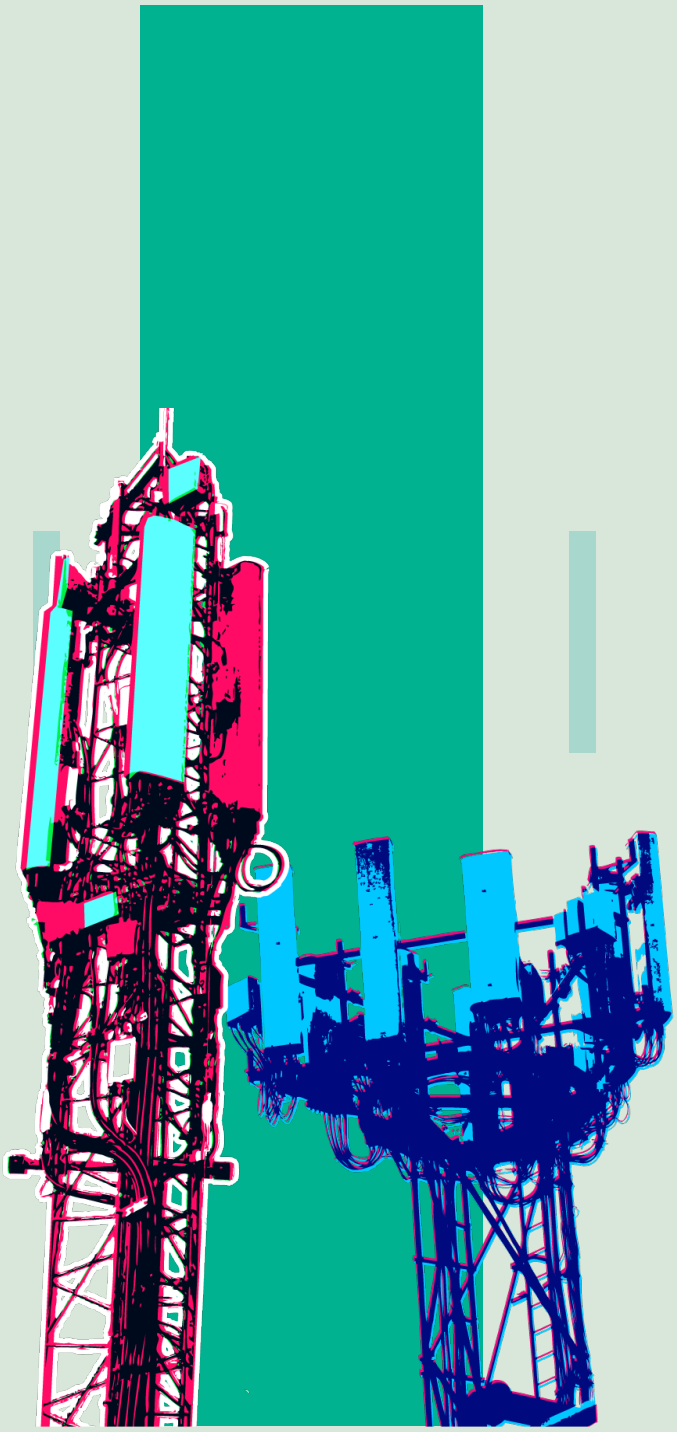
WHITE PAPER



PRIVATE 5G DEPLOYMENT MODELS FOR ENTERPRISES

The acceptance of 5G technology has become increasingly popular among enterprises, as it offers enhanced speeds, lower latency, and increased capacity compared to previous generations of wireless network 4G/LTE. This has led to the growth of private 5G networks, allowing enterprises to deploy dedicated/shared and secure networks for specific use cases.

This paper assesses the different available private 5G deployment models from an applicability, suitability and sustainability perspective for various industry segments, along with the associated pros and cons.

Further, we look at a recommendation of appropriate private 5G deployment models for relevant industry segments that System Integrators can implement. Through its alliance ecosystem of OEM and vendor partnerships, IP solutions and MNO alliances, Infosys can help enterprises implement a bespoke private 5G deployment.

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Introduction

One of the most promising opportunities in the wireless communications field is the combination of cellular 3GPP and non-cellular technologies to enhance the capabilities of enterprise and private non-public networks. 3GPP release 16 specifications introduce support for non-public networks (NPN) where a private enterprise or government may deploy a non-public network for industrial use cases. In addition, the favorable regulations and policies that allow for more spectrum and licensing options have enabled the integration of cellular technologies and spectrum into non-public networks.

The private 5G network, also termed NPN by 3GPP, will play a critical enabling role in digital transformation in various industry sectors like utility and energy, agriculture, retail, healthcare, transportation and manufacturing, and industry 4.0.

There are mainly six key solution enablers for the success of private 5G network deployment:

1. **Diverse spectrum** – diverse spectrum, including licensed, unlicensed and shared spectrum options with low, mid and high frequency bands, play a critical role in supporting key KPI requirements like latency, throughput, reliability, and availability
2. **Deterministic Transport Network** – the data plane network layer must be able to handle deterministic QoS sensitive traffic to implement URLLC use cases. Deterministic network technologies like TSN (Time sensitive network), layer 2 and DetNet (L3) help in realizing this requirement
3. **Open-RAN** – the adoption of O-RAN for standardized, customizable, secure, vendor-agnostic, network-agile and cost-effective deployments
4. **Edge Computing** – Multi-access Edge Computing (MEC) brings computing and storage closer to the end user, reducing latency and improving the user experience. It enables low-latency processing of data generated by IoT devices and supports new use cases like augmented and virtual reality applications, industrial automation and autonomous vehicles
5. **Positioning** – enables the network to determine the geographic position and, optionally, the velocity of the User Equipment (UE), especially those important to enabling manufacturing automation use cases like Augmented Reality (AR) applications, motion control and Automated Guided Vehicles (AGVs) in factories
6. **Security** – advanced security mechanisms are required to provide solutions related to device-to-network communications, which include device authentication and credentials management, end-to-end traffic integrity and encryption (both at user and control plane levels).

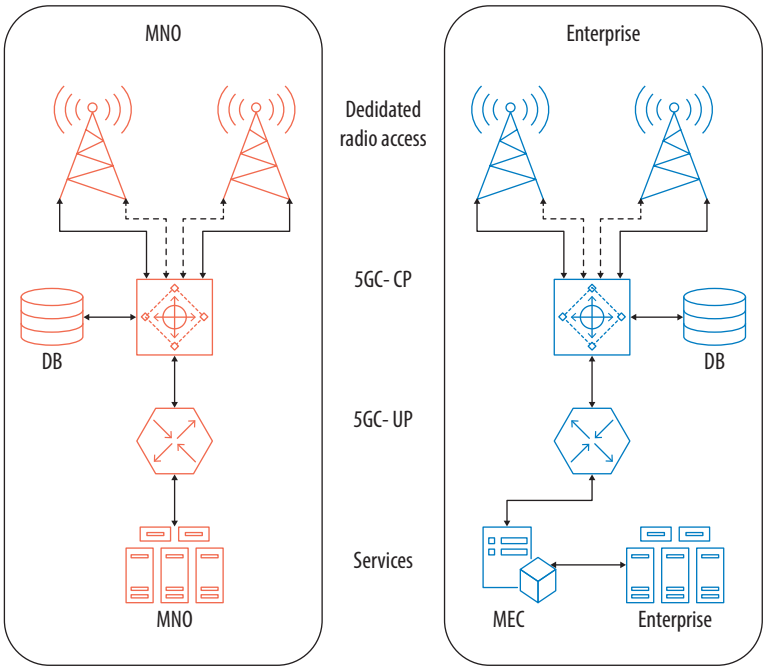
There are mainly two possible types of deploying a 5G NPN:

1. **Standalone Non-Public Network (SNPN)**, which is not dependent on any mobile operator or PLMN
2. **Public Network Integrated-Non-Public Network (PNI-NPN)** is deployed by sharing the resources of the mobile operator or PLMN.

Standalone (SNPN)

A standalone NPN is a completely independent network not connected to any public 5G network. This deployment model provides the highest level of security and control but requires a separate infrastructure and radio access network.

Figure 1: Standalone NPN

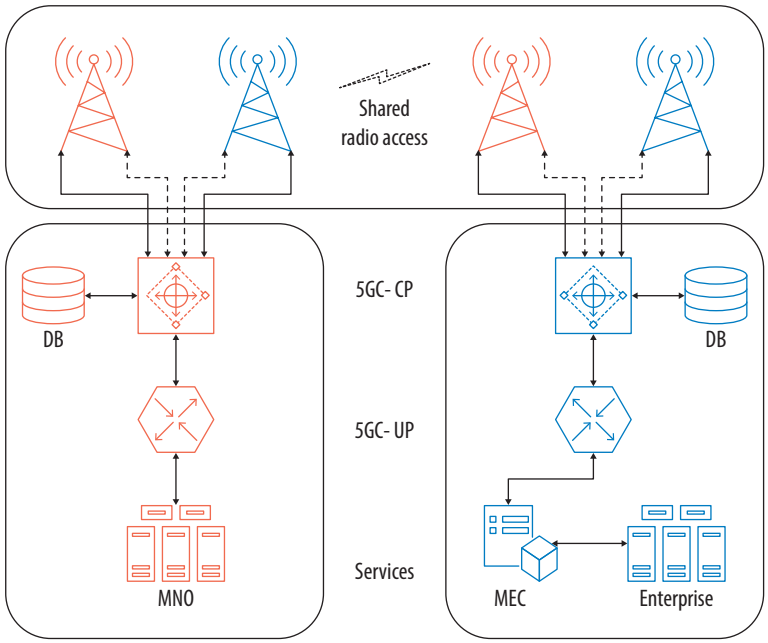


- Complete isolation from public network
- Data stored locally
- Data is highly secure
- Full control with enterprise
- Ultra-low latency due to the proximity of all components
- No monthly recurring charges to MNO if subscribed for unlicensed spectrum
- High capex toward hardware
- May be affected by interference in the case of unlicensed spectrum
- Skilled resources required for network maintenance
- UPF and MEC are located within the enterprise for supporting Edge applications that require URLLC

Public network integrated (PNI) NPN:

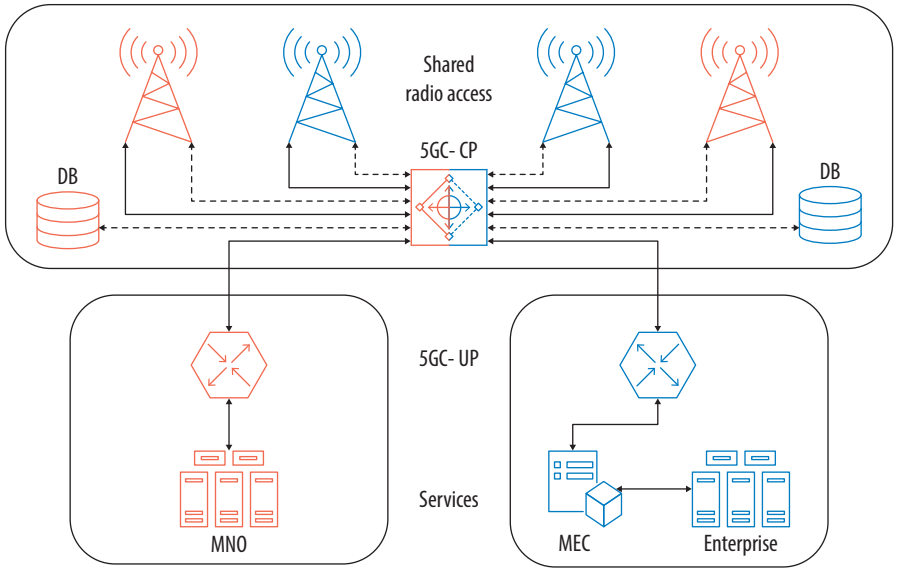
This is a non-public network deployed with the support of a PLMN. This deployment model provides a lower level of security and control than a standalone NPN but requires less infrastructure and can be deployed more quickly.

Figure 2: PNI NPN – RAN sharing



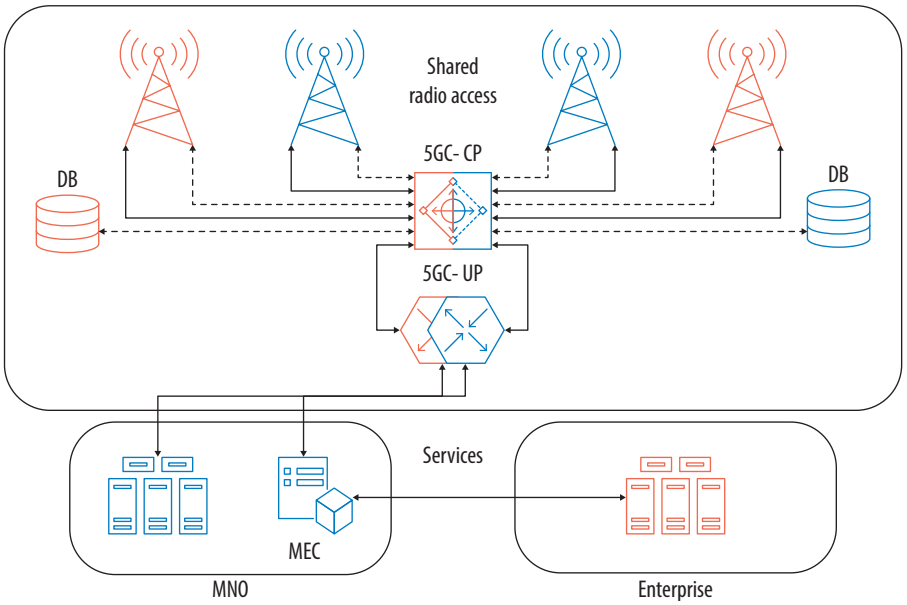
- Complete isolation from public network
- Data stored locally
- Data is highly secure
- Full control with enterprise on Data & Control plane
- Ultra-low latency due to the proximity of all components
- Recurring charges to MNO for licensed spectrum
- High capex toward hardware and spectrum fee
- Less prone to interference owing to licensed spectrum
- Skilled resources required for network maintenance
- UPF and MEC are located within the enterprise for supporting Edge applications that require URLLC

Figure 3: PNI NPN - RAN + Control Plane Sharing



- Not complete isolation from public network
- Data stored locally
- Data is highly secure
- No control with enterprise for control plane
- Ultra-low latency due to the proximity of all components
- Monthly recurring charges to MNO for licensed spectrum and services
- Network maintenance by MNO with SLA in place
- Comparatively less capex towards hardware and spectrum fee for enterprise
- The case of licensed spectrum
- Skilled resources required for network maintenance
- UPF and MEC are located within the enterprise for supporting Edge applications that require URLLC

Figure 4: PNI NPN – E2E Network Slice Sharing



- Logical isolation from public network
- Data stored in MNO Database
- Data is comparatively less secure as subscriber information is hosted on MNO network
- No control with enterprise for the control and the data planes
- Moderate or high latency based on UPF placement by MNO (edge or core)
- Monthly recurring charges to MNO for E2E services
- Network maintenance by MNO with SLA in place
- Capex is very low
- 2 Network Slices defined by MNO – one for Public services & 1 for Edge applications
- Less prone to interference in the case of licensed spectrum
- Reduced wiring and physical devices on the factory floor due to high capacity, reachability
- Skilled resources required for network maintenance for L1 troubleshooting

Pros and cons of the deployment models

For each deployment option, we discuss the pros and cons:

Table 1: Pros and cons of the deployment models

Deployment Type	Deployment Sub-Type	Summary	Pros	Cons
SNPN -physically isolated private 5G network	Standalone mode (SNPN	Enterprise controlled 5G network full set (gNB, UPF, 5GC CP, UDM, MEC) within its premise	• Low Opex • Privacy and security • Ultra-low latency • Scalable on demand as per enterprise needs	• High Capex • Fully independent and isolated spectrum, with no access to mobile operators' licensed spectrum • Need skilled engineering team
	PNI-NPN RAN sharing	• Shared responsibility model - UPF, 5GC CP, UDM, and MEC are deployed in the enterprise and physically separated from the PLMN. • gNB within the enterprise is shared between private and PLMN	• Low Capex • Access to Local 5G (e.g., CBRS) and operator licensed spectrum • In-house management of subscription, operations and security • Ultra-low delay between device - gNB-UPF-MEC	• High Opex • Enterprise base stations support 'operators' public devices also and may cause security concerns to enterprise authorities • Dependence on the mobile operator for scalability
PNI-NPN - Private 5G networks sharing the mobile operator's public 5G network resources	PNI-NPN RAN and control plane sharing	• Private and dedicated UPF, MEC in enterprise • 5G gNBs in enterprise • 5GC CPs and UDMs in operator's edge cloud shared (control plane sharing)	• Low Capex • Access to Local 5G (e.g., CBRS) and operator licensed spectrum • Ultra-low delay communication between device-gNB- UPF-MEC	• Management of subscription information in the mobile operator's network • Dependence on the mobile operator for scalability
	PNI-NPN E2E network slice sharing	• gNB is deployed inside the enterprise. • UPF and MEC exist only in the mobile operator's cloud.	• Least capex costs to build a private 5G network compared to other cases • Access to mobile operator licensed spectrum only	• Potential network latency • Traffic transferred to the operator's network • Dependence on the mobile operator for scalability

Who will benefit from Private 5G, and where can it be deployed?

Infosys works closely with many enterprises across industries through our global engagements in IT, networks and solution development. Based on our knowledge, expertise, and experience, we have assessed the industry-specific needs for Private 5G for which appropriate models are relevant. Our recommendations are shown in Table 2.

Table 2: Suitable NPN models of deployment for specific industry segments, along with the key parameters

	Suitable Private 5G/NPN Deployment		Key parameters					
			Secure	Reliable	Cost effective	Scalable	Large coverage	Ultra low latency
Manufacturing	ON PREM, OFF PREM	SNPN	✓	✓		✓		
Public transport	OFF PREM	E2E Network Slice Sharing PNI NPN		✓	✓		✓	✓
Financial services	ON PREM, OFF PREM	RAN Sharing PNI NPN	✓	✓	✓		✓	✓
Healthcare	ON PREM	SNPN	✓	✓		✓		✓
Mining	ON PREM	SNPN	✓	✓		✓		
Automobile	ON PREM, OFF PREM	RAN & Control Plane	✓	✓	✓		✓	
Retail	ON PREM, OFF PREM	RAN Sharing PNI NPN	✓	✓	✓		✓	
Media & entertainment	OFF PREM	E2E Network Slice Sharing PNI NPN	✓	✓	✓			
Agriculture	ON PREM, OFF PREM	RAN & Control Plane Sharing PNI NPN	✓	✓	✓		✓	
Energy & utilities	ON PREM, OFF PREM	RAN & Control Plane Sharing PNI NPN	✓	✓	✓		✓	✓
Public safety & smart cities	OFF PREM	E2E Network Slice Sharing PNI NPN	✓	✓			✓	✓
Food industry	ON PREM, OFF PREM	RAN Sharing PNI NPN	✓	✓	✓		✓	✓
Oil & gas	OFF PREM	SNPN	✓	✓		✓		✓
It offices, parks	OFF PREM	E2E Network Slice Sharing PNI NPN	✓	✓	✓			
Gaming &gambling	OFF PREM	E2E Network Slice Sharing PNI NPN	✓	✓	✓		✓	
Warehouses & logistics	ON PREM	SNPN	✓	✓		✓		

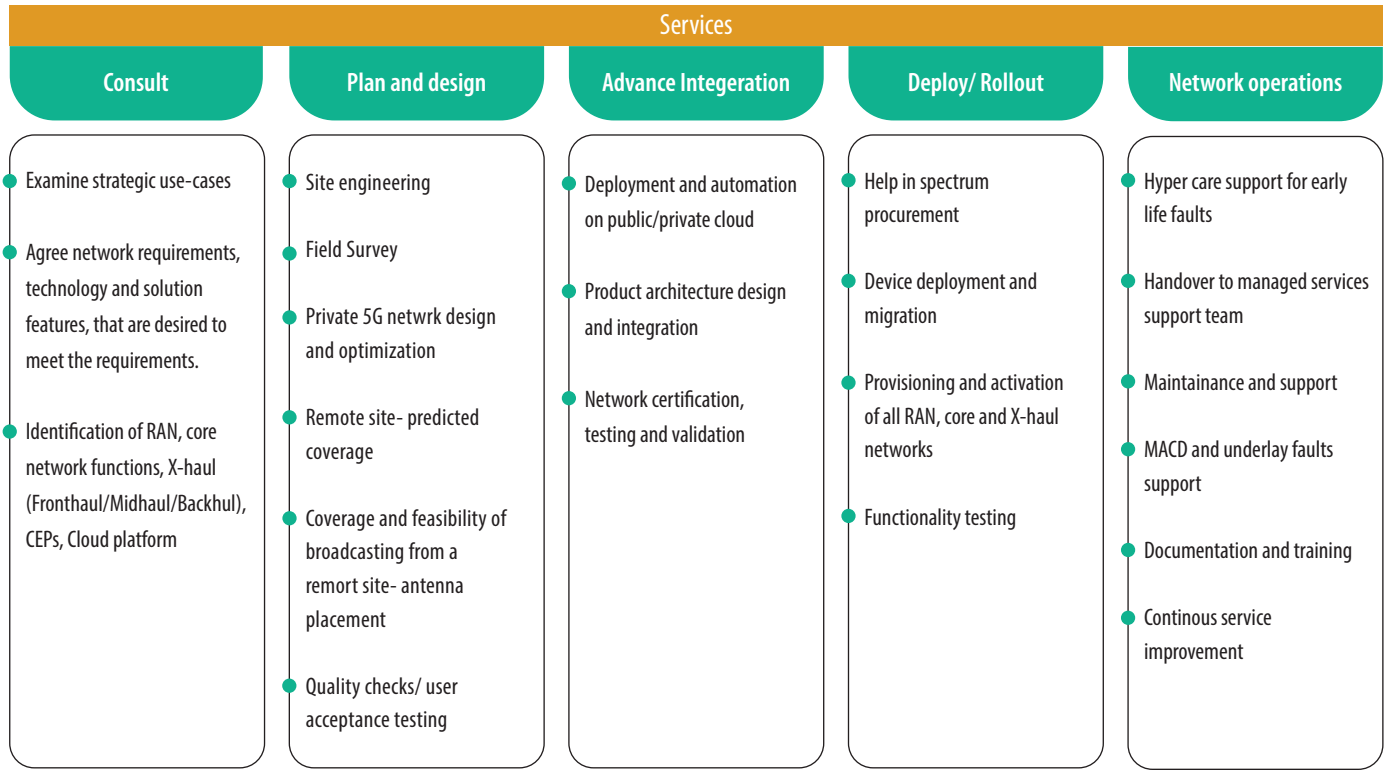
How can System Integrators (SIs) support enterprises with Private 5G implementation?

With enterprises transforming their network and connectivity requirements, Private 5G networks have developed as the preferred option for supporting a wide variety of their use cases more efficiently and by ensuring lower latency, greater security and higher reliability. Furthermore, the predictions for enterprises looking to deploy private 5G wireless networks easily and cost-effectively have improved significantly due to the conjunction of several features - spectrum sharing via CBRS in the US, the development of 5G standards and technology, an Open RAN and core network components.

While the challenges and intricacies of deploying and operating a private 5G wireless network can overwhelm, a developing ecosystem of OEM vendors, software providers and systems integrators makes the task possible.

The role of the SI integrates all building blocks of Private 5G and helps enterprises across all phases of deploying Private 5G NPN networks.

These SIs enable enterprises through consulting, planning and designing, advanced integration, deployment and network operations.



How can Infosys support enterprises with Private 5G implementation?

While enterprises face new challenges with their disaggregated architecture, Infosys as a SI can play a vital role in end-to-end solutioning to fast-track Private 5G NPN deployments.

There are mainly three challenges for SIs as they implement Private 5G NPN networks.

- Multi-vendor environment
- Ensuring guaranteed carrier-grade service
- Integration with new-age vendor solutions

Infosys can help enterprises overcome these challenges through the following credentials:

- **Multi-vendor environment**
  - We have a strong ecosystem of OEM vendors, cloud solution providers, 5G RAN and core device partners and bring in knowledge garnered through our global experience
  - Private 5G NPN is integrated into Infosys 5G Living Labs to validate the end-to-end solution. This will help reduce the certification cycle of chosen network & Vendor partners by the enterprise
- **Ensuring guaranteed carrier-grade service**
  - Infosys has built several IPs and tools for Private 5G NPN Management and AI-enable assurance solutions to monitor the service to ensure a carrier-grade experience
- **Integration with new-age Vendor solutions**

We have created an ecosystem of new-age OEMs and vendor solutions through the Infosys alliance channel.

Infosys solution offerings and tools that can be customized for Private 5G deployments.

Table 3 provides an overview of Infosys solution offerings and tools that can be customized for Private 5G NPN deployments.

Table 3: Infosys solution offerings & tools

Infosys IPs/Tools	Brief description of functionality
Infosys Private Network Management (IPNM)	Single pane of glass for managing private 5G networks
Radio Planner	Tool for 5G radio planning for millimeter wave spectrum (FR2)
Infosys 5G Slice Designer	Granular network slice management solution for 5G networks
Infosys Network Controller (INeC)	SDN controller, based on a hardened version of ONOS, used for network function configuration
Infosys Virtual Network Infra Platform (IvNET)	A CaaS platform for 5G network workloads
Infosys Active Inventory	TMF Open API based resource and service inventory solution supports real-time search operations with huge data volume and has ML enabled data analysis for 5G networks
Infosys Network Function Automation (INFA)	Automated VNF onboarding solution
Infosys 5G Network Security	Lightweight and vendor agnostic solution for detection, prevention, and mitigation of security threats to 5G virtual network functions
Infosys Smart Network Assurance (ISNA)	ML driven closed loop assurance solution that can be utilized for 5G network monitoring
Infosys Edge Application management (IEAM)	For the user to deploy an application on edge cloud

Infosys strong partnership ecosystem in 5G RAN and Core.

Infosys has a well-established ecosystem of

- OEM partners (RAN, Core)
- Cloud Providers (AWS, Azure)
- Field Services Engineering
- Devices

This ecosystem has uniquely positioned Infosys in these ways:

- Capitalize on Infosys 5G Global Living Labs to develop prototypes for bespoke Private 5G solutions based on the device of choice for enterprises
- Certification of devices

Benefits of going with Infosys

- **Reduced TCO**
  - Ready to use customizable E2E Private 5G Network Management Platform
  - Advance enterprise's Private 5G digital transformation footprint to reduce TCO
- **Flexibility**
  - Lego block architecture allows the mix and match of vendors through a partner ecosystem
  - As-a-service model construct
  - Bespoke solutions for industry segment alignment
  - Solutions for any-size deployment
  - Options for cloud/on-premise deployments
- **User Satisfaction Index**
  - Integrating newer technologies into the ecosystem to enhance enterprise experiences

Conclusion

Private 5G networks offer numerous benefits for enterprises, such as increased network capacity, improved coverage and enhanced security. There are several models for deployment, including in-house deployment, co-creation with network operators and the use of managed service providers. Each model has its advantages and disadvantages, and the choice of the best deployment model will depend on the specific requirements and resources of the enterprise. Therefore, it is crucial for enterprises to carefully evaluate their needs and work closely with the right partners to ensure the successful deployment and implementation of private 5G networks.

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