent-driven networks that can dynamically allocate bandwidth and computing resources based on AI task priorities.

AI-native transport layers, integrated with network slicing, SRv6, and software-defined fabrics, will be essential to maintain predictable performance. Moreover, AI for networking (AIOps) and network for AI (data movement and synchronization) will converge, making orchestration intelligence a core part of infrastructure design.

6.2.3 CapEx Investments for AI Service Enablement

The introduction of AI across telecom operations, customer services, and network automation demands incremental CapEx for compute infrastructure, AI-optimized data centers, and advanced software ecosystems. Operators must choose between AI producers (offering AI-driven services) and AI consumers (using AI to optimize networks), as both require distinct investment models.

Key CapEx drivers include:

- AI model training and inference hardware (GPUs/TPUs)
- Storage and high-speed interconnects for data pipelines

- AI-optimized RAN nodes and edge compute deployments
- Green data center retrofits and cooling systems
- Techniques such as model compression (including pruning, quantization, and knowledge distillation), along with the use of lightweight inference models and efficient architectures like MobileNet and EfficientNet, offer effective ways to lower energy consumption without compromising performance.

To prevent cost escalation, operators can explore shared AI infrastructure, cloud-based training environments, and cooperative AI hubs supported by public-private partnerships.

6.2.4 Compute Options and Energy Efficiency

Not all AI workloads justify GPU-level performance. Model-parallel compute orchestration, mixed-precision processing, and model compression techniques can substantially reduce energy consumption and cost. Operators can distribute workloads across:

- **CPU clusters** for lightweight inference and network AI (like RIC/rApp, NWDAF)
- **GPU or NPU clusters** for centralized model training
- **Edge AI accelerators** for real-time inference near towers

Energy consumption remains a central challenge, as AI inference often accounts for up to 80% of the total power usage associated with AI applications over prolonged periods. AI-aware energy scheduling, aligning compute-intensive operations with renewable availability or off-peak hours, can mitigate power strain. India's renewable energy grid and government-backed green data center policies can be pivotal in enabling energy-conscious AI growth.

6.2.5 Public vs Private Cloud Strategy Alignment:

Balancing data sovereignty, cost, and scalability is central to shaping India's AI compute model. While public clouds enable rapid scalability, managed services, and industrialized AI tools, they come with dependency and data governance concerns. In contrast, private clouds or sovereign clouds, developed under initiatives such as BharatNet or C-DOT, provide localized AI compute capabilities that ensure control over data residency, energy efficiency, and cost-effectiveness.

The most pragmatic solution lies in adopting hybrid AI cloud fabric, leveraging public clouds for agile experimentation and large-scale model training. While deploying sovereign cloud infrastructure for secure, low-latency inference workloads closer to end users. This balanced

architecture would support both innovation and national priorities in AI-driven digital transformation.

6.3 From India Affordability lens

For diverse and fast-growing economies like India (Bharat), AI infrastructure scaling is constrained by cost, energy, and accessibility. However, scalable affordability can be achieved through various strategies:

- **Federated learning and Edge AI:** Deploying AI at the distributed edge (e.g., in towers or regional data nodes) reduces backhaul traffic and infrastructure costs. Telecom networks are best positioned to leverage and build regional data centers at the far edge or at the cell site towers.
- **Shared AI Platforms:** Telecom operators can co-develop AI platforms, especially for the network side of RAN and NWDAF, to lower development costs and avoid duplication, which can benefit the whole industry and national building use-cases.
- **AI-as-a-Service (AIaaS):** Government-supported AI compute grids, akin to common service centers, can democratize access for smaller operators, enterprises, and startups.
- **Green Data Centers:** Encourage use of air cooling, liquid immersion cooling, and renewable power to reduce AI's carbon and water footprint in data centers.

By embracing these approaches, India can democratize AI access while maintaining cost discipline. This creates a sustainable and inclusive AI-native telecom ecosystem aligned with its 6G ambitions. We next discuss the use cases of AI-native 6G from Indian perspective.

7 Native AI-Enabled Use Cases in 6G

India's story is unlike any other country. We are a country where a farmer in a remote village, a doctor in a tier-2 town, a student in a suburban school, and an engineer in a tier-1 city all rely on the same digital backbone. 5G has helped improve connectivity, but it was never designed to be *intelligent at the core*. Many advanced applications that demand real-time decisions, ultra-low latency, or context-aware adaptation were either too costly, too complex, or simply not feasible on the 5G network. AI-native 6G transforms this equation by embedding intelligence directly into the core fabric of cellular networks, enabling systems that are not only faster and more efficient but also smarter and inherently more inclusive. In the following discussion, we

present India-centric use cases and explain why they cannot be supported by 5G networks. We also discuss how these use cases align with the global use cases put forth by the ITU.

7.1 India-Centric Use Cases

7.1.1 Smarter Farms, Stronger Rural Economy

To support this use case, soil sensors, drones, and AI models must work together to guide irrigation, predict crop diseases, and connect small farmers to markets in real-time. All these aspects together strengthen the rural economy.

- *Why not in 5G: Too many devices, too much data, and not enough intelligence at the edge to make farming analytics affordable and real-time.*

7.1.2 Life-Saving Networks for Disasters

In the case of a disaster/natural calamity, AI-native drone fleets can establish resilient mesh communications that remain active even when towers fail. Further, AI can be used to collect sensory information from the temperature/pressure sensors and proactively predict floods/cyclones and alert the UEs in active disaster regions such as landslide-prone mountains/earthquake fault lines.

- *Why not in 5G: Centralized and fragile networks could not reconfigure themselves or scale autonomous disaster response.*

7.1.3 Healthcare for Every Village

The use of AI-enabled diagnostic kits in rural clinics and real-time monitoring of vital signs, thereby bridging the gaps for people living outside cities.

- *Why not in 5G: Latency (~10ms) was too high for surgery or real-time diagnostics; AI integration was shallow.*

7.1.4 Education Without Boundaries

To enable Immersive and adaptive learning in vernacular languages, AI-enabled augmented reality (AR)/virtual reality (VR) classrooms for remote or underserved students can be designed.

- *Why not in 5G: Streaming was possible, but personalization, semantic translation, and immersive delivery were missing.*

7.1.5 Smarter Cities and Crowded Spaces

Dynamic spectrum allocation and AI traffic management in metros are crucial for scenarios such as mega events and transport hubs, where millions of users connect simultaneously. By intelligently sensing spectrum usage and predicting traffic demand in real time, the network can

allocate resources adaptively, which reduces congestion, latency, and ensures reliable connectivity.

- *Why not in 5G: Static spectrum allocation meant inefficiencies and congestion under ultra-dense conditions.*

7.1.6 Manufacturing for All

From large industries to micro, small, and medium enterprises (MSMEs), AI-native 6G enables predictive maintenance, robotics, and intelligent logistics.

- *Why not in 5G: Network slicing existed but was too rigid and not intent-driven to serve diverse industrial contexts.*

7.1.7 Financial Inclusion and Citizen Services

Fraud detection in mobile payments, multilingual AI assistants for e-governance, and secure know your customer (KYC) at scale.

- *Why not in 5G: No built-in multilingual AI or adaptive fraud detection; limited automation of citizen services.*

7.2 Global Use Cases

7.2.1 Holographic Communication

AI-driven compression, rendering, and real-time synchronization applications can support life-sized 3D meetings, virtual classrooms, and precise remote surgery.

- *Why not in 5G: Bandwidth-hungry holography needed 90% better compression and sub-ms latency beyond 5G's reach.*

7.2.2 Autonomous Mobility and Drone Fleets

AI-enabled vehicles, taxis, and delivery drones cooperate in real-time to manage traffic, logistics, and air mobility corridors.

- *Why not in 5G: While 5G enabled V2X, it lacked the scale and swarm-level intelligence required for safe, coordinated autonomy.*

7.2.3 Joint Communication and Sensing (JCAS)

To support this use case, the network can also function as sensors, detecting air quality, intrusions, collisions, unauthorized drones, and seismic events with centimeter-level accuracy.

- *Why not in 5G: Latency, sensing precision, and AI feedback loops were insufficient for such real-time environmental intelligence.*

7.2.4 Immersive Media & Extended Reality

AI-driven content adaptation can support seamless extended reality (XR)/VR/AR experiences for entertainment, education, and collaboration.

- *Why not in 5G: 5G could deliver high throughput, but lacked semantic understanding and personalization at scale.*

7.2.5 Smart Industry and Digital Twins

Factories, power grids, and supply chains, mirrored in real-time digital replicas to optimize operations and sustainability.

- *Why not in 5G: Limited sensing fusion and compute orchestration in 5G prevented scaling digital twins to complex systems.*

7.2.6 Personalized Ambient Intelligence

AI agents embedded in homes, workplaces, and cities that adjust light, temperature, and services to the human context.

- *Why not in 5G: Networks were not context-aware, nor could they support the always-on personalization required.*

7.2.7 Cybersecurity by AI

Proactive anomaly detection, instant breach response, and self-healing network functions powered by AI at the edge.

- *Why not in 5G: 5G security was rules-based; it lacked adaptive, predictive intelligence to counter AI-driven attacks.*

For India, AI-Native 6G is about inclusion and scale: bringing healthcare, education, and financial services to every corner of the country. Globally, it is about immersion, autonomy, and sensing: building networks that feel alive, responsive, and deeply integrated into daily life. Together, these perspectives underscore why 5G was merely a stepping stone and why AI-native 6G is the true unlock for transformative digital futures.

8 Monetization Models

The shift toward AI-Native 6G will generate entirely new revenue streams for telecom operators, moving the focus from basic connectivity to delivering AI-driven value across industries and society. The revenue herein will no longer be limited to bandwidth or data plans, but instead will come from AI-driven insights, adaptive services, and ecosystem partnerships.

For India, with its scale and diversity, this transition presents both immense opportunities and unique challenges, which are discussed in the subsequent sections.

8.1 Monetization Opportunities

1. AI as a service (AIaaS)

- Operators can deliver on-demand AI capabilities such as automated network optimization, predictive maintenance, and security threat detection.
- Beyond telecom, AIaaS can power sectoral solutions like precision agriculture, healthcare diagnostics, and smart manufacturing

2. Intelligence-driven value chains

- Embedding AI into the radio, core, and service layers transforms operators from bandwidth providers into orchestrators of intelligence.
- This unlocks opportunities for B2B2X collaborations with hyperscale's, device makers, and application developers

3. Data and API monetization

- AI-native 6G enables Data-as-a-Service (DaaS) platforms, giving enterprises privacy-protected access to curated datasets for mobility, retail, or urban planning.
- API marketplaces allow developers to access AI models, analytics, and network functions, fueling new digital services.

4. Adaptive SLAs and premium experiences

- With AI predicting and tuning network performance in real time, operators can offer tiered service levels for latency, reliability, and energy efficiency.
- Enterprises can pay for premium, intent-driven connectivity or AI-optimized network slices.

8.2 Potential Monetization Models

- **Hyper-granular network slicing:** Charging by user, device, or application context, e.g., ultra-low-latency slices for autonomous mobility or immersive XR.
- **AI marketplaces:** Hosting vertical-specific AI apps (healthcare, energy, logistics) on operator infrastructure, with revenue-sharing between telcos and developers.
- **Bundled AI + connectivity plans:** Combining traditional data plans with AI-driven features such as real-time analytics, automation, or localized vernacular AI tools.
- **Platform-based revenue:** Telecom operators acting as AI platforms, enabling B2B2X services where enterprises not only consume connectivity but also host and sell digital services on top of telecom infrastructure

- **Public-private partnerships:** Especially in India, monetization can emerge from AI-powered agriculture, education, and healthcare solutions that deliver both social impact and commercial returns.

By adopting these models, telecom operators can transition from pure connectivity providers to **orchestrators of the AI economy**, designing revenue strategies that align global innovation trends with India's unique market dynamics. However, this revenue creates various potential challenges for telecom operators, which are discussed next in the following subsection.

8.3 Potential Challenges

- **Affordability and market sensitivity:** India's price-conscious market may limit adoption of premium AI services unless affordable tiers are designed.
- **Regulatory and sovereign AI concerns:** National priorities for data sovereignty, AI governance, and privacy require telecom operators to maintain compliance while innovating.
- **Trust and explainability:** AI-driven services must be transparent, auditable, and explainable to build user and regulator confidence.
- **Ecosystem complexity:** Revenue-sharing models with hyperscale's, AI developers, and vertical players need clear frameworks to avoid disputes over data ownership and monetization rights.
- **Operational risks:** AI-native automation introduces new vulnerabilities, including adversarial attacks and model poisoning, which could undermine monetization strategies if not mitigated.

To summarize, AI-native 6G will enable operators to transition from selling **megabytes to monetizing intelligence**. By offering AIaaS, enabling data-driven platforms, and fostering cross-sector collaborations, telecom operators can unlock new revenue streams. However, success will depend on solving challenges of affordability, governance and trust, areas where India's scale and innovation ecosystem can set a global example.

9 Strategic Recommendations

As 6G takes shape globally, India's expectation for 6G are motivated by its unique requirements. We are a country of contrasts, from crowded metros to remote villages, from high-end smartphones to entry-level feature-rich devices, and from English-speaking professionals to hundreds of millions using local languages. This diversity means that AI in 6G

cannot simply focus on speed or efficiency; it must also encompass **inclusion, affordability, and sustainability**. With our scale and talent, India has the opportunity not only to benefit from 6G but also to shape the world's perspective on building **AI-native networks that truly serve everyone**. Some of the specific recommendations that clearly came out include:

- **Digital democracy at scale:** 6G must be designed for India's billion-plus population, where affordability is not optional but foundational. AI/ML should bridge the digital divide, not widen it.
- **Greener networks → Greener nation:** To cater India's vast geography and energy footprint, AI must be harnessed to create energy efficient networks, aligning with India's sustainability goals.
- **Network that sense and adapt:** To serve both dense metros and remote villages, India needs context-aware networks that can learn traffic patterns, user mobility and energy needs, and adapt in real time.
- **Intelligence at the edge to cater diversity:** India's diversity spans not only in geography but also in language and culture. With edge-hosted AI in 6G, networks should deliver local, vernacular and low-latency intelligence, making the network more personalized for every Indian.
- **India as the world's testbed for Scalable AI-6G:** India is a unique country, which offers a combination of scale, cost sensitivity, and innovation talent. This makes Bharat the natural leader to pilot, validate, and export affordable AI-native 6G frameworks to the world.

Following are some steps that could help in achieving the above Bharat-specific recommendations from the AI perspective:

- Invest in open-source AI models optimized for telecom
- Support public-private partnerships for infrastructure and training
- Accelerate AI standardization within 3GPP/ITU/IEEE
- Build AI-native testbeds and open innovation platforms
- Promote explainable and trusted AI in telecom
- Enable regulatory sandboxes for AI-native trials.

10 Annexures / Appendices

Glossary

2D	Two dimensional
3GPP	3 rd Generation Partnership Project
5G	3GPP 5 th Generation wireless technology
5G-A	3GPP 5 th Generation Advance wireless technology
6G	3GPP 6 th Generation wireless technology
AI	Artificial Intelligence
AIaaS	AI as a service
API	Application Programming Interface
AR	Augmented Reality
B2B2X	Business-to-Business-to-X
B5G	Beyond 5G
CapEx	Capital Expenditure
CBS	Codebook-Based Schemes
CSI	Channel State Information
DoT	Department of Telecommunications (India)
DPD	Digital Pre-Distortion
DSS	Dynamic Spectrum Sharing
ETSI	European Telecommunications Standards Institute
EU	European Union
FM	Foundational model
IAB	Integrated Access and Backhaul
IAIC	IndiaAI Innovation Centre
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunications-Advanced
IPR	Intellectual Property Rights
ISAC	Integrated Sensing and Communication
ITU	International Telecommunication Union
gNB	5G Generation NodeB
GNSS	Global Navigation Satellite System
GPT	Generative Pre-training Transformer
GPU	Graphics Processing Units
JCAS	Joint Communication and Sensing
KPI	Key Performance Indicator
LLM	Large Language Model
LNA	Low Noise Amplifier
MAC	Medium Access Control
MAPE-K	Monitor, Analyze, Plan, Execute – Knowledge
MeitY	Ministry of Electronics and Information Technology (India)
MIMO	Multiple Input Multiple Output
ML	Machine Learning
MLOps	Machine Learning Operations

MoE	Mixture of Experts
NICT	National Institute of Information and Communications Technology (Japan)
NIST	National Institute of Standards and Technology (US)
NITI Aayog	National Institution for Transforming India
NTN	Non-Terrestrial Network
NR	New Radio
NTIA	National Telecommunications and Information Administration
NWDAF	Network Data Analytics Function
OFDM	Orthogonal Frequency Division Multiplexing
QoE	Quality of Experience
RAG	Retrieval-Augmented Generation
RBAC	Role-based Access Control
SLA	Service level agreement
SLM	Small Language Model
SMO	Service Management and Orchestration
TSDSI	Telecommunications Standards Development Society, India
URLLC	Ultra-Reliable Low Latency Communication
V2X	Vehicle to Everything
VLM	Vision Language Model
VR	Virtual Reality
WOLA	Weighted Overlap and Add
XR	Extended Reality

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Network Services, Tech Mahindra

A seasoned telecom leader with over two decades of experience in next-gen wireless technologies, including 5G, O-RAN, and AI-powered networks, Sandeep drives innovation, shapes industry standards, and builds strategic partnerships that are redefining the future of telecommunications. A recognized thought leader, Sandeep is a frequent speaker at high-impact forums and author of influential white papers that are helping steer the industry toward 6G. With deep expertise in product management, network planning, and pre-sales, he has led world-class teams across both mature and emerging markets. His vision continues to unlock new growth opportunities and enhance network capabilities in an increasingly digital world.



Rajat Agarwal

Product Manager, Emerging Technologies,
Network Services, Tech Mahindra

Rajat is a passionate telecom professional with experience, specializing in product management and pre-sales for 4G/5G RAN and O-RAN solutions. He is an active contributor to 6G forums, ORAN Alliance forums, and recognized as an emerging thought leader in areas such as NTN, 6G, AI-RAN, and network evolution consulting.



Jyotirmay Saini

Senior Project Executive Officer
Indian Institute of Technology Kanpur

Jyotirmay is engaged in 5G+/6G research and standardization at IIT Kanpur. He serves as a 3GPP RAN/RAN1 delegate currently contributing to 3GPP, on topics like Ambient IoT, 6G sensing and communication, energy efficiency for 6G. Previously, he has worked on 5G advanced topics like Network-Controlled Repeaters and Positioning Enhancements for the NR Air Interface. His research interests span 5G air interface design and implementation, sensing and localization, repeaters, reconfigurable intelligent surfaces, and low-power wide-area (LPWA) technologies.



Sabyasachi Mukhopadhyay

Group Manager
Tejas Networks

Sabyasachi Mukhopadhyay is a Group Manager and AI Lead in the NMS team in Tejas Networks. His team currently works on AI Agents solving critical issues like Root Cause Analysis, Troubleshooting in Telecom Networks, and Predictive Analytics using Foundation models and Network optimization. He also contributes to 5G, 5G Advanced, and 6G in 3GPP in AI/ML, Networking slicing, and AIoT. He has also built AI/ML platforms working on Telecom issues in his earlier organizations. A passionate Technological thought leader and life-long learner, his interests lie in AI Agents, Foundation Models, and AI-enabled Networks.



Astha Sharma

Assistant Director (Technology),
Bharat 6G Alliance

Dr. Astha Sharma is a dynamic technologist with over 15 years of experience in wireless communication, research, and innovation, bringing a strategic and technical perspective to the development of 6G and beyond. A Ph.D. from IIT (ISM) Dhanbad and an Erasmus Mundus scholar at the University of Bologna, she has contributed extensively to indigenous 5G/6G initiatives, including her role at the DST-sponsored Technology Innovation Hub at IIITB COMET Foundation, Bengaluru. An IEEE Senior Member and Innovation Ambassador, her expertise spans Cognitive Radios, AI-driven solutions, and wireless systems. As Assistant Director (Technology) at the Bharat 6G Alliance, she plays a pivotal role in shaping India's 6G strategy, driving innovation, policy engagement, and global collaboration.



Runjun Das

Research Engineer,
CEWiT

Runjun is working as a Research Engineer in Centre of excellence in Wireless Technology, focusing on RAN1 5G advanced and 6G research and standardization. She serves as 3GPP WG1 Delegate and has contributed to 3GPP Release 19 AI/ML Positioning accuracy enhancement and Release 20 studies on AI/ML for 6GR. Her research interests include AI/ML for air interface.



Shiv Shankar

Principal Research Engineer,
CEWiT

Shiv Shankar is working as a Principal Research Engineer in Centre of Excellence in Wireless Technology and has over nine years of experience in wireless R&D. He began his career working on PHY-layer algorithms for synchronization, RF impairment mitigation, and hardware accelerator development. Currently he is leading the AI/ML group for 5G Advanced and 6G in CEWiT. His interests include AI/ML for air-interface design, ISAC, and digital twins for network resource management.

He has been an active 3GPP delegate for the past three years, contributing to AI/ML use cases in positioning and CSI enhancement.



Jeeva Keshav S

PhD Scholar
IIT Madras

Jeeva Keshav S is a PhD scholar in the field of Wireless Communications at IIT Madras and a Prime Minister's Research Fellow. He played a key role in developing the Physical Layer of India's indigenously designed 5G NR base station. His research focuses on building machine learning models and frameworks to integrate AI/ML into the Physical Layer of 5G and beyond systems. He is also an active delegate at 3GPP

RAN/RAN1, with contributions to Release 19 in areas such as Beam Management for the NR Air Interface and Ambient IoT.



Dheeraj Naidu Amudala

Senior Project Executive Officer
IIT Kanpur

Dheeraj received the M.Tech. (integrated) and Ph.D. degrees from the Department of Electrical Engineering, Indian Institute of Technology Kanpur, India, in 2023. He is currently a Senior Project Executive Officer with IIT Kanpur. He is currently a 3GPP RAN1 delegate contributing to energy efficiency for 6G and 6G study items. His research interests include practical massive MIMO system design, near-field communications, transceiver design, integrated sensing and communications, and machine learning applications for wireless communication. He has received the

outstanding PhD thesis award from IIT Kanpur for the quality and quantity of work done in PhD and the TCS Research scholarship for the duration 2020-2023 during his PhD.



Chethan R

Project Executive Officer
IIT Kanpur

Chethan is a Project Executive Officer at IIT Kanpur, actively involved in 5G+/6G research and standardization. He serves as a 3GPP RAN/RAN1 delegate and has contributed to 3GPP Releases 19 and 20, particularly on topics such as AI/ML for CSI enhancements. His research interests include 5G air interface design and implementation, sensing and localization, AI systems, and low-power wide-area (LPWA) technologies. He holds an M.Tech. degree from the Department of Electrical Engineering, IIT Kanpur, where he received the Vijay K. Verma Award for the best

master's thesis.

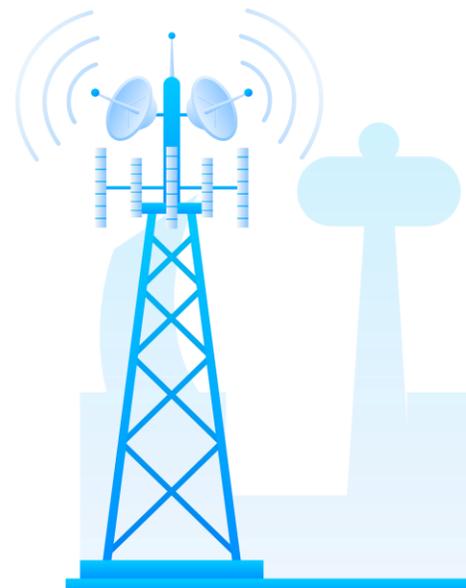


Dr. Rohit Budhiraja

Professor
IIT Kanpur

Rohit Budhiraja is currently a Satish Chandra Agarwal Chair Professor at IIT Kanpur, where he recently led an effort to design the first indigenous 5G network. This 5G technology was transferred to the industry. He is now leading an Indian Government project from IIT Kanpur to design 5G+/6G standards. He also works closely with the industry, government organizations and R&D labs to investigate 5G+/6G wireless technologies. He is currently a vice chairman of Bharat 6G alliance, and member of governing council of TSDSI, India's standard develop organization. He has 25 years of experience in building 2G, 3G, 4G and 5G wireless systems. His current research interest is to design 5G+/6G wireless networks by using machine learning and optimization-based methods, and then investigate their performance by prototyping them. He has received CNR Rao award from IIT Kanpur for architecting and designing the indigenous 5G network, IIT Kanpur Excellence in Teaching Award, Visvesvaraya Fellowship and Early Career Research Award from the Government of India.

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