Bharat6G Alliance

BHARAT 6G

DPR for Bharat 6G Roadmap 2030

Translating the Bharat 6G Vision into Standards, Testbeds, and Ecosystem Development for Deployment

Under the aegis of
Department of Telecommunications
Ministry of Communications
Government of India

Prepared by
Bharat 6G Alliance

April 2026

Bharat
6G Vision Statement

Design, develop and deploy 6G network technologies that provide ubiquitous intelligent and secure connectivity for high quality living experience for the world

DPR for Bharat 6G Roadmap 2030

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Bharat 6G Vision (March 2023)
National 6G Roadmap 2025–2030 (August 2025)

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1.0 Executive Summary

India is at a decisive juncture in its journey toward becoming a global leader in 6G. Building on the Bharat 6G Vision announced in March 2023, the Bharat 6G Alliance (B6GA) has developed this Detailed Project Report (DPR) to translate the high-level strategy outlined in the National 6G Roadmap 2026–30 into a concrete, actionable, and fundable plan.

The DPR sets out the vision, objectives, institutional framework, milestones, financial requirements, and sustainability model for India's 6G programme. It aligns national efforts with global timelines in 3GPP and ITU, while ensuring that India contributes meaningfully to global standards, creates a strong intellectual property base, and develops indigenous technologies, products and solutions for large-scale deployment by 2030.

Vision and Objectives

- Facilitate India's efforts to secure at least 10% of global 6G patents by 2030
- Establish multi-institutional testbeds that support pre-standard and standards-based research and prototyping
- Drive India-specific 6G applications in healthcare, agriculture, logistics, education, disaster management, and smart cities, aligned with Sustainable Development Goals (SDGs)
- Position India as a net technology exporter with globally competitive 6G products and solutions
- Build a skilled human capital base of engineers, researchers, PhD scholars, and standardization experts in 6G technology to sustain long-term leadership

Economic Impact and Return on Investment

The proposed programme is expected to generate significant economic value to India through indigenous technology development, IPR creation, and enhanced participation in global 6G standards. The global telecommunications market is projected to reach multi-trillion-dollar scale by 2030, presenting a significant opportunity for India to increase its share. Within this context, investments in 6G R&D and testbeds are expected to yield multiple-fold returns, with potential economic impact estimated in the range of ₹1-2 lakh crore over the programme lifecycle. The initiative is also expected to enable substantial IPR generation and export opportunities, while reducing import dependence in critical telecom technologies. Further details on the economic analysis and assumptions are provided in later sections of this document.

Phased Approach

Phase 1 (Years 1-2): Pre-standardization (₹1,500 Cr)

Establish pre-standardization testbeds (AI/ML with mMIMO, THz, NTN, ORAN, Core), initiate prototypes, file initial IPRs, and train 200 standardization professionals for 3GPP/ITU engagement.

Phase 2 (Years 3-5): Standards-based Development (₹2,500 Cr)

Expand to at least two integrated end-to-end testbeds with strong industry participation, execute standards-compliant sectoral pilots, scale up IPR/SEP filings, and grow the manpower base to around 300 standardisation professionals.

2030 and Beyond: PoC & Commercial Readiness (₹3,000 Cr)

Large-scale proof-of-concept trials, deployment of standards-based prototypes, commercialization of indigenous 6G technologies, and showcasing of India-specific use cases at ITU Plenipotentiary 2030.

Institutional Framework

The Department of Telecommunications (DoT) will fund and monitor the programme through its established mechanisms, along with 6G aligned initiatives in Ministry of Electronics & Information Technology (MeitY), Department of Science and Technology (DST), Research, Development, and Innovation (RDI) Fund and Anusandhan National Research Foundation (ANRF). The role of Bharat 6G Alliance (B6GA) will be facilitative working alongside the different ministries in defining requirements, recommending strategies, participating in monitoring, and helping identify potential institutions for execution.

B6GA recommends a Hub-and-Spoke model, with anchor institutions leading R&D and testbeds, supported by spoke institutions, startups, MSMEs, industry, and TSPs for prototypes, pilots, and deployments. This model has been successfully implemented in large national initiatives under DoT and DST. This ensures accountability under DoT while leveraging B6GA's strategic inputs for inclusive and efficient implementation.

Financial and Sustainability Model

The total funding requirement is estimated at ₹7,000 Cr for the period 2025–2030 and beyond, covering testbeds, R&D, ASIC development, standardization, and IPR. It is

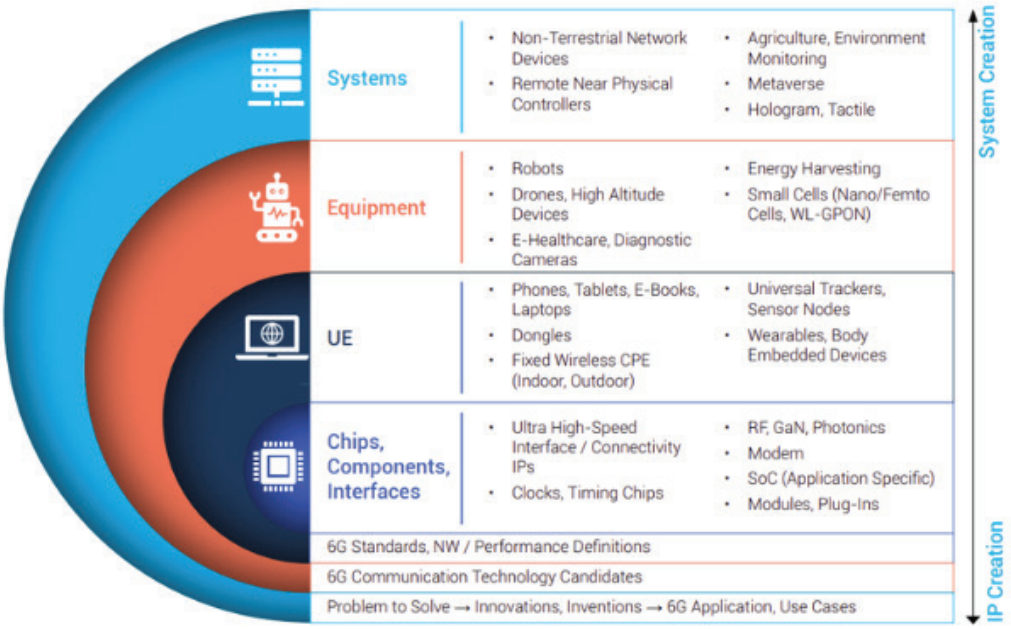
envisaged that this funding will come through multiple 6G aligned initiatives under DoT, MeitY, DST, Research, Development, and Innovation (RDI) Fund and ANRF.

- Early phases rely on Government of India support.
- Later phases transition to increasing levels industry co-funding, patent monetization, spectrum sandbox fees, and commercialization revenues, ensuring long-term sustainability.
- CSR funding of specific initiatives can also be considered.

Expected Outcomes

- 10,000+ 6G patents by 2030, including SEPs
- Significant contributions to 3GPP Release 20/21 and ITU IMT-2030.
- Development of indigenous 6G components, ASICs, chipsets, and devices.
- Demonstrated India-specific 6G pilots across critical national missions.
- A globally recognized skilled workforce and research ecosystem in 5G Adv and 6G.
- Positioning India as a strong player in 6G standards and technology exports.

This DPR provides the Government of India with a comprehensive plan for funding, governance, and execution that will transform India's 6G vision into reality, ensuring technological leadership, economic growth, and societal impact by the end of this decade.



2.0 Context and Background

India's telecommunications sector is entering a pivotal phase, moving from the rapid rollout of 5G to preparing for global leadership in 6G. The Bharat 6G Vision, launched in March 2023 by the Hon'ble Prime Minister, set the target of positioning India as a key contributor to global 6G standards and securing at least 10% of global 6G patents by 2030. This vision emphasizes affordability, universal access, sustainability, and the creation of indigenous products and solutions.

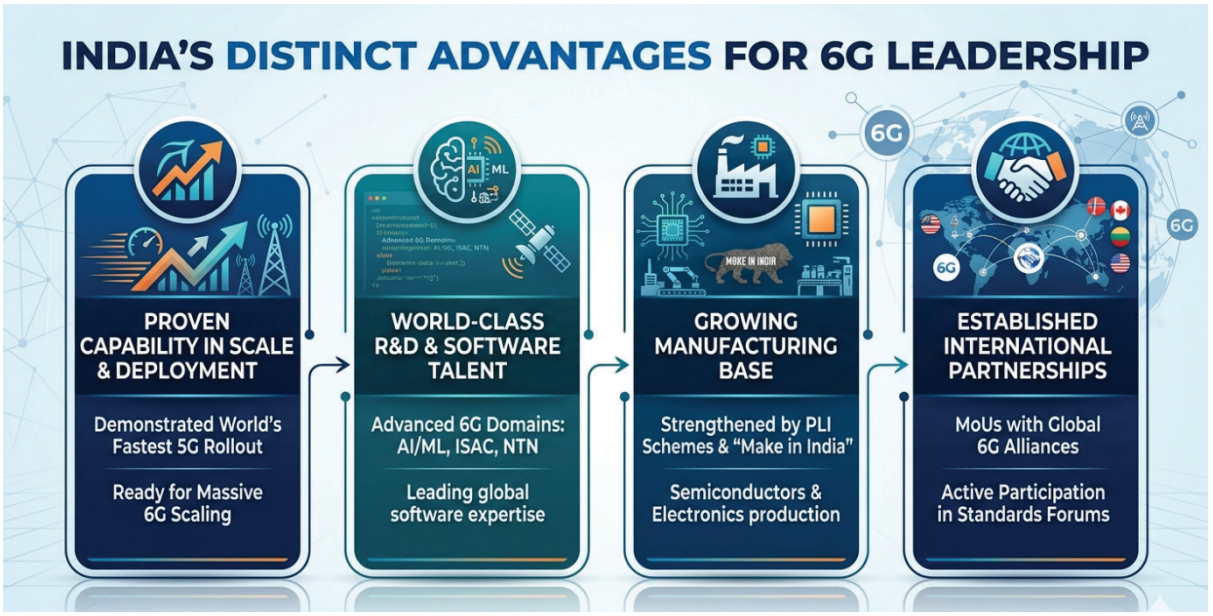
The Bharat 6G Alliance (B6GA) was constituted in July 2023 to translate this vision into action. It brings together industry, academia, startups, MSMEs, R&D institutions, and government bodies on a common platform to drive research, testbeds, prototyping, standardization, and eventual deployment of 6G technologies. By doing so, B6GA provides a structured mechanism to align India's national efforts on 6G with international developments, particularly within 3GPP and ITU IMT-2030 frameworks.

The global 6G race is already underway, with leading countries announcing 6G roadmaps and investments. For India, the initial phase of the programme offers a critical window to influence the 3GPP Release 21 specifications and the ITU IMT-2030 requirements. Any delay in initiating the 6G related activities would risk reducing India's global influence, while timely action can consolidate its position as both a standard- influencer and a technology supplier.

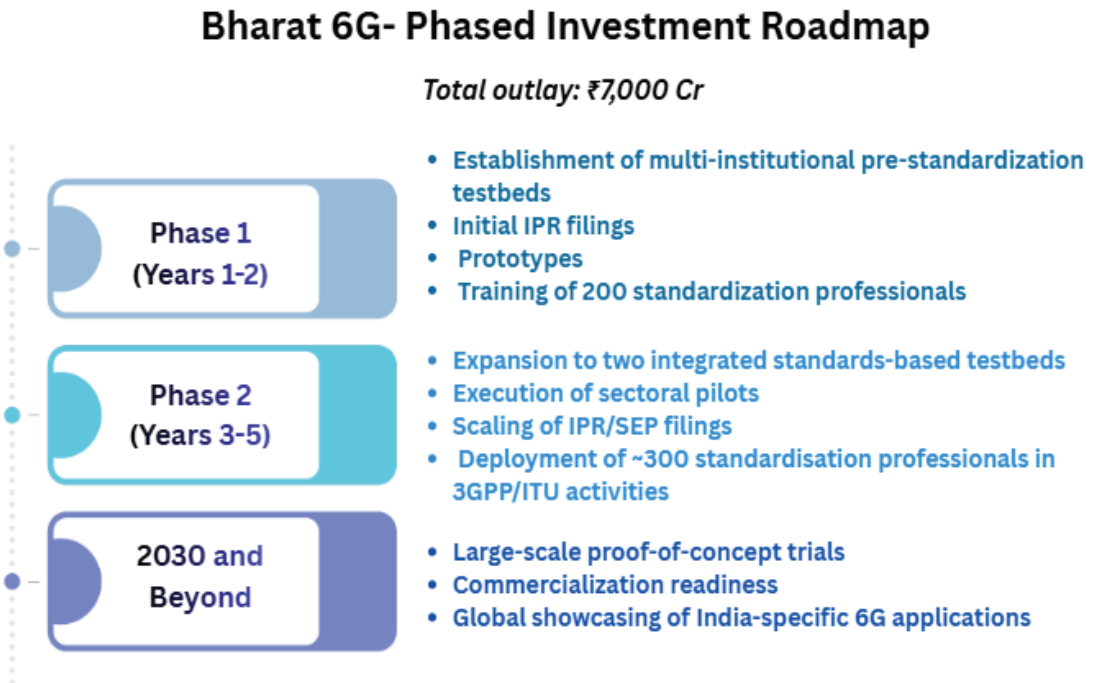
India holds distinct advantages that can be leveraged for 6G:

- Proven capability in scale and rapid deployment, demonstrated during the world's fastest 5G rollout.
- World-class R&D and software talent pool, capable of addressing 6G domains such as AI/ML, Integrated Sensing and Communication (ISAC), Non-Terrestrial Networks (NTN), and many others.
- Growing semiconductor and electronics manufacturing base, strengthened by Production-Linked Incentive (PLI) schemes and "Make in India" initiatives.

- Established international partnerships through Memoranda of Understanding (MoUs) with global 6G alliances with active participation in 6G technology development and in standardization.



The Government of India has recognized the need for phased large-scale investment to achieve these ambitions. As outlined in the roadmap and financial framework, a total outlay to the tune of ₹7,000 Cr is proposed across three phases:



The hub-and-spoke model proposed by B6GA ensures depth in anchor institutions while engaging a wide ecosystem of spoke institutions, startups, and industry partners. This structure, coupled with government support in early phases and increasing industry co-funding and patent monetization in later phases, provides a sustainable pathway to India's 6G leadership.

In summary, this DPR builds on the Bharat 6G Vision and the National 6G Roadmap 2025–30, providing the strategic context for India's 6G programme. It highlights the urgency, the national strengths, and the phased framework necessary to ensure that India not only keeps pace with global developments but emerges as a net exporter of 6G technologies and solutions by 2030.

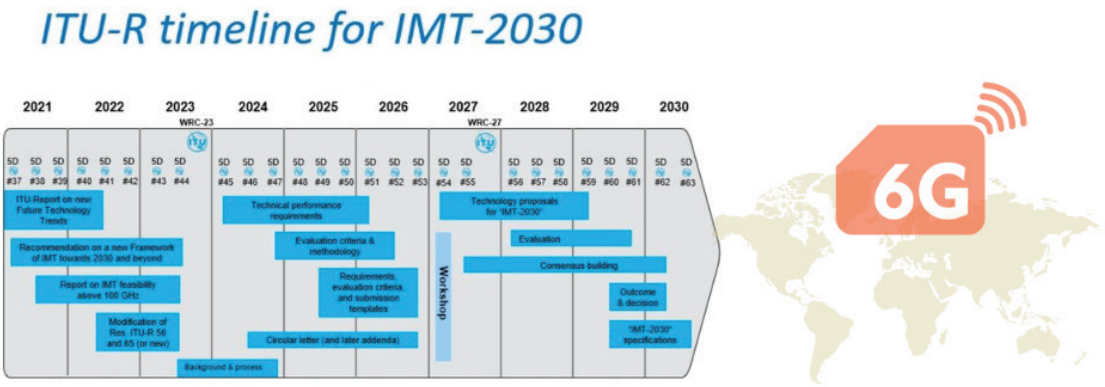
2.1 National and Global 6G Landscape

Global 6G Developments

The race to 6G is firmly underway, with major economies announcing dedicated roadmaps, funding commitments, and strategic objectives:

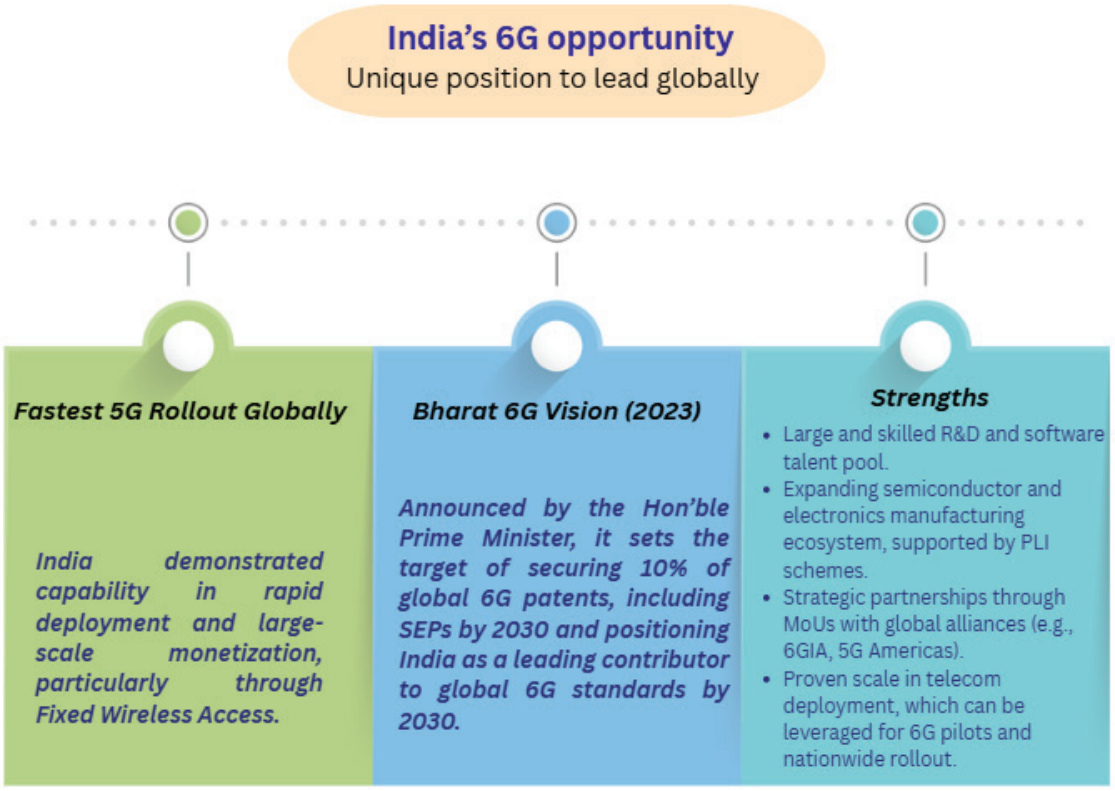
- **International Telecommunication Union (ITU):** ITU has initiated the IMT-2030 framework to define 6G requirements. Work on defining vision, capabilities, and performance indicators is progressing, with finalization expected during the ongoing pre-standardization phase. IMT-2030 will serve as the global foundation for 6G spectrum, architecture, and use-case definitions.
- **3rd Generation Partnership Project (3GPP):** 3GPP has started 6G study items in Release 19 (2026 timeframe), with Release 20 (target 2027) and Release 21 (target 2029) expected to carry the first wave of 6G features. These releases will be pivotal in shaping the global technical baseline. Participation in 3GPP Study (Rel. 19) and Work Item (Rel. 20) phases is critical for influencing specifications.
- **Regional Roadmaps and Initiatives:**
    - Europe (6GIA, Hexa-X, Hexa-X-II): Strong focus on sustainability, human-centric design, and sovereignty.
    - United States (Next G Alliance): Prioritizes spectrum innovation, semiconductor leadership, and global competitiveness.
    - China, Korea, Japan: Early trials and large-scale testbed investments with ambitions to lead standardization and deployments.
    - Brazil and other Global South partners: Exploring 6G use cases relevant to agriculture, rural connectivity, and sustainable development.

These initiatives underline that 6G is not merely a technological evolution, but a strategic driver of national competitiveness, digital sovereignty, and economic growth.



National 6G Context

India has a unique opportunity to build on its recent successes:



Comparative Positioning

While advanced economies have already initiated testbeds and 6G spectrum-related research, India's comparative strengths lie in:

- **Cost-Effective Innovation:** Ability to design frugal, scalable solutions for both domestic and global south markets.
- **Large-Scale Test Environment:** India's diverse geography and population enable real-world validation of applications in healthcare, agriculture, logistics, and education.

- **Global Influence Potential:** By acting early in WRC-27 spectrum decisions and 3GPP Release 21 contributions, India can shape international outcomes.

However, delays in engagement could reduce India's influence. This phase is therefore a critical window to establish leadership.

India's Strategic Imperatives

To consolidate India's role in the global 6G landscape:

- **Active Global Engagement:** Strengthen India's presence in ITU IMT-2030 and 3GPP Release 20/21, with at least 200–300 experts engaged across phases.
- **Spectrum Preparedness:** Define India's position for WRC-27 and WRC-31 agenda items covering spectrum allocations, with focus on mid-band (6–8.4 GHz), high-band (14.8–15.35 GHz), and THz spectrum.
- **National Testbeds:** Multi-institutional pre-6G standard testbeds aligned with global focus areas such as AI/ML for networks, NTN, ISAC, ORAN, Core evolution, and positioning.
- **IPR Creation:** 10,000+ 6G patents, including SEPs, to secure economic and strategic returns.
- **Showcasing Use Cases:** Develop India-specific use cases aligned with national missions (Digital Health, AgriStack, GatiShakti) and showcase them at platforms like the ITU Plenipotentiary 2030.

Outlook

By aligning with global 6G timelines while leveraging its unique national strengths, India can transition from being a fast adopter of 5G to a standards-shaper and technology supplier in 6G. The Bharat 6G Alliance (B6GA), with its hub-and-spoke execution model, provides the institutional mechanism to ensure India's coordinated participation in the global 6G ecosystem.

This positioning is not only about technology but also about digital sovereignty, economic growth, and societal impact, making 6G a strategic national priority.

2.2 Policy Alignment

Alignment with National Digital and Telecom Policies

The Bharat 6G Alliance (B6GA) anchors its vision within the framework of India's overarching digital and telecom policy priorities:

- **National Digital Communications Policy (NDCP-2018):** B6GA's focus on indigenous R&D, affordable and ubiquitous connectivity, and creation of a globally competitive manufacturing ecosystem supports NDCP's strategic objectives of ensuring universal broadband, enhancing India's contribution to global standards, and promoting innovation.
- **Digital India and Atmanirbhar Bharat:** B6GA's emphasis on indigenous chipset/ASIC development, IPR generation, and testbed-led validation strengthens India's technological sovereignty and reduces dependence on external ecosystems.

- **National AI and Semiconductor Missions:** B6GA's activities intersect with AI-driven 6G use cases and semiconductor innovation, contributing directly to national capacity building in high-value technology domains.

Alignment with International Commitments and Global Goals

India's role as a responsible global actor necessitates coherence between domestic initiatives and multilateral frameworks. B6GA aligns with:

- **United Nations Sustainable Development Goals (SDGs):** By embedding affordability, green technologies, and inclusive connectivity, B6GA contributes to SDG 9 (Industry, Innovation, Infrastructure), SDG 10 (Reduced Inequalities), and SDG 13 (Climate Action).
- **Global Digital Compact (GDC):** B6GA supports GDC's principles of inclusive digital transformation, fostering trust, and bridging the digital divide by contributing to globally harmonized standards that reflect Global South priorities.
- **International Telecommunication Union (ITU):** Active Indian participation in ITU-R and ITU-T ensures that 6G vision documents and IMT-2030 frameworks incorporate India's perspectives on affordability, sustainability, and inclusivity (ubiquitous coverage).

Alignment with Sectoral and Cross-Sectoral Policies

6G is expected to underpin multiple sectors beyond telecom. B6GA ensures alignment with:

- **Energy Policy:** Development of energy-efficient 6G systems and green telecom aligns with India's National Action Plan on Climate Change and renewable energy commitments.
- **Manufacturing & Industrial Policy:** Contributions to "Make in India" and Production Linked Incentive (PLI) schemes through a 6G manufacturing ecosystem for devices, sensors, and components.
- **Data Protection and Cybersecurity Frameworks:** Ensuring trust, resilience, and secure deployment of 6G networks complements India's Digital Personal Data Protection Act and National Cybersecurity Strategy.
- **Health, Education, and Agriculture Missions:** Alignment with digital public infrastructure initiatives, telemedicine platforms, smart farming, and remote learning applications that rely on advanced communication networks provided by 5G and 6G.

Policy Enablers for B6GA Activities

To operationalize these alignments, B6GA identifies specific enablers:

- **Funding Alignment:** Leveraging DoT's Telecom Technology Development Fund (TTDF), MeitY's R&D support, DST's NMICPS, RDI Fund, ANRF and other schemes for sustaining testbeds and IPR creation.
- **Standards and IPR Policy:** Strengthening India's presence in 3GPP, ITU, and other global SDOs, with a focus on facilitating the national target of 10% share in global 6G patents by 2030.

- **Spectrum Policy:** Advocating timely approval of spectrum sandboxes, trial bands, and experimental licenses to accelerate innovation.
- **Public–Private Partnerships:** Structuring joint efforts between academia, startups, large industry, and government to maximize policy outcomes.

2.3 Synergy with National Missions and Programmes

India's journey towards 6G is closely linked with several other national technology programmes. Rather than working in isolation, the Bharat 6G Alliance (B6GA) will draw strength from these initiatives, ensuring that efforts are complementary and avoid duplication. This approach will help make the most of investments already made by the Government and position 6G as part of a larger ecosystem of national missions.

National Technology Missions

The Bharat 6G programme will connect with a number of flagship technology missions already underway:

- Under the National Semiconductor Mission, India is investing heavily in chip design and fabrication. These capabilities will be directly relevant for 6G, particularly in ASICs, chipsets, and devices.
- The National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) has established 25 Technology Innovation Hubs across the country. These hubs cover areas such as AI, ML, robotics, cybersecurity, and quantum—all of which intersect with future 6G technologies.
- The National Quantum Mission provides opportunities for secure communications, post-quantum cryptography, and quantum networking—critical elements for 6G security and resilience.
- India's Manufacturing and Atmanirbhar Bharat initiatives, including Production-Linked Incentive (PLI) schemes, can accelerate the development of a domestic manufacturing base for telecom and electronics, ensuring that 6G hardware and devices are produced within the country.

Department of Telecommunications (DoT) Programmes

The Department of Telecommunications is already supporting a wide range of projects that are directly relevant to 6G. These include:

- The Telecom Technology Development Fund (TTDF) "Accelerated Research on 6G Ecosystem", under which 118 projects have been approved, with a 6G focus.
- National testbeds such as the Advanced Optical Communications Testbed and the Terahertz Technologies Testbed, which provide the foundation for early trials and experimentation in key 6G domains.
- Spectrum sandboxes and experimental licensing frameworks that will allow proof-of-concepts and pilots to be conducted more rapidly, feeding back into both research and standardization activities.

Cross-Ministerial Coordination

B6GA will also ensure close engagement with parallel efforts led by other ministries and agencies:

- MeitY's work on next-generation wireless research and semiconductor design will be linked with 6G prototypes and devices.
- DST's NM-ICPS hubs and National Quantum Mission will be tied into communications, quantum security, and AI-enabled systems.
- Defence R&D efforts will be connected through domains such as secure communications, integrated sensing, and THz technologies.

This coordination will extend to flagship national programmes such as Digital India, BharatNet, Smart Cities, GatiShakti, and AgriStack, ensuring that 6G pilots and use cases are embedded within them.

Principles of Engagement

The guiding principle for B6GA is to complement—not duplicate—existing efforts. Wherever possible, testbeds, pilots, and research programmes that have already received government support will be extended and integrated into the 6G programme. The outcomes of these national missions will feed into B6GA's broader goals of generating IPR, contributing to standards, and building commercially viable products. This approach will ensure efficient use of resources, stronger alignment across ministries, and faster progress towards India's 6G leadership.

2.4 Current Gaps in the Indian Ecosystem

India has made remarkable progress in telecommunications over the past decade—from leading the world's fastest 5G rollout to building an extensive digital public infrastructure that reaches nearly every citizen. Yet, as the country transitions toward 6G, several structural and systemic gaps remain that must be bridged to unlock the full potential of the emerging wireless technologies.

These gaps are not weaknesses but areas that require strategic attention and investment. The Bharat 6G programme aims to address them systematically through its hub-and-spoke model, capacity-building framework, and phased R&D roadmap.

Fragmented Research Efforts

While India's academic and research ecosystem is rich in talent, much of the work in advanced communications remains fragmented. Research groups often operate in isolation, with limited coordination between institutions, ministries, and funding agencies. Projects in areas such as AI-driven networking, non-terrestrial systems, and integrated sensing are currently scattered across multiple programmes under DoT, MeitY, DST, and DRDO, making it difficult to build cumulative impact or shared infrastructure.

The absence of a unified national repository of 6G-related R&D also restricts visibility into ongoing efforts. Without a mechanism to align priorities, outcomes may remain siloed, delaying the translation of promising ideas into deployable prototypes. The Bharat 6G Alliance, through its national testbeds and coordination role, is designed to close this gap by promoting shared facilities and open collaboration across academia and industry.

Limited Industry-Academia Collaboration

Although India has seen successful partnerships in DoT's National 5G Testbed Project and the TTDF-funded projects, broader industry participation with academic in R&D is still limited. Startups and MSMEs face challenges in accessing expensive research infrastructure, while large enterprises often invest independently in proprietary projects. This disconnect slows the transfer of innovations from labs to markets and weakens the pipeline for commercialization.

The current funding ecosystem also lacks long-term instruments that reward collaborative R&D. Industry contributions to public research programmes remain below global benchmarks, and mechanisms for joint IPR ownership or revenue sharing are still evolving. Strengthening public–private co-investment and creating shared IPR frameworks will be key to transforming India's research strength into deployable 6G technologies.

Gaps in Testbed and Certification Infrastructure

India's National 5G testbed demonstrated the value of shared national platforms, but the infrastructure for 6G is still at an early stage. Testbeds for Terahertz, Integrated Sensing and Communication (ISAC), AI-native networks, and non-terrestrial connectivity are under development but not yet fully operational or integrated. Access to these facilities remains limited to select institutions, with few formal pathways for startups and regional universities to participate.

The absence of a common certification and conformance framework also limits industry confidence in prototypes developed within academic environments. Establishing standardized interfaces, open-access testbeds, and clear certification mechanisms—aligned with TEC and BIS standards—will be essential to ensure that research outcomes can transition smoothly into market-ready products.

Shortage of Trained Manpower in Standards and IPR

India's participation in international standards has increased significantly in recent years, yet the pool of trained experts remains relatively small compared to leading economies. The number of engineers familiar with 3GPP and ITU processes is limited, and most operate on short-term project funding. Continuity between successive study and work item phases often depends on a few individuals, making India's contributions vulnerable to attrition and funding delays.

In addition, structured mentorship for new entrants into standards work is still lacking. Universities and technical institutes have not yet institutionalized standardization training within their curricula, and awareness of IPR strategy—including SEP identification, claims

drafting, and portfolio management—remains low among researchers. The Bharat 6G programme's human-capital plan directly addresses this gap through dedicated fellowships, travel support, and capacity-building initiatives, but sustained participation will require ongoing government and industry commitment.

Dependence on Imported Hardware and Components

Despite significant progress under the PLI and semiconductor missions, India's telecom equipment and component supply chain still depends heavily on imports. Key gaps exist in areas such as advanced RF front ends, high-speed data converters, photonic components, and baseband ASICs. Indigenous design capability is growing but production volumes and fabrication infrastructure remain limited.

This dependence constrains the ability to prototype and scale indigenous 6G solutions rapidly. The lack of accessible domestic foundry capacity for high-frequency or low-power designs forces Indian developers to rely on overseas fabs, adding cost and lead time. Building a coordinated semiconductor-telecom manufacturing strategy will be critical to reducing this vulnerability and ensuring self-reliance in the 6G era.

Funding and Incentive Limitations

Although substantial funding is proposed under the DPR, India's current R&D expenditure as a percentage of GDP (around 0.7%) remains below the global average. The available schemes—while impactful—often focus on short-term deliverables rather than sustained institutional growth. Many smaller institutions and startups struggle with delays in disbursement or limited visibility into upcoming calls, which affects continuity and planning.

Moreover, early-stage research in deep-tech areas like Terahertz communication or satellite networking demands long gestation periods before commercialization. Traditional grant structures are not always suited to such timelines. Introducing milestone-based, multi-phase funding and incentive models that encourage private-sector participation will be key to overcoming these barriers.

Limited Global Visibility and Partnerships

While B6GA has established formal partnerships with several global 6G alliances, India's institutional representation in ongoing projects and international working groups still needs to expand. Compared to counterparts in Europe, Korea, or the U.S., Indian participation in cross-national R&D projects, researcher exchanges, and joint whitepapers and patent filings remains modest.

Greater visibility at global platforms such as ITU-R WP 5D and 3GPP is necessary to ensure that India's perspectives on affordability, sustainability, and inclusion are reflected in international standards. This visibility is also crucial for ensuring that the indigenous R&D outputs translate into globally adopted Standards Essential Patents (SEP). Structured international fellowships and reciprocal testbed access agreements—as proposed under the Capacity Building and Ecosystem chapters—will help bridge this gap.

Inclusion and Regional Imbalance

India's innovation ecosystem remains concentrated around a few metropolitan and academic clusters such as Bengaluru, Chennai, Hyderabad, and Delhi. Many promising Tier-2 and Tier-3 institutions lack the infrastructure, funding, or mentorship to participate effectively in high-end telecom R&D. As a result, regional diversity and inclusion in the innovation pipeline remain limited.

To ensure that the benefits of 6G extend nationwide, the Bharat 6G programme envisions wider participation through spoke institutions, regional labs, and open-access testbeds. This distributed approach will not only deepen the talent pool but also create new opportunities for local innovation and entrepreneurship.

Bridging the Gaps

The gaps identified above are precisely the drivers for the interventions proposed across the DPR. By integrating fragmented research, deepening industry linkages, building testbeds, developing talent, and strengthening indigenous manufacturing, the Bharat 6G programme will transform today's challenges into tomorrow's competitive advantages.

Addressing these gaps with urgency and coordination will ensure that India's 6G journey is not just technologically advanced but also inclusive, sustainable, and globally relevant.

3.0 Opportunities to be Leveraged

India enters the 6G decade with a strong foundation built over years of progress in research, manufacturing, and digital transformation. The rapid rollout of 5G, expansion of fibre and satellite connectivity, and growth of a dynamic technology ecosystem have positioned the country among the world's most capable telecom markets. These developments now provide a launchpad for 6G innovation.

The Bharat 6G programme aims to build on this foundation rather than start anew. By linking ongoing national missions, existing testbeds, and India's expanding R&D base, it will accelerate the creation of home-grown 6G technologies, standards, and solutions that address both domestic and global needs.

3.1 Strength in Research and Innovation

India's academic and research ecosystem is one of the largest in the world, spanning IITs, IISc, NITs, and several research laboratories under MeitY, DST, and DoT. The success of the Indigenous 5G Testbed, which brought together eight premier institutions to deliver an end-to-end test platform, has proven India's ability to translate academic research into deployable solutions. The same collaborative model—now strengthened by the hub-and-spoke structure—will drive pre-standardization research in AI/ML for networks, Integrated Sensing and Communication, Non-Terrestrial Networks, and Open RAN.

India's growing publication and patent footprint, supported by initiatives such as the Telecom Technology Development Fund (TTDF) and MeitY's "5G & Beyond" programme, provides a strong pipeline of technologies ready to evolve into 6G prototypes. The presence of multidisciplinary talent in AI, quantum communication, cybersecurity, and semiconductor design offers fertile ground for cross-domain research and innovation.

3.2 Expanding Manufacturing and Design Ecosystem

The domestic manufacturing landscape has transformed significantly through schemes such as the Production Linked Incentive (PLI), Make in India, and the India Semiconductor Mission. Indigenous companies now design and manufacture RAN equipment, optical systems, and components such as power amplifiers, filters, and SoCs. Startups are emerging in critical domains like 5G/6G modems, automotive IoT, secure phones, and edge devices.

These achievements create a unique opportunity to link manufacturing with early-stage R&D, shortening the innovation-to-production cycle. The Bharat 6G programme will strengthen these linkages, enabling collaborative product design between academia, startups, and large industry partners. By connecting innovation with domestic manufacturing, India can move from being a technology consumer to a technology exporter in the global 6G value chain.

3.3 Global Standardization and IPR Advantage

India's growing presence in global standards bodies is one of its most strategic assets. Through TSDSI, Indian experts have contributed to 3GPP and ITU for over a decade. The

inclusion of India's 'Low Mobility Large Cell' (LMLC) technology in IMT-2020 stands as a clear example of how domestic innovation can shape international standards.

Building on this momentum, more than 200 experts will be trained and deployed during Phase 1, and around 300 by Phase 2 of the 6G programme to strengthen India's voice in 3GPP and ITU. Patent facilitation mechanisms, such as the proposed Sovereign Patent Fund and national IPR mentoring programmes, will help secure and commercialize the intellectual property emerging from publicly funded R&D. These steps position India to achieve its national target of securing at least 10 percent of global 6G patents by 2030.

3.4 Digital Infrastructure and Data Readiness

India's vast digital infrastructure offers a living laboratory for 6G applications. The success of initiatives such as BharatNet, Digital India Stack, GatiShakti, AgriStack, and the Digital Health Mission has created interoperable platforms that can host new communication technologies. The presence of over 800 million internet users, a rapidly growing IoT base, and widespread digital payments adoption make India a natural testbed for large-scale 6G trials.

The country's experience in building secure, scalable, and inclusive digital public infrastructure also provides lessons for developing 6G use cases in education, healthcare, logistics, and governance. By aligning 6G pilots with these national platforms, India can demonstrate use cases that directly improve citizen services while contributing to SDG targets such as inclusion and climate resilience.

3.5 Human Capital and Skill Development

The large and growing pool of engineers, researchers, and innovators forms another critical advantage. India produces over 1.5 million engineering graduates each year, supported by a strong base of higher-education institutions and a network of skill councils. The Bharat 6G programme builds on this strength by funding PhD scholars, training standardization experts, and embedding 6G modules into university curricula.

The hub-and-spoke model ensures that this talent development is distributed across the country, enabling participation from Tier-2 and Tier-3 institutions. By 2030, India is expected to have a globally recognized cadre of 6G researchers and standards professionals who can lead R&D and policy efforts both domestically and abroad.

3.6 Opportunities for Global Collaboration

Bharat 6G Alliance has already established Memoranda of Understanding with global alliances such as 6GIA (Europe), Next G Alliance (USA), 6G Forum (Korea), 6G Brasil, and XGMF (Japan). These partnerships open doors for joint research calls, shared testbeds, and academic exchanges.

India's active participation in ITU IMT-2030 and 3GPP Releases 20 and 21 offers a strategic window to shape global specifications. Through mutual access to testbeds and

co-development of use cases for the Global South, India can amplify its technical and diplomatic footprint in the global 6G ecosystem.

3.7 Translating Opportunities into Action

The DPR framework converts these national strengths into actionable initiatives through its phased approach. Phase 1 will leverage existing testbeds, research grants, and manufacturing schemes to create pre-standard prototypes and initial IPR outputs. Phase 2 will scale these efforts through integrated testbeds, pilots, and standards-based demonstrations.

By 2030, these combined actions will position India as a technology provider for both domestic and global markets. The opportunity for India is not just to adopt 6G early but to shape its future—turning the country's research depth, manufacturing base, and digital infrastructure into a platform for global leadership and inclusive growth.

4.0 Vision, Aims and Objectives

4.1 Overall Vision

India will position itself as a global leader in 6G technologies by 2030, shaping international standards, securing a 10% share of global 6G Patents by 2030, and ensuring that 6G delivers affordable, inclusive, and sustainable connectivity to all.

The vision rests on four pillars:

- **Affordability and Universal Access** – ensuring that advanced 6G services reach rural and underserved populations.
- **Technological Sovereignty –** building indigenous capabilities in core technologies, devices, semiconductors, and applications.
- **Global Leadership in Standards** – contributing decisively to ITU IMT-2030 and 3GPP Releases 20/21 and beyond.
- **Sustainable and Inclusive Growth** – aligning 6G development with the Sustainable Development Goals (SDGs), green telecom principles, and India's national missions.

4.2 Aims

- Research & Innovation Leadership
    - Establish multi-institutional 6G testbeds and centres of excellence, covering AI/ML, NTN, ISAC, THz, Open RAN, and Core network evolution.
    - Foster a robust pipeline of prototypes and proofs of concept (PoCs) aligned with national priorities such as Digital Health, AgriStack, GatiShakti, and Smart Cities.
- Standards & IPR Leadership
    - Achieve at least 10,000 6G patents by 2030, including SEPs.
    - Enhance India's participation in global standards forums (ITU, 3GPP) through trained manpower, aiming for 200 standardisation professionals in Phase 1 and 300 in Phase 2.
- Human Capital Development
    - Support 100+ PhD scholars and a wider research ecosystem resulting in 500+ research papers and annual filing of over 200 patents.
    - Build a sustained cadre of standardization experts, innovators, and entrepreneurs.
- Commercialization and Ecosystem Growth
    - Position India as a net technology exporter with globally competitive products and solutions.
    - Promote startups and MSMEs in the 6G value chain through funding support, capacity building, and participation in pilots.

  - Ensure early adoption of indigenous 6G applications in critical sectors such as healthcare, logistics, education, agriculture, disaster management, and public safety.

- Sustainability and Inclusivity
  - Embed energy efficiency, green telecom metrics, and circular economy practices in 6G research and deployments.
  - Ensure that 6G applications are aligned with SDG 9 (Industry, Innovation, Infrastructure), SDG 10 (Reduced Inequalities), and SDG 13 (Climate Action).

4.3 Specific Objectives

- Establish pre-standard 6G testbeds during the initial phase of the programme, expand to multi-institutional standards-based testbeds by 2030, and scale towards commercial readiness thereafter.
- Drive sector-specific pilots that validate India-centric use cases and demonstrate multi-vendor interoperability.
- File high-quality patents and SEPs, backed by Patent Facilitation Centres for optimization and monetization.
- Secure India's position in WRC-27 and WRC-31 agenda items covering spectrum allocations, particularly in mid-band (6–8.4 GHz), high-band (14.8–15.35 GHz), and THz frequencies.
- Ensure that funding and execution models follow a phased approach: government-supported in early years, transitioning to industry co-funding, patent monetization, spectrum sandbox fees, and commercialization revenues for sustainability.
- Showcase India-specific 6G innovations at major global platforms, including ITU Plenipotentiary 2030.

4.4 Milestones and Deliverables

Phase 1 (Years 1-2): Pre-Standardization and Foundation Building

Key Milestones

- Establishment of multi-institutional pre-standard testbeds in domains such as AI/ML with mMIMO, Joint Sensing & Communications (JSAC), Terahertz (THz), Non-Terrestrial Networks (NTN), Core Network evolution, Intelligent Reflecting Surfaces (IRS), and Open RAN.
- Launch of prototype development and sector-specific proofs-of-concept (PoCs) aligned with national missions such as Digital Health, AgriStack, and GatiShakti.
- Filing of initial IPRs and Standard Essential Patents (SEPs) with focus on high-value domains.
- Training and deployment of 200 standardization experts for active participation in ITU and 3GPP Study Items.
- Preparation of India's spectrum position for WRC-27 (mid-band, high-band, THz).

Expected Deliverables

- Operational pre-standard testbeds.
- Significant initial IPR filings, including early SEPs, from pre-standard testbed-linked R&D and prototypes.
- These will establish the foundation for scaling towards the target of 10,000+ 6G patents by 2030.
- Prototypes for priority use cases in healthcare, agriculture, logistics, and education.
- 200 trained experts contributing technical documents (TDocs) to 3GPP Release 20/21 and ITU IMT-2030.

Phase 2 (Years 3-5): Standards-Based Development and Scaling

Key Milestones

- Expansion into at least two fully integrated end-to-end testbeds with strong industry leadership in consortium mode.
- Execution of standards-compliant pilots across healthcare, logistics, rural broadband, education, agriculture, and disaster response.
- Scaling of IPR/SEP portfolio with global reach, targeting 10,000 6G patents cumulatively by 2030.
- Growth of standardization manpower to 300 experts, ensuring sustained contributions in 3GPP Work Items.
- Development of indigenous ASICs, chipsets, and devices for 6G-ready networks.

Expected Deliverables

- At least 2 national-level integrated testbeds operational.
- Pilot deployments in at least 5 strategic sectors.
- Substantial additional IPR filings, with a growing share of SEPs identified, driven by standards-compliant pilots, ASIC development, and global standardization engagement.
- Together with ecosystem-wide contributions from academia, startups, MSMEs, and industry, these will ensure steady progress towards the 10,000 cumulative filings by 2030.
- 300 experts consistently participating in 3GPP and ITU.
- Demonstrated multi-vendor interoperability and KPI compliance.

2030 and Beyond: Large-Scale Deployment and Commercial Readiness

Key Milestones

- Conduct medium-to-large scale PoC trials of standards-based prototypes at TRL 7/8/9.
- Demonstrate commercial readiness of indigenous 6G products and applications.
- Showcase India-specific innovations at global platforms (e.g., ITU Plenipotentiary 2030).
- Establish industry–TSP partnerships for national rollout of 6G.

Expected Deliverables

- Large-scale PoC deployments across smart cities, rural broadband, public safety, and disaster management.

- Commercialization-ready 6G technologies exported to global markets.
- Recognition of India as a leading technology provider and standards shaper in 6G.

Cross-Phase Deliverables

- **Testbeds:** Transition from pre-6G standard (Phase 1) to 6G standards-compliant integrated testbeds (Phase 2), scaling to commercial PoCs (2030+).
- **IPR & SEPs:** Progressive filing of high-quality patents, supported by Patent Facilitation Centres, to facilitate India **achieving** 10% of global 6G patents by 2030.
- **Human Capital:** Development of a pipeline of 100+ PhD scholars, 500+ research papers, and 400+ patents from academic programmes.
- **Standards Contributions:** Significant and growing participation in ITU and 3GPP, with India's inputs shaping IMT-2030 and beyond.
- **Societal Impact:** Demonstration of India-specific use cases aligned with SDGs, ensuring inclusivity, sustainability, and affordability.

5.0 Institutional Framework

The institutional framework forms the backbone of India's 6G programme. It defines the allocation of roles, responsibilities, and governance mechanisms necessary to translate strategic intent into actionable outcomes. In line with national practice, the Department of Telecommunications (DoT) will act as the nodal authority, ensuring that the programme is funded, monitored, and evaluated as per its established mechanisms.

The Bharat 6G Alliance (B6GA), will serve in an advisory and facilitative role. Its primary functions will include:

- Defining requirements for research, testbeds, and pilots in line with national priorities.
- Recommending strategies for phased implementation.
- Participating in the monitoring mechanism to provide domain-specific technical inputs.
- Facilitating the identification and recommendation of capable institutions for project execution.

This division of responsibility ensures that while DoT retains leadership and accountability, B6GA supports the programme with expertise, strategic foresight, and stakeholder mobilization.

5.1 Roles and Responsibilities

Department of Telecommunications (DoT)

- **Funding Authority:** Allocate resources across phases, ensuring adequate support for R&D, testbeds, IPR generation, and pilots.
- **Monitoring Mechanism:** Track progress through milestone-based monitoring, annual reviews, and third-party evaluations.
- **Policy Integration:** Align the 6G programme with broader national missions such as Digital India, Atmanirbhar Bharat, and SDG commitments.
- **International Representation:** Ensure India's positions at ITU and 3GPP reflect national priorities, supported by programme outputs.

Bharat 6G Alliance (B6GA)

- **Requirement Definition:** Identify thematic areas (AI/ML for networks, NTN, ISAC, ORAN, semiconductor design, etc.) requiring focus.
- **Implementation Strategy:** Recommend models for phased roll-out, prioritization of domains, and integration of academia, industry, and startups.
- **Monitoring Participation:** Nominate technical experts to contribute to DoT-led monitoring committees.
- **Facilitation Role:** Help identify anchor and spoke institutions, ensuring the best mix of capability, inclusivity, and regional representation.

Implementing Institutions

- **Anchor Institutions (Hubs):** Lead R&D in identified domains, establish testbeds, and provide technical leadership.
- **Spoke Institutions:** Contribute to domain-specific components, prototypes, and pilot projects.
- **Startups and MSMEs:** Bring agility and fresh ideas to areas such as device prototyping, application development, and commercialization.
- **Industry & TSPs:** Enable productization, scaling, and real-world pilots, ensuring commercial readiness and deployment pathways.

5.2 Hub-and-Spoke Model

B6GA recommends the adoption of a Hub-and-Spoke model for implementation, which balances depth of research at anchor institutions with breadth of participation across the ecosystem.

- Anchor Institutions (Hubs): Leading academic/research organizations and industry anchors selected by DoT, with B6GA's inputs, will act as hubs. Their responsibilities will include:

  - Hosting national-level testbeds.
  - Coordinating R&D in priority domains.
  - Driving standardization engagement and IPR creation.

  Each hub will operate in a virtual model, coordinated by a lead institution (hub coordinator) and an identified Point of Contact (POC). The hubs will bring together academic and research organizations, telecom service providers (TSPs) and industry partners with a proven track record in developing 4G/5G systems and a strong presence in 3GPP and ITU activities. The industry and TSPs will contribute resources and expertise for commercialization and will validate use cases under real-world conditions.

  Academic/research organizations may include:

  - IITs,
  - CEWiT
  - SAMEER
  - C-DOT
  - IISc
  - Other top NIRF-ranked institutions

  Industry anchors, which may include the following, will play key roles, particularly in RAN, Core and TSP domains:

  - Tejas Networks
  - WiSig
  - Lekha Wireless
  - VVDN
  - Coral Telecom

- HFCL
- Reliance Jio
- Bharti Airtel
- BSNL
- Vodafone Idea

- Spoke Institutions: Tier-1/Tier-2 universities, startups, MSMEs, and research labs will act as spokes, enabling wide participation and regional inclusivity. Their contributions will include:

  • Domain-specific R&D
  • Prototype development
  • Joint trials with hubs and industry

  - Specific spokes identified:
    - IITs
    - NITs
    - IISER Trivandrum
    - Other NIRF-ranked institutions

Every TTDF grantee, other than hubs, must be associated with at least one hub. Spokes can identify up to three areas of interest, with mandatory linkage to a primary hub. They will also assist in standardization and IPR activities wherever needed.

This structure ensures that the programme is both centralized for leadership and distributed for inclusivity and innovation.

Technology Matrix

Each hub will be mapped to one or more priority technology domains, such as:

- AI/ML for network
- Integrated Sensing and Communication (ISAC)
- Non-Terrestrial Networks (NTN)
- Physical layer technologies
- Fixed Wireless Access
- RF and transceiver modules
- Baseband ASICs
- RAN L2/L3 SW
- Core network Software Stack
- Antennas and IRS
- Open RAN
- IoT and V2X
- Security
- Backhaul (optical, mmWave, THz)
- Spectrum and licensing

Spokes will be mapped to their selected areas, ensuring wide coverage of research domains.

5.3 Industry Participation

A strong industrial base is critical for the successful execution of India's 6G roadmap. The implementation framework will draw upon the strengths of indigenous companies that have demonstrated expertise in RAN, Core, and Backhaul domains. These organizations will partner with identified hubs and spoke institutions to accelerate research translation into deployable products, ensuring that India's 6G ecosystem evolves in step with global standards.

RAN Device Ecosystem

India has a growing set of companies engaged in the design and manufacturing of Radio Access Network (RAN) components. The focus areas include power amplifiers (PAs) based on GaN technology, low-noise amplifiers (LNAs), front-end switches, phase shifters, and filters. Companies such as Siliizium Circuits, MMRFIC, MosChip Technologies, Fermionic Design and AGNIT Semiconductors are contributing to the development of advanced RF front-end modules.

In the area of processor chips, companies including InCore Semiconductors, Mindgrove Technologies, Manjeera Digital Systems, MBit Wireless, and Ananth Technologies are developing indigenous processing and SoC solutions tailored for wireless baseband and signal processing applications.

For RF filtering components, Andhra Electronics Ltd, SGR Electronics, Raamtel, and Nimble are engaged in the development of cavity filters, while R&N Microwave (Hyderabad) and Raamtel India are active in ceramic filter technologies. These companies collectively form the foundation for India's indigenous RAN hardware capability, which will be aligned with the 6G testbed and prototyping programmes.

RAN and Core Network Industry Base

The national 6G programme will be supported by key industry players with proven expertise in telecom system design and deployment. Organizations such as C-DOT, Coral Telecom, Lekha Wireless, Reliance Jio, Tejas Networks, VVDN Technologies, and WiSig Networks will anchor the development of end-to-end RAN and Core systems. Their participation will ensure continuity from pre-standard research to commercial-grade implementations, contributing to standardization activities in 3GPP and ITU, and to large-scale pilot deployments during Phases 2 and 3.

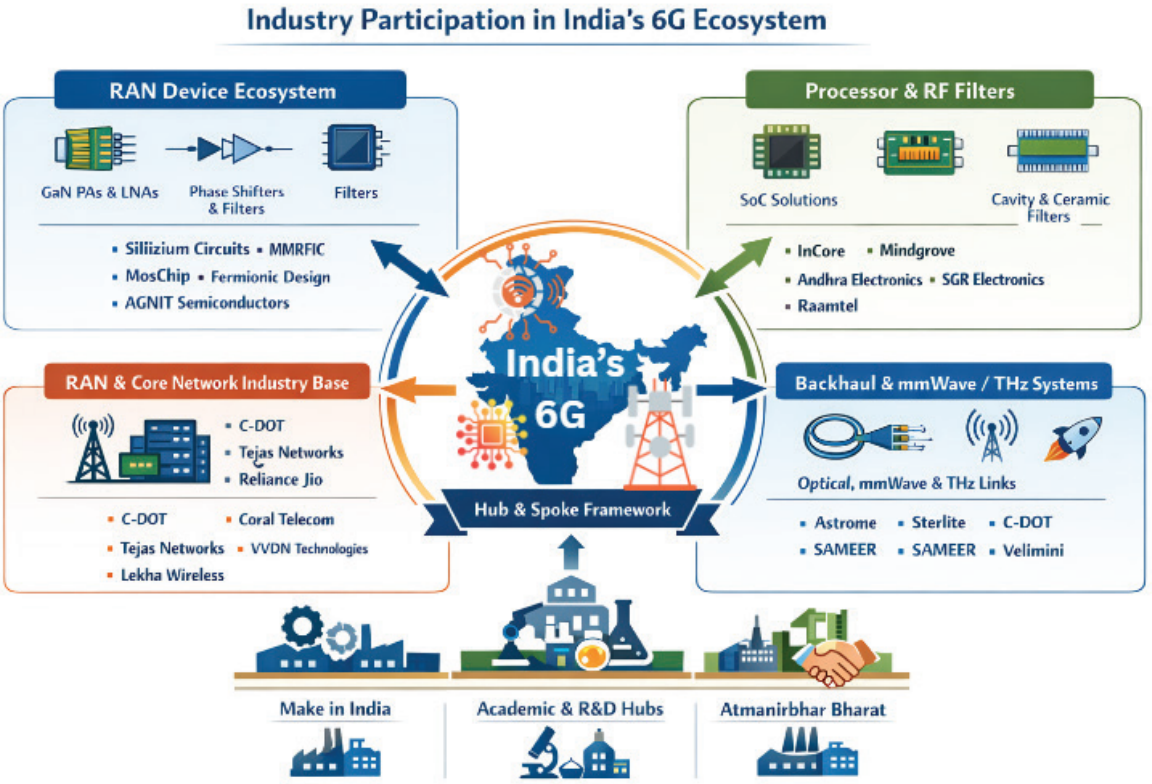
Backhaul, Optical, and mmWave/THz Ecosystem

Reliable backhaul solutions, including optical, mmWave, and THz links, are essential for 6G network scalability and performance. Indian organizations such as Astrome, C-DOT, SAMEER, Sterlite, and Velimini are developing cutting-edge solutions in these domains. Their combined expertise covers free-space optical and high-capacity wireless backhaul,

photonic integration, and high-frequency transceiver technologies. These capabilities will directly contribute to national testbeds for validating integrated access–backhaul solutions for future 6G deployments.

Industry partners will play a central role in the Hub-and-Spoke implementation framework. Depending on their technical leadership and infrastructure capabilities, they may serve either as hubs, leading specific technology domains such as RAN, Core, or Backhaul, or as spokes contributing components, subsystems, and integration support. Their participation will ensure that the research outcomes from academic and R&D institutions are translated swiftly into manufacturable and deployable systems.

This inclusive structure aligns with the Make-in-India and Atmanirbhar Bharat missions, strengthening India's capability to design, develop, and manufacture advanced telecom systems within the country. By enabling both academic and industrial hubs, the framework will foster deep linkages between research, standardization, and production—creating a globally competitive and self-reliant 6G industrial ecosystem.



5.4 Governance and Monitoring

- **DoT Monitoring Committees:** Will have oversight of all projects, ensure milestone-linked funding, and approve disbursements.
- **B6GA's Participation in Monitoring:** B6GA will nominate technical experts to join monitoring reviews, providing independent inputs on progress in testbeds, IPR filings, and pilots.

- **Anchor Institution Accountability:** Each anchor institution will be directly accountable to DoT for deliverables and milestones.
- **Transparency and Reviews:** Progress will be tracked through quarterly reviews, half-yearly steering committee reports, and annual consolidated evaluations.

5.5 Rationale for the Institutional Model

The proposed structure is designed to ensure:

- **Clarity:** Clear separation of roles, avoids duplication and ensures accountability.
- **Efficiency:** DoT-led funding and monitoring ensures government oversight, while B6GA's facilitative role ensures stakeholder engagement.
- **Inclusivity:** The Hub-and-Spoke model promotes broad participation from academia, industry, startups, and MSMEs.
- **Alignment:** Ensures India's domestic 6G efforts remain synchronized with global developments in 3GPP, ITU, and WRC.

The institutional framework firmly places DoT as the funding and monitoring authority, while enabling B6GA to serve as a facilitator and strategic advisor. The recommended Hub-and-Spoke model ensures excellence at anchor institutions and inclusivity through spoke participation, while industry and TSPs provide the bridge to commercialization and deployment.

This framework offers a balanced, accountable, and scalable pathway for achieving India's 6G vision, ensuring measurable outcomes in IPR, standardization, pilots, and human capital development.

6.0 Focus Areas of Research and Innovation

The Bharat 6G Programme identifies the technological domains and innovation pathways that will anchor India's leadership in 6G. These focus areas span the complete 6G stack—from fundamental science to applied engineering, from testbeds to pilots, and from hardware to applications.

The programme adopts a hub-and-spoke model, enabling anchor institutions to lead R&D and testbed development while a broad ecosystem of spoke institutions, startups, and industry partners contributes specific technologies, algorithms, and prototypes. Research outcomes will be channelled into 3GPP Release 20/21 and ITU IMT-2030 activities, ensuring that Indian innovations translate directly into global standards.

6.1 Structure of Research

Layer	Objective	Key Outputs
Basic Research **(TRL 1-2)**	Advance fundamental science in communication, sensing, and computation	New algorithms and models, open datasets, core intellectual property (IP) and foundational publications
Applied Research **(TRL 3-4)**	Translate concepts into demonstrable technologies and components	Prototypes, PoC demonstrations, reference modules, testbed results, validated software stacks, standardization contributions
Integration & Innovation **(TRL 5 and upwards)**	Combine outputs into interoperable, standards-aligned systems	End-to-end demonstrators, SEPs, deployable testbeds, commercial products/services, societal impact

6.2 Thematic Priorities

- AI/ML for Networks

  Embedding intelligence across all network layers through AI-native design and continuous learning. Focus: self-optimizing networks, predictive resource management, AI-based spectrum sharing, and digital-twin-enabled network planning.

- Massive MIMO and Advanced Waveforms

  Large antenna arrays, holographic beamforming, and full-duplex transceivers for higher spectral and energy efficiency.

- Integrated Sensing and Communication (ISAC)

  Joint radar-communication systems for precision positioning, sensing and environmental awareness.

- Non-Terrestrial Networks (NTN)

  Integration of LEO/MEO satellites, HAPS, and UAVs for universal, resilient coverage.

- Open RAN and Core Network Evolution

  RIC-driven automation, disaggregated and software-defined RAN architectures for interoperability and vendor diversity. Cloud-native, distributed, and secure core networks with edge-integrated service functions.

- Terahertz and Optical Wireless Communications

  Exploration of 100 GHz–1 THz and optical bands for ultra-high-capacity, multi-Gbps connectivity.

- Fixed Wireless Access (FWA) and Rural Broadband

  High-capacity, affordable broadband solutions for semi-urban and rural regions.

- IoT, V2X and Cyber-Physical Integration

  Ultra-reliable, low-latency connectivity for Industry 5.0, autonomous systems and smart transportation.

- Security, Trust and Resilience

  Intrinsic security through post-quantum cryptography, zero-trust frameworks and AI-assisted threat detection.

- Sustainable Hardware & Devices

  Low-cost, energy-efficient RF front-ends, chipsets, and antennas for 6G, including device innovations for FR3 and beyond.

6.3 Pre-Standard Testbeds

To accelerate India's early and effective contributions to 3GPP Release-21 and ITU IMT-2030, the Bharat 6G Programme will establish a suite of pre-6G standard testbeds during Phase-1 (Years 1-2). These testbeds are conceived as shared national infrastructures that enable system-level experimentation, integration, interoperability testing, dataset generation, early IPR creation, and standards-aligned validation across critical 6G technology domains.

A few representative examples are the ISAC, NTN, massive MIMO, Core Network, ORAN and PHY-layer testbeds, whose scope and objectives are summarised below. Together, these address key gaps identified in the current national R&D and TTDF project landscape.

In addition to the above, the design and operation of pre-standard testbeds should incorporate application-driven demonstrations that validate system-level capabilities in realistic or representative environments. These demonstrations should integrate multiple technology components and network segments, illustrating how emerging 6G functionalities—such as NTN, ISAC, and AI-native networks—can jointly support sector-specific use cases in areas such as healthcare, agriculture, logistics, and disaster management. Such an approach will help bridge the gap between laboratory-scale experimentation and real-world deployment, and provide early confidence to industry and standards bodies on the feasibility and performance of integrated 6G systems.

Pre-Standard ISAC Testbed

The Integrated Sensing and Communications (ISAC) testbed will bring together sensing and communication functions on a unified FR-3 platform to support novel 6G applications.

Scope & Objectives

- Develop a modular ISAC platform (FR-3: 6–12 GHz) supporting joint communication–sensing experiments.
- Enable research on waveforms, localisation, detection, and AI-enhanced sensing.
- Provide shared infrastructure for academia, startups, and industry.
- Support early Indian inputs to 3GPP RAN1/RAN3 and ITU-R WP5D.

Key Deliverables

- TRL-7 ISAC demonstrator with reference nodes.
- Open datasets and APIs for national use.
- 10+ TDocs and 5+ patents in ISAC-related technologies.

Pre-Standard NTN Testbed

The Non-Terrestrial Networks (NTN) testbed will integrate satellite, aerial, and terrestrial components to validate India-relevant NTN architectures and use cases for 6G.

Scope & Objectives

- Build an experimental NTN platform combining LEO/MEO/GEO, HAPS, UAVs, and terrestrial 6G components.
- Validate waveforms, mobility, hybrid access, multi-connectivity, and handover schemes.
- Produce FR-1/FR-3 and Ka/Ku band channel models aligned with IMT-2030 methodologies.
- Strengthen contributions to 3GPP RAN/SA and ITU-R.

Key Deliverables

- Operational TRL-7 NTN testbed.
- Open datasets and reference architectures.
- 10+ standards contributions and 5+ patents.

Pre-Standard Massive MIMO Testbed

The Massive MIMO testbed will establish a national capability for very large antenna array systems, which are central to achieving the spectral efficiency, coverage, and energy-efficiency targets envisioned for 6G.

Scope & Objectives

- Develop a 256 Tx + 256 Rx over-the-air (OTA) Massive MIMO platform aligned with IMT-2030 performance expectations.
- Enable system-level validation of real-time beamforming, channel estimation, calibration, synchronization, and multi-user MIMO operation.
- Support experimentation under realistic propagation, mobility, and traffic conditions relevant to urban, semi-urban, and FWA scenarios.
- Provide a shared national infrastructure accessible to academia, startups, MSMEs, and industry.
- Generate early technical evidence and datasets to support 3GPP RAN1/RAN2 studies and ITU-R activities.

Key Deliverables

- A TRL-7 operational Massive MIMO testbed with OTA multi-user capability.
- Configurable reference deployments and measurement frameworks.
- Open datasets and performance evaluation reports.
- 10+ TDocs to relevant standards bodies and 5+ patent filings, with potential early SEPs.

Pre-Standard Core Network Testbed

The 6G Core Network testbed will serve as a foundational platform for validating the evolution of the core network into an AI-native, cloud-native, and service-aware system, tightly integrated with heterogeneous access networks and vertical applications.

Scope & Objectives

- Design and implement a pre-standard 6G Core Network platform building on and extending 5G Service-Based Architecture concepts.
- Enable AI-native, intent-driven control, orchestration, and automation across network functions and services.
- Support end-to-end integration with RAN (including ORAN), NTN, ISAC, edge computing platforms, and vertical use cases.
- Provide a shared, open test infrastructure for system-level experimentation and benchmarking.
- Strengthen India's contributions to 3GPP SA Working Groups and ITU IMT-2030 studies.

Key Deliverables

- A TRL-7 pre-standard 6G Core Network testbed with configurable reference deployments.
- Performance evaluation reports covering latency, scalability, resilience, and service orchestration.
- Open documentation, datasets, and technical reports.
- 10+ standards contributions and 5+ patent filings, with a roadmap toward Phase-2 evolution.

Pre-Standard Open RAN (ORAN) Testbed

The ORAN testbed will enable system-level validation of disaggregated, open, and interoperable RAN architectures, which are expected to be integral to future 6G networks.

Scope & Objectives

- Establish an end-to-end ORAN testbed covering CU, DU, RU, near-RT and non-RT RIC, and cloud infrastructure.
- Validate open fronthaul, midhaul, and control interfaces, supporting multi-vendor interoperability.
- Enable experimentation with xApps/rApps and AI/ML-driven RAN optimization and automation.
- Provide a neutral national platform for interoperability testing, benchmarking, and standards-aligned evaluation.
- Generate early Indian inputs to 3GPP, ITU-R, and ORAN-related specifications relevant to IMT-2030.

Key Deliverables

- A TRL-7 operational ORAN pre-standard testbed.
- Reference architectures, integration guidelines, and interoperability reports.
- Open APIs, datasets, and experimentation tools.

- 10+ TDocs and 5+ patent filings, with a clear roadmap toward Phase-2 scaling.

Pre-Standard PHY Layer Testbed

The PHY layer testbed will provide a national, system-level platform for integrating and benchmarking advanced 6G physical-layer technologies across multiple frequency bands and use cases.

Scope & Objectives

- Develop a modular, reconfigurable pre-standard PHY-layer testbed spanning sub-6 GHz, FR3, mmWave, and sub-THz bands.
- Enable real-time experimentation with advanced waveforms, numerologies, channel coding, receivers, synchronization, and AI/ML-assisted PHY techniques.
- Support PHY-level validation for ISAC, NTN, FWA, and high-mobility scenarios.
- Provide open-access infrastructure for standards-aligned evaluation and dataset generation.
- Strengthen India's technical contributions to 3GPP RAN Working Groups and ITU IMT-2030.

Key Deliverables

- A TRL-6/7 operational PHY-layer testbed with real-time multi-band capability.
- Configurable reference PHY implementations and performance evaluation reports.
- Open datasets and technical documentation.
- 10+ standards contributions and 5+ patent filings, with a roadmap toward Phase-2 compliance.

6.4 Strategic Role of Pre-Standard Testbeds

Together, these pre-standard testbeds will:

- Address system-level gaps not covered by component-centric TTDF projects and Integrate outputs of ongoing DoT/MeitY projects to ensure coherence across India's research ecosystem.
- Provide a coherent national experimentation backbone aligned with global 6G timelines.
- Enable early IPR/SEP creation, standards influence, and ecosystem capacity building.
- Form the foundation for standards-compliant integrated testbeds and sectoral pilots in Phase-2 (Years 3-5).

6.5 Hardware and Semiconductor Technologies

The Bharat 6G Programme will build a strong indigenous foundation across both semiconductor design and hardware systems, ensuring that India develops capabilities spanning from silicon to subsystems. This combined focus covers two complementary domains—Semiconductor & ASIC Development and Hardware Development—that together form the physical layer backbone of India's 6G technology stack.

Semiconductor and ASIC Development

The Programme will prioritise indigenous design of semiconductor devices and ASICs that power 6G user equipment and base stations. The key thrust areas include System-on-Chip (SoC) and modem design for user equipment (UE) and high-performance base station (BS) processors and accelerators to support next-generation radio and core network functions. Efforts will leverage RISC-V architectures, chiplet-based integration, and AI/ML acceleration to create power-efficient, reconfigurable, and secure chipsets. The objective is to establish domestic silicon design capability, reduce dependence on imported processors, and ensure India's participation in the global semiconductor value chain.

Hardware Development

Complementing the semiconductor effort, the Programme will strengthen India's capabilities in system-level hardware and RF front-end engineering. Focus areas include RF and antenna subsystems (wideband phased-array antenna panels for the FR3 band, reconfigurable front-ends, and high-efficiency filters), power and low-noise amplifiers (GaN-based amplifiers, driver stages, and adaptive biasing circuits), high-speed data converters and transceivers (energy-efficient ADC/DAC modules and modular transceiver platforms covering mmWave and THz frequencies), and edge devices and terminals (6G-ready UE and CPE prototypes integrating AI/ML-enabled modems and secure connectivity modules). Projects will be industry-led with active academic and startup participation, ensuring manufacturable, interoperable, and cost-efficient components validated through national 6G testbeds and scaled to production within two years. Together, these initiatives will enable India to develop end-to-end 6G hardware capability, reinforcing technological self-reliance and competitiveness in the global market.

This combined focus draws on broad inputs from national initiatives on strategic 6G technologies, emphasizing modular, interoperable, and manufacturable innovations that advance India's vision of creating a sovereign, globally competitive 6G technology ecosystem—from silicon to systems.

6.6 Software Development

Parallel to hardware innovation, the Bharat 6G programme will create open, modular software stacks across the network lifecycle:

- **Network Intelligence Software:** AI/ML algorithms for self-learning RAN and core.
- **Open Source Stacks:** interoperable software components (L1, L2, L3) for ORAN, core, and edge computing.
- **Network Digital Twins:** simulation and emulation environments for design, testing, and validation.
- **Security Frameworks:** integrated software libraries for cryptography, privacy, and compliance.

All software developed through public funding will follow open-source licensing wherever feasible to maximize reuse, transparency, and global visibility.

6.7 Sector-Specific Pilots and 6G Applications

Sectoral pilots will translate research into tangible impact. These demonstrations will validate India-specific 6G use cases and provide feedback into global standards. Focus sectors include:

- **Healthcare:** Tele-surgery, remote diagnostics, and AI-assisted care over ultra-reliable links.
- **Agriculture:** Precision farming, autonomous equipment and sensor networks connected via NTN and ISAC frameworks.
- **Education and Skill Development:** immersive classrooms and extended-reality learning environments.
- **Smart Cities:** Digital-twin-based infrastructure monitoring and real-time resource optimisation.
- **Disaster Management and Public Safety:** Resilient networks using NTN and ad-hoc connectivity, real-time drone networks for assessment and response.
- **Logistics & Supply Chain:** 6G-enabled asset tracking, warehouse automation, and real-time operational visibility.
- **Defence & Security:** ISAC-enabled surveillance, secure tactical communications, and resilient mesh networking.
- **Smart Transportation:** ISAC-enabled vehicle positioning, connected highways, and autonomous mobility systems.

These pilots will be implemented through consortium-based projects under DoT's oversight, using national 6G testbeds as shared platforms for experimentation and validation, and standards-aligned refinement.

6.8 Standards, IPR and SEP Targets

Standardization and IPR generation form the core of India's 6G leadership strategy. The target is to facilitate the national vision of 10% of global 6G patents by 2030, supported by a portfolio of 10,000 patents and sustained representation in global SDOs.

Metric	Phase 1 (Years 1-2)	Phase 2 (Years 3-5)	2030 and Beyond
Experts in SDOs	≈200 (75 academic + 125 industry)	≈300 (100 academic + 200 industry)	>300 sustained
Patent applications (per year)	≈900 (India + US)	≈1,500 (India + US + PCT)	10,000 cumulative including SEPs
TDocs to 3GPP	≈2000	≈10%	>10% sustained

6.9 Key Technology Outcomes

- Over 10,000 patent (including SEPs) linked to 3GPP Rel-21 and IMT-2030.
- Two national testbeds serving as integrated validation platforms.
- Five or more sectoral pilots demonstrating India-specific 6G applications.
- More than 300 experts actively engaged in standards fora.
- Indigenous ASICs and 6G devices ready for commercial trials by 2030.

By uniting hardware and software development, cross-sector pilots, and standards-driven IPR creation, this chapter defines the core innovation strategy of Bharat 6G. It ensures that India's research translates into measurable global impact—strengthening technological sovereignty, stimulating new industries, and aligning national advances with international 6G timelines.

7.0 Ecosystem Development

A strong and vibrant 6G ecosystem is essential to transform India's ambitions into measurable achievements. It must bring together researchers, innovators, startups, manufacturers, service providers, and investors in a way that each link reinforces the other. The aim is to ensure that every strand of effort—from academic research to international standardization—feeds into a coherent and self-sustaining national innovation framework.

India already has many of the building blocks for such an ecosystem: leading academic institutions, globally competitive industry players, and a dynamic base of startups and MSMEs. The 6G programme provides the opportunity to weave these elements together through structured collaboration, open testbeds, and inclusive funding mechanisms.

The journey from research to commercialization requires a seamless innovation pipeline. Basic and applied research must lead to prototypes, trials, and finally deployable products. To make this happen, the national 6G testbeds will be positioned not just as research infrastructure but as open, shared platforms accessible to academia, startups, and industry. These testbeds will act as the bridge between discovery and deployment—enabling experimentation, validation, and certification of technologies developed within India.

7.1 Startups and Entrepreneurship

Startups will be a key driver of innovation. Many of them already work on areas such as RF front ends, AI for networks, chip design, and sensing systems. The 6G ecosystem will provide them with access to advanced tools, common test facilities, and mentorship through the hub-and-spoke network. Seed grants, IP facilitation, and accelerator programmes linked to the hubs will help them translate ideas into market-ready solutions. The goal is to nurture a pipeline of deep-tech ventures that can contribute to both domestic and global 6G markets.

7.2 Industry Participation and Co-Investment

Industry participation is equally vital. Indian manufacturers and telecom service providers will play an active role in co-developing technologies, hosting pilots, and validating systems under live conditions. Their early engagement will help ensure that products developed through public funding are relevant, scalable, and commercially viable. Consortium-based projects—bringing together anchor industries, startups, and academic institutions—will encourage joint investment and faster translation of R&D outputs into deployment-ready solutions.

7.3 Academia–Industry–Startup Linkages

Academia–industry collaboration will be encouraged through structured agreements that clearly define research ownership, IP sharing, and revenue models. Doctoral and postdoctoral fellowships supported by industry will ensure continuity of expertise in key domains such as RAN, Core, and non-terrestrial networks. Cross-disciplinary collaboration will also be promoted, linking 6G research with national missions in semiconductors, quantum technology, and cyber-physical systems.

7.4 Regional and Thematic Clusters

Regional and thematic clusters will help broaden participation. While hubs will anchor national-level testbeds, smaller institutions across the country will serve as spokes focusing on niche areas. This distributed approach will allow wider participation, ensure regional diversity, and build capacity in emerging centres of excellence.

7.5 International and Cross-Sector Engagement

International engagement will be an integral part of ecosystem development. The Bharat 6G Alliance has already established partnerships with leading global 6G alliances and standardization bodies. These relationships will be used to open pathways for joint research, testbed interconnection, and visibility of India's contributions at the global level. Indian prototypes and use cases will be demonstrated in international forums, reinforcing the country's position as a contributor and thought leader.

7.6 Sustainability and Inclusivity

The ecosystem must also be sustainable and inclusive. Every project will be encouraged to embed energy efficiency, green design, and circular economy principles into its technology and business models. Equal emphasis will be placed on gender diversity, regional inclusion, and affordability—ensuring that the benefits of 6G extend to rural areas, MSMEs, and the broader society.

7.7 Outcome and Impact

The strength of India's 6G ecosystem will ultimately be measured not only by patents or standards contributions but also by its ability to generate new enterprises, attract co-investment, and create skilled jobs. By nurturing interconnected networks of innovation and trust, the Bharat 6G programme will build a technology foundation that continues to grow long after the initial phases of funding have ended. It will enable India to emerge as a global source of ideas, products, and solutions—truly realizing the vision of technological sovereignty and inclusive growth.

8.0 Capacity Building and Infrastructure

The success of India's 6G mission depends as much on the strength of its people and institutions as on the technologies they create. Capacity building and infrastructure development are therefore central to the Bharat 6G programme. This chapter outlines how the programme will nurture a skilled talent pool, build world-class research facilities, and ensure that institutions across India are ready to drive innovation, standardization, and deployment of 6G technologies.

The approach moves beyond isolated training initiatives to create a sustained, nationwide effort linking education, research, and standardization. Capacity building here extends beyond scientists and engineers—it includes entrepreneurs, innovators, and policymakers who will shape India's digital future. Sustainability principles will be embedded, ensuring that new skills and infrastructure promote energy efficiency, green design, and responsible innovation aligned with national climate and development goals.

8.1 Human Capital for a 6G-Ready Workforce

India's greatest strength lies in its people. The Bharat 6G programme will harness this through a structured and continuous framework for education, research, and professional development. Opportunities will be created across all levels—from undergraduate and postgraduate students to working professionals and standardization experts.

Over a hundred PhD scholars will be supported through specialized fellowships in leading academic and research institutions. Their work will span critical domains such as AI and machine learning for networks, Integrated Sensing and Communication, Non-Terrestrial Networks, semiconductor design, and Open RAN. Each fellowship will combine deep academic research with hands-on engagement in testbeds and standards work, creating a strong bridge between theory and practice.

In addition, about two hundred experts will be trained and deployed in the first phase (Years 1-2) and around three hundred in the second phase (Years 3-5) to represent India in ITU and 3GPP standardization. This will ensure India's consistent voice and growing influence in global study and work items.

Universities will be encouraged to introduce new electives and laboratory modules on emerging 6G topics, supported by AICTE, UGC, and MeitY platforms. Short, hybrid certification and reskilling programmes will help industry professionals keep pace with fast-moving standards. Together, these initiatives will build a diverse and future-ready community of researchers, engineers, and innovators capable of steering India's 6G leadership.

8.2 Building Research and Innovation Infrastructure

The programme envisions a distributed but well-connected network of advanced laboratories and testbeds. These will include multi-institutional testbeds, specialized labs, and shared experimental infrastructure enabling joint research, prototyping, and validation.

Each national testbed will function both as a research facility and as a learning platform. Students, startups, and engineers will use them for experiments, prototyping, and trials under real-world conditions. Open access will encourage collaboration among institutions that might otherwise work in silos.

The hub-and-spoke institutional model described earlier provides the backbone of this network. Hubs—anchor institutions hosting major testbeds—will be supported by spokes drawn from TTDF grantees, universities, and startups. Existing assets such as the 5G Testbed and DST's Technology Innovation Hubs will be integrated, ensuring efficient use of national infrastructure. Over time, this will evolve into a National Grid of 6G Laboratories supporting the full path from basic research to standards-compliant validation.

8.3 Fellowships, Training, and Knowledge Exchange

Capacity building will go far beyond classrooms. Scholars and professionals supported under this programme will actively participate in ITU-R, ITU-T, 3GPP, and IEEE groups, ensuring direct contributions to global standards. Mentorship and travel support are built into the funding framework, enabling sustained Indian presence in these fora.

Bharat 6G Alliance will conduct workshops, hackathons, and training sessions with its international partners to expose participants to best practices in R&D management, IPR creation, and standards processes. Faculty-oriented "Train-the-Trainer" programmes will help academic institutions update their curricula and mentor student projects in emerging 6G areas.

8.4 Integration with National Missions and Skill Platforms

The capacity-building framework will align closely with existing national programmes to ensure coherence and avoid duplication. Coordination with the Telecom Sector Skill Council, Skill India, and the PM GatiShakti Digital Training Network will harmonize certification frameworks and career pathways.

AICTE, NPTEL, and MeitY will collaborate to create online and hybrid courses on 6G fundamentals, network intelligence, and sustainable telecom design—making advanced learning accessible to students and engineers across India, including Tier-2 and Tier-3 cities.

Linkages will also be built with the National Quantum Mission, the Semiconductor Mission, and DST's NM-ICPS Technology Innovation Hubs. Joint fellowships and co-supervised research projects will promote interdisciplinary learning, connecting communication engineering with quantum security, chip design, and AI-driven network management.

8.5 International Collaboration and Exchange

Global partnerships will play a vital role in building India's 6G talent base. Through its links with 6G IA, Next G Alliance, and 6G Forum Korea, the Bharat 6G Alliance will facilitate joint research workshops, exchange programmes, and short residencies. Indian researchers will spend time in leading global labs, and international scholars will be invited to Indian

institutions for collaborative work. These exchanges will align India's research priorities with international developments and foster mutual understanding and trust.

8.6 Creating a Sustainable Institutional Framework

All capacity-building initiatives will operate within an institutional framework designed for continuity and accountability. Bharat 6G Alliance will work closely with the Department of Telecommunications to ensure transparent selection of fellows, equitable access to testbeds, and measurable outcomes.

Participating institutions will prepare their own plans for training, mentorship, and infrastructure utilization. Over time, the most successful will evolve into Centres of Excellence for 6G Research and Education, sustaining the knowledge and capabilities beyond the project period.

Progress will be tracked through the Monitoring and Evaluation framework defined in the DPR, using indicators such as number of PhD scholars, experts trained, workshops held, and technical contributions to ITU and 3GPP. Funding for these activities, as outlined in the Finance and Sustainability chapter, will cover salaries, travel, and patenting costs, ensuring that experts can focus on substantive technical outcomes.

8.7 Outcome and Long-Term Vision

The combined capacity-building and infrastructure efforts will create a self-sustaining ecosystem of people and facilities. By 2030, India will host more than one hundred doctoral researchers, several hundred trained standardization experts, and a robust network of interconnected laboratories driving continuous innovation.

These assets will strengthen India's role as a standards shaper and technology exporter while deepening its scientific and industrial base. The outcomes will extend beyond 6G—building the foundation for a long-term knowledge economy that supports future generations of wireless innovation and contributes to global sustainability and inclusivity.

9.0 Finance and Sustainability

The Bharat 6G Alliance (B6GA) proposes a comprehensive financial and sustainability framework to enable India's leadership in the global 6G mission. This chapter presents a detailed view of the financial outlay, sustainability strategies, and risk mitigation measures necessary to support research, development, standardization, and commercialization of indigenous 6G technologies. The framework ensures a phased, well-balanced approach that addresses both immediate and long-term needs, while aligning with India's national priorities.

9.1 Phased Financial Outlay

The financial plan for B6GA is structured across three phases: Phase 1 (Years 1-2), Phase 2 (Years 3-5), and 2030 and Beyond. Each phase builds upon the preceding one, ensuring continuity in R&D, testbed development, standardization, IPR creation, and pilot deployments. The following sections describe each phase with detailed allocations.

Phase 1 (Years 1-2): Pre-Standardization

This phase focuses on laying the foundation for India's 6G ecosystem through multi-institutional testbeds, prototypes, and early intellectual property creation. Testbeds in this phase will include AI/ML with mMIMO, Joint Sensing and Communication (JSAC), Terahertz (THz), Non-Terrestrial Networks (NTN), Core Network, Intelligent Reflecting Surfaces (IRS), and Open RAN (ORAN). Manpower development with around 200 experts will ensure effective participation in ITU and 3GPP activities. The year-wise breakup of Phase 1 allocations is provided below:

(All figures in ₹ Cr)

Year	Testbeds, Hardware and Software	ASIC Dev	R&D	Standardization and IPR
Year 1	250	150	40	100
Year 2	400	350	60	150
Total	**650**	**500**	**100**	**250**

In this phase, emphasis will be placed on Proof of Concepts (PoCs) that are vertically aligned with national missions, such as Digital Health, AgriStack, and GatiShakti. Multi-institutional testbeds will provide the foundation for these demonstrations, enabling early validation of 6G technologies in mission-critical domains and supporting initial intellectual property creation.

Testbeds, ASIC, Hardware, and Software Development

The Testbed roadmap integrates ASIC design with hardware and software development to build end-to-end 6G platforms.

Pre-Standard Testbeds

Pre-standard testbeds will be developed in Phase 1 to validate technologies, enable shared use of expensive resources across institutions, and integrate TTDF grantees. The table below provides details on the focus area, duration, cost, and recommended participating institutions.

(All figures in ₹ Cr)

Testbed Focus Area	Duration	Costing	Recommended Participating Institutions
AI/ML with mMIMO	2 years	70	IITM, IITK, CEWiT and SAMEER
Integrated Sensing & Communication (ISAC)	2 years	40	
Non-Terrestrial Networks (NTN)	2 years	35	
Core Network	2 years	40	IITB (Partially funded by TTDF project already)
Open RAN (ORAN)	2 years	50	C-DoT
PHY layer technologies	2 years	40	
Total		**275**	

- **ASIC Development**
  - UE Development (SoC + Modem): Creation of advanced system-on-chip and modem solutions for user equipment.
  - BS ASIC Development (Processor): Development of base station processors to support high-performance 6G radio and core functions.
  - Budget: ₹500 Cr in Phase 1
- **Hardware Development**
  - Covers RF modules, including power amplifiers, low-noise amplifiers, radio frequency transceivers and ADC/DACs.
  - Budget: ₹275 Cr in Phase 1
- **Software Development**
  - Focus on protocol stack development, ensuring standards-compliant, interoperable, and secure implementations for both the Radio Access Network and the Core Network.
  - Essential for validating testbeds and enabling early sectoral pilots.
  - Budget: ₹100 Cr in Phase 1.

(All figures in ₹ Cr)

Component	Academia	Industry	Total
Layer 1 (L1)	10.5	22.5	33
Layer 2/3 (L2/L3)	10.5	22.5	33
Core Network	10.5	22.5	33

Costing Model (suggested model) :

- **Academia:** 15 members at ₹70 Lakhs per person (two years) → ₹10.5 Cr
- **Industry:** 15 members at ₹150 Lakhs per person (two years) → ₹22.5 Cr

Key Technology Focus Areas

The funding will prioritize research and testbed creation in domains that are expected to deliver globally significant innovations, IPR, and standards influence. The identified areas are:

- Massive MIMO and advanced waveforms
- Artificial Intelligence / Machine Learning for Networks
- Fixed Wireless Access (FWA)
- Vehicle-to-Everything (V2X)
- Open RAN (ORAN)
- Core Network Evolution and Positioning
- Non-Terrestrial Networks (NTN)
- Integrated Sensing and Communications (ISAC)
- IoT and Network Security
- Advanced Positioning Technologies

These focus areas will guide both testbed design and ASIC development activities, ensuring that India achieves leadership in priority 6G domains.

Budget: ₹100 Cr in **Phase 1**

The exploratory projects to be undertaken in Phase 1, providing the scientific and conceptual base for subsequent testbeds, standardization inputs, and patent generation is listed below. Each project is budgeted over a two-year period to ensure focus and measurable outputs.

(All figures in ₹ Cr)

Topics (Tentative)	No of projects	Per project Cost for 2 years	Total cost
AI/ML	10	2	20
ISAC+ positioning	5	2	10
NTN	5	2	10
Network energy saving	5	2	10
Massive MIMO (e.g., Code book design, Rx alg.)	10	2	20
Full duplex	5	2	10
DPD/CFR and Front end	5	2	10
PUSCH	5	2	10
Total	**50**		**100**

Sector-specific pilots and 6G Applications

Once the foundational R&D and interoperability activities are completed, the focus will shift to sector-specific 6G pilots covering healthcare, logistics, rural broadband, education, agriculture, and disaster response. Testbeds will evolve into fully integrated end-to-end

platforms with strong industry participation. This phase also envisages the roll-out of indigenous 6G applications over public infrastructure initiatives such as Smart Cities, BharatNet, and e-Governance, ensuring that the technology directly supports India's socio-economic priorities.

Intellectual Property and Human Capital

B6GA targets over 10,000 6G patents during the mission, supported by Patent Facilitation Centres to optimize costs and maximize SEP monetization. The human capital programme will include funding for 100 PhD students and training of 200–300 standardisation professionals to actively contribute to ITU and 3GPP. This ensures India's long-term leadership in global standardization.

The Standardization and IPR program provides structured support to academia and industry to ensure impactful contributions in ITU, 3GPP, and other global fora, while driving indigenous patent filings.

Category	Funding Model	Expected Output
Academia (75 experts)	₹75 Lakhs/person/year (salaries:25, travel:25, patents:15, overheads:10)	225 India patents + 75 US patents annually; TDOCs; Training
Industry (85 experts)	₹125 Lakhs/person/year (salaries:73, travel:25, patents:27)	425 India patents + 170 US patents annually; TDOCs; SEP focus
Total (160 experts)	Cost: 250 Cr (With cost sharing, manpower can be increased - model under discussion with DoT)	~650 India patents + ~245 US patents per year; strengthened 3GPP/ITU presence

Phase 2 (Years 3-5): Standards-Based Development

Phase 2 emphasizes scaling pre-standardization outputs into standards-based, integrated testbeds and pilot trials across sectors such as healthcare, logistics, rural broadband, education, agriculture, and disaster response. At least two integrated end-to-end testbeds will be developed under a consortium approach, with strong industry involvement and leadership by experienced institutions. Manpower will expand to about 300 experts, significantly strengthening India's representation in 3GPP and ITU. The year-wise allocation for Phase 2 is provided below:

(All figures in ₹ Cr)

Year	Testbeds, hardware and software	R&D	ASIC Dev	Standardization and IPR
Year 3	450	50	300	250
Year 4	400	50	150	250
Year 5	300	50	–	250

Total	**1150**	**150**	**450**	**750**

2030 and Beyond: PoC Trials and Commercial Readiness

The third phase will focus on large-scale Proof-of-Concept trials and commercialization readiness. By this stage, indigenous 6G technologies will be deployed in medium-to-large scale pilots, with strong emphasis on applications aligned with India's development priorities. This phase is shown only as a consolidated allocation to allow flexibility in implementation.

(All figures in ₹ Cr)

Phase	Prototypes/Trials	Standardization	IPR	Total
2030+	2300	300	400	3000

Precursor to Phase 1 (Initial preparatory period prior to programme commencement)

In view of the rapid developments underway in global standardization bodies such as 3GPP and the ITU, a short preparatory phase is proposed as a precursor to Phase 1 of the Bharat 6G programme. This phase will enable India's timely and effective participation in ongoing study items and working group discussions related to IMT-2030 and 3GPP Release 21.

The activities under Phase 0 will focus on mobilizing a limited number of institutions that already possess familiarity with 3GPP and ITU processes. These institutions—comprising a balanced mix of academic, research, and industry partners—will initiate tangible contributions such as TDoc (submission of technical documents), patent filings, and Standard Essential Patent (SEP) identification. The work will also include aligning India-specific technology propositions with global 6G study items, identifying gaps for pre-standardization research, and creating draft specifications and use-case inputs for 3GPP and ITU.

Approximately 8–10 organizations (equally distributed between academia and industry) are envisaged to participate, with about five persons per institution. The total manpower would thus be around 40 (20 academic + 20 industry). The indicative budget for this phase is ₹13 crore, calculated as follows:

Academic staff: ₹25 lakh × 20 = ₹5 crore

Industry staff: ₹40 lakh × 20 = ₹8 crore

Total: ₹13 crore

The targets for this short period include (a) submission of a defined number of TDocs to 3GPP and ITU study groups, and (b) generation of at least two patent filings per person in priority 6G domains. This precursor phase will ensure continuity between the ongoing national R&D initiatives and the formal launch of Phase 1 upon programme approval, thereby securing India's early visibility and influence in global 6G standardization activities.

9.2 Cost-Benefit Analysis

The projected investment of ₹7,000 Cr is expected to yield transformative returns in the form of:

- Cumulative filing of 10,000+ 6G patents by 2030, including Standard Essential Patents (SEPs).
- 500+ high-quality research papers
- international recognition of India's 6G leadership
- indigenous products and services ready for commercialization and
- socio-economic benefits across healthcare, agriculture, logistics, and education.

9.3 Risk Analysis and Mitigation

Key risks include potential delays in global standardization, limited industry adoption, and high patenting costs. These will be mitigated through strong government-industry partnerships, early pilot trials, diversified patenting strategies, and industry co-funding mechanisms.

9.4 Financial and Environmental Sustainability

Beyond government funding, sustainability will be ensured through industry co-funding, SEP licensing revenues, and export of indigenous 6G solutions. Equally important, 6G research will integrate energy-efficient designs and contribute to India's climate commitments, ensuring that 6G becomes a green and inclusive technology.

9.5 Proposed Execution Model

As detailed in the earlier chapter, the Bharat 6G Alliance will adopt a Hub-and-Spoke execution model:

- **Hubs (Anchor Institutions):** Lead R&D, manage testbeds, coordinate standardization inputs.
- **Spokes (Partner Institutions):** Conduct domain-specific research, prototype development, and trial participation.
- **Industry & Telecom Service Providers:** Provide market relevance, deployment expertise, and co-funding.

This structure ensures both depth in research and breadth of participation across academia, startups, and MSMEs.

10.0 Monitoring and Evaluation

A robust Monitoring and Evaluation (M&E) framework is essential to ensure accountability, transparency, and measurable outcomes for the Bharat 6G programme. The Department of Telecommunications (DoT), as the funding and monitoring authority, will directly oversee implementing institutions through its established mechanisms. The Bharat 6G Alliance (B6GA) will play a supporting role - defining requirements, recommending the hub-and-spoke model, facilitating identification of capable institutions, and participating in DoT's monitoring process.

10.1 Objectives of the M&E Framework

- **Accountability:** Ensure that public resources are effectively utilized by implementing institutions under DoT's oversight.
- **Transparency:** Provide structured reporting directly to DoT, with B6GA ecosystem inputs integrated as advisory.
- **Performance Measurement:** Track key indicators such as patents, standards contributions, testbeds, and pilots.
- **Course Correction:** Allow timely adjustments based on DoT-led evaluations, with B6GA providing facilitation.
- **Impact Assessment:** Measure outcomes in terms of technology leadership, industry growth, and societal impact.

10.2 Monitoring Mechanisms

- **DoT-Led Milestone Reviews:** Quarterly and annual reviews of implementing institutions against agreed milestones (testbeds, prototypes, IPR filings, manpower deployment).
- **Institutional Reporting:** Hubs and spokes submit structured technical and financial reports directly to DoT.
- **B6GA Inputs:** B6GA consolidates Working Group perspectives and shares ecosystem observations for DoT's monitoring process.
- **Steering Committee Participation:** DoT will chair half-yearly reviews, with B6GA leadership participating.
- **Independent Audits:** DoT will commission periodic third-party audits to validate achievements and fund utilization.

10.3 Evaluation Framework

- **Mid-Term Evaluation (during programme lifecycle):** DoT evaluates Phase I outcomes - testbed readiness, early IPR filings, spectrum preparedness for WRC-27, manpower in 3GPP/ITU.
- **Final Evaluation (at programme completion):** DoT assesses cumulative achievements across Phases I & II, readiness for PoC trials, and India's global 6G standing.

- **Post-2030 Evaluation:** Focus on commercialization readiness, SEP monetization, and societal impact.

10.4 Key Performance Indicators (KPIs)

KPIs will be defined and tracked by DoT, with B6GA providing facilitation:

- **Technology Development:** Operational testbeds, prototypes, TRL levels.
- **Standards & IPR:** Patents filed, SEPs declared, 3GPP/ITU contributions.
- **Human Capital:** PhD scholars supported, training programmes, standardization experts deployed.
- **Industry & Startups:** Participation in pilots, ASICs and devices developed, commercialization readiness.
- **Societal Impact:** Pilots in healthcare, agriculture, education, disaster management, and bridging the digital divide.
- **Sustainability:** Green telecom practices, energy efficiency, and circular economy metrics.

10.5 Reporting and Dissemination

- **DoT Progress Reports:** Implementing institutions provide quarterly reports to DoT.
- **Annual Reviews:** DoT issues consolidated progress reports, integrating B6GA's observations.
- **Public Dashboards:** Select KPIs published for public awareness.
- **Global Dissemination:** DoT and B6GA jointly highlight achievements in ITU, 3GPP, and global alliances.

10.6 Risk Mitigation through M&E

- **Early Warning Indicators:** DoT's dashboards flag delays or underperformance.
- **Adaptive Planning:** DoT reallocates resources or adjusts timelines; B6GA facilitates coordination.
- **Policy Feedback Loop:** Monitoring insights feed into spectrum policy, IPR facilitation, and capacity building.

The M&E framework reflects that DoT is the central authority for both funding and monitoring. Implementing institutions are directly accountable to DoT, while B6GA provides strategic recommendations, facilitates institutional engagement, and participates in DoT-led monitoring processes. This structure ensures transparency, accountability, and adaptability, aligning the 6G programme with India's national objectives and global leadership ambitions.

10.7 Economic Rationale, Return on Investment, and Deployment Outcomes

The Bharat 6G programme is positioned not only as a research and innovation initiative but as a strategic national investment aimed at generating measurable economic returns, strengthening domestic capabilities and enabling global competitiveness.

Global experience indicates that next-generation telecom technologies represent a multi-trillion-dollar economic opportunity, driven by large-scale investments in network infrastructure, devices, applications, and digital services. The mobile ecosystem alone contributes over USD 5 trillion annually to global GDP and is expected to grow further over the coming decade. Telecom operators are expected to invest approximately USD 1 trillion in network infrastructure between 2023 and 2030, underscoring the scale of opportunity across the telecom value chain.

India's participation in this opportunity can yield substantial economic value through a combination of domestic deployment, export of products and solutions, and participation in global value chains. Even a modest participation of 5–10% in emerging 6G and associated technology markets can translate into an economic value of the order of ₹1–2 lakh crore over time, depending on the pace of adoption and ecosystem development.

The proposed initiatives under the Bharat 6G programme—including testbeds, research platforms, and ecosystem development activities—are therefore designed to deliver outcomes beyond research publications and prototypes. The focus is on enabling:

- Conversion of research outputs and intellectual property into deployable products and solutions, including network elements, platforms, and applications
- Development of indigenous technologies and solutions across the 6G stack, including radio, core, devices, and software systems
- Creation of globally competitive startups and industry players, particularly in emerging areas such as Open RAN, AI-native networks, non-terrestrial networks, and advanced applications
- Facilitation of commercial deployment and adoption of developed solutions by telecom operators and enterprises
- Export of telecom products, platforms, and services, contributing to India's participation in global telecom markets

The testbeds and collaborative platforms proposed under this programme play a critical role in this transition by providing system-level validation, interoperability testing, and pre-standardization environments, which are essential for moving from research to real-world deployment.

In addition to direct economic value generation, the programme is expected to result in:

- Reduction in network deployment and upgrade costs, including through adoption of disaggregated and software-driven architectures
- Strengthening of domestic manufacturing and design capabilities, aligned with national initiatives such as *Make in India* and *Atmanirbhar Bharat*
- Enhanced participation of startups and MSMEs in the telecom ecosystem
- Increased contribution of India to global standards and technology development

The return on investment from the Bharat 6G programme should therefore be assessed not only in terms of immediate financial returns but also in terms of long-term strategic gains, including technology leadership, ecosystem development, and global market participation.

To ensure that these outcomes are realized, proposals and programme activities will incorporate clear pathways for productization, deployment, and commercialization, along with measurable indicators such as:

- Number of technologies transitioned from lab to field deployment
- Number of products and platforms commercialized
- Participation of industry and startups in development and deployment
- Contribution to standards and intellectual property generation
- Export potential and market adoption of developed solutions

This outcome-oriented approach will ensure that the Bharat 6G programme delivers tangible economic and strategic benefits to the country, aligned with national priorities and global opportunities.

11.0 Expected Outcomes

The Bharat 6G Roadmap DPR is designed to deliver measurable outcomes that position India as a global leader in the next generation of telecommunications. These outcomes span technology development, global standards, intellectual property, industry growth, and societal impact. They serve as benchmarks for evaluating the success of investments made by the Government of India and the collective effort of stakeholders under the Bharat 6G Alliance (B6GA).

11.1 Technology Development and Deployment

- **Multi-Institutional Testbeds:** Establishment of pre-standard testbeds (Phase 1) and fully integrated standards-compliant testbeds (Phase 2), scaling to large-scale proof-of-concept (PoC) deployments by 2030.
- **Prototypes and Pilots:** Development of indigenous prototypes across AI/ML, NTN, ISAC, ORAN, and Core network domains; execution of pilots in healthcare, education, agriculture, logistics, rural broadband, and disaster response.
- **ASICs and Devices:** Indigenous development of 6G-ready ASICs, chipsets, sensors, and devices for domestic and export markets.
- **Commercial Readiness:** Demonstration of 6G solutions at TRL 7/8/9, ready for nationwide rollout and global deployment.

11.2 Standards Contributions and Intellectual Property

- **Patent Filings:** Cumulative filing of 10,000+ 6G patents by 2030, including Standard Essential Patents (SEPs).
- **Global Standards Leadership:** Significant Indian contributions to 3GPP Release 20/21 and ITU IMT-2030 specifications.
- **Patent Facilitation Centres:** Optimized filings and monetization of SEPs, positioning India as a technology exporter.
- **10% Global Share of 6G patents:** Facilitating the national target to secure a competitive and influential role in global 6G markets.

11.3 Industry and Strategic Sector Benefits

- **Startup and MSME Participation:** Active involvement of startups, MSMEs, and academia in the 6G value chain through testbeds, pilots, and commercialization support.
- **Make-in-India Ecosystem:** Strengthened domestic semiconductor, device, and telecom manufacturing capacity aligned with Production-Linked Incentive (PLI) schemes.
- **Export-Ready Solutions:** Indigenous 6G products and platforms developed for global markets, especially the Global South.

- **Strategic Sector Applications:** Deployment of India-specific applications in healthcare, agriculture, education, disaster management, logistics, and public safety, enhancing resilience and national competitiveness.

11.4 Human Capital and Ecosystem Growth

- **Skilled Workforce:** In the period 2026-20230, Development of 100+ PhD scholars, 500+ research papers, 200+ academic patents annually, and a pipeline of 200–300 trained standardization experts.
- **Knowledge Economy:** Strengthening of India's R&D ecosystem with multi-disciplinary centres of excellence in priority areas such as AI/ML, NTN, ISAC, and semiconductor design.
- **Entrepreneurship:** Promotion of indigenous startups, fostering a vibrant innovation ecosystem in telecom and adjacent domains.

11.5 Societal Impact and Global Alignment

- **Bridging the Digital Divide:** Affordable and inclusive connectivity solutions targeting underserved and rural populations.
- **Alignment with SDGs:** Contributions to SDG 9 (Industry, Innovation, Infrastructure), SDG 10 (Reduced Inequalities), and SDG 13 (Climate Action).
- **Sustainability:** Adoption of energy-efficient networks, circular economy practices, and green telecom metrics.
- **Global Recognition:** Prominent showcasing of India-specific innovations at international platforms such as ITU Plenipotentiary 2030 and global 6G alliances.

The Bharat 6G Roadmap DPR will deliver not only technological advancements but also broad-based economic and societal gains. By 2030, India is expected to emerge as a standards shaper, technology exporter, and innovation hub, with measurable contributions to global standards, intellectual property, and sustainable development. These outcomes ensure that this Roadmap DPR provides high returns on public investment while positioning India at the forefront of the global 6G era.

Appendices

Technology Matrix for Hubs and Spokes †

Hub Institutions

Technology Hub Institute	Massive MIMO (256 Tx +256 Rx)	AI/ML	NTN	FWA (mm Wave)	ISAC + Positioning	PHY layer technologies	ORAN	RAN L2 + L3	Core Network
IIT Kanpur									
IIT Madras									
IIT Hyderabad									
CeWiT									
IIT Bombay									
SAMEER									
CDOT									
IISc									
IIT Kharagpur									
Tejas Networks									
WiSig									
Lekha Wireless									
Reliance Jio									
Airtel									
Tech Mahindra									
IIT Roorkee									
IIIT Delhi									
IIT Dharwad									
IIT Jodhpur									
IIST									
HFCL									
CDAC									
Ramanujan College Delhi University									

VNIT Nagpur									
XIUS									

Spoke Institutions

Technology Spoke Institute	Massive MIMO (256 Tx +256 Rx)	AI/ML	NTN	FWA (mm Wave)	ISAC + Positioning	PHY layer technologies	ORAN	RAN L2 + L3	Core Network
IIT Patna	✔	✔		✔	✔	✔	✔	✔	
TechPhosis, Gurgaon		✔	✔		✔		✔	✔	✔
IIIT Naya Raipur		✔	✔		✔	✔			
IISER , Kerala		✔			✔				
IIT Tirupati	✔						✔		
IIT Indore	✔	✔	✔	✔	✔	✔	✔	✔	✔
Rohde & Schwarz India Pvt Ltd	✔	✔	✔	✔	✔	✔	✔	✔	
SIT Pune		✔						✔	
Coral Telecom									✔

† The Hub and Spoke institutions listed are based on responses to an Expression of Interest (EoI) call to B6GA members and represent indicative expressions of interest only. No evaluation or selection has been undertaken by B6GA.

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