White Paper

Private 5G: Empowering Digitalization for Enterprise and Industrial Organizations

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IN THIS PAPER

This paper offers a current and pragmatic examination of the private 5G market and covers how private 5G can be used to help drive digital transformation (DX), which includes subconcepts such as "digitalization." In addition, this paper seeks to inform and provide answers to key questions including:

- What is the private 5G value proposition, and how does that intersect with DX?
- What are the components that make up the private 5G solution, and how do those components interact to create value?
- What can private 5G provide today, and how will it evolve over time?
- What are the key use cases within select verticals that private 5G is best positioned to address?
- How can organizations optimally address implementation and consumption of private 5G through a fast-developing set of channels/suppliers?
- How should we think of private 5G in an already rich world of enterprise network solutions?

EXECUTIVE SUMMARY

IDC defines digital transformation as the act of transforming an organization into one that can scale all or part of its business and innovate at a pace that is an order of magnitude greater than traditional businesses. Indeed, while the definition is broad, this concept is applicable across nearly all enterprise and industrial organizations today as they explore ways to migrate to digital technologies, innovate faster, enhance reliability and resiliency, and improve customer experience.

If DX is a broader, outcomes-based interpretation, digitalization can be thought of as the ability to define projects within an organization to achieve transformation including process automation, movement to platform-based offerings, or simply adoption of a new digital technology.

As such, to accomplish the broader goals of DX and support digitalization projects, organizations expect network connectivity to play a larger role. Amid this backdrop, private 5G is fast emerging as a new way to reliably connect, manage, secure, and control end devices and IoT endpoints across the organizational footprint.

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Private 5G: What Is It and What Should Enterprises Consider?

IDC defines the broader private cellular network (PCN) infrastructure market (e.g., 5G and LTE) as:

> Any 3GPP-based cellular network deployed for a specific enterprise/industry vertical customer that provides dedicated access to private resources. This could include dedicated spectrum and dedicated hardware and software infrastructure that have the ability to support a range of use cases spanning fixed wireless access, traditional and enhanced mobile broadband, IoT endpoints/sensors, and ultrareliable, low-latency applications.

As previously noted, while this paper generally highlights many of the key enhancements that 5G networks offer, private LTE/4G has already been deployed globally across many verticals. For the most part, private LTE/4G is leveraged as a dedicated wide area network (WAN) solution, providing mobile broadband connectivity across large, distributed, or remote operations. However, with the advent of 5G, new features and enhancements will expand the value of what private cellular networks can support, including an additional focus on deploying private 5G as a LAN solution for industrial IoT use cases.

While the key features of what private cellular network infrastructure can provide are included in the definition, another key characteristic is the deployment of a "dedicated" or private solution set for enterprise consumption. This also implies enterprise-grade tools that enable a customized, form-fitted connectivity solution, apart from some of the generalized, or "one-size-fits-all," telecom offerings delivered over the past decade. For reference, expected features and tools commonly present in today's enterprise network space, and which we expect will help further define private 5G solutions going forward, include the following:

- **Unified service management:** Unified service management includes the ability of an organization to view the network, and service, through a single-pane model, which includes the unified life-cycle management of the service spanning device, network, and policy. This could include a single-pane model to run multiple access networks (e.g., LTE/5G, Wi-Fi 6) simultaneously.
- **Advanced policy management:** Advanced policy management includes the ability to define security, device, or network policy, which dictates how devices act as they interact with both public and/or private networks; how data is circulated, compiled, and processed within a network; and what functions the device performs under specific circumstances.
- **Flexible consumption model:** Many traditional telecom products have been sold through a capex-based model, while today's enterprise network space is beginning to see the shift to a network-as-a-service (NaaS), consumption-based approach. As such, private 5G solutions should be available in multiple consumption models that can fulfill the needs of different enterprises.
- **Optimized form factor:** Enterprises expect many of 5G's components, including the radio access network (RAN), packet core, transport, and edge servers, to be "downsized" for private enterprise use, as opposed to use in a large-scale, public 5G network for consumers and businesses.
- **Seamless enterprise integration:** Enterprises expect that private LTE/5G networks are not deployed in silos, or as a pure overlay, but rather can be integrated into the existing enterprise infrastructure to support capabilities such as unified identity.

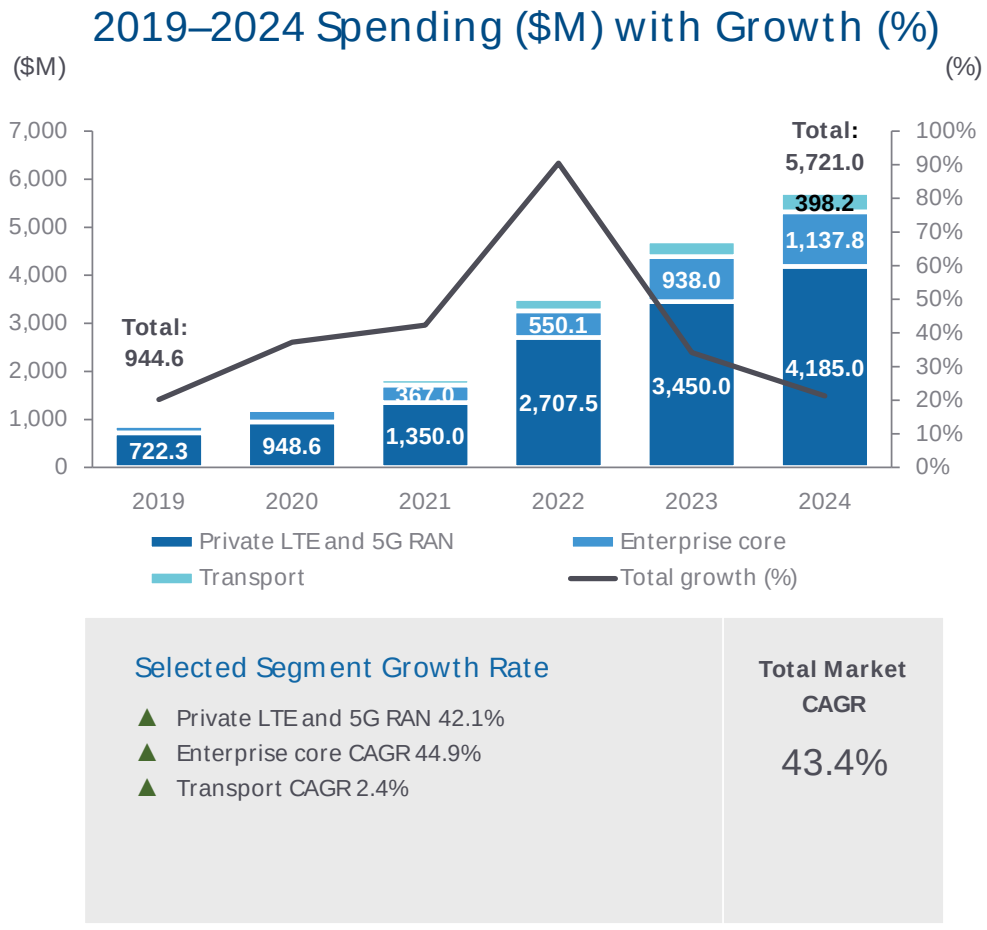
Of note, not all early private 5G solutions currently offer "enterprise grade" toolsets. As such, organizations would be wise to spend time evaluating solutions to determine the viability and alignment with use case and organizational needs. Said differently, deploying private 5G is emerging as a promising solution to help organizations address key challenges; however, as with any new technology, there is work to be done before it achieves its full potential.

Private 5G Capabilities and Value Proposition

While most private 5G contracts remain in proof of concept (POC) today, a few organizations have already commercially deployed private 5G across the manufacturing, energy, and public sector verticals to generally positive results. As part of that, IDC has observed leading communications service providers (SPs), vendors, cloud providers, systems integrators, and other market players packaging and selling private 5G solutions into the market. Indeed, IDC views the combined spending on private LTE and 5G network infrastructure (RAN, core, and transport) by organizations to surpass $5.7 billion by 2024 (see Figure 1).

FIGURE 1

Worldwide Private LTE and 5G Infrastructure, 2020-2024



Selected Segment Growth Rate

- ▲ Private LTE and 5G RAN 42.1%
- ▲ Enterprise core CAGR 44.9%
- ▲ Transport CAGR 2.4%

Total Market CAGR

43.4%

Note: Data provided is from *Worldwide Private LTE/5G Infrastructure Forecast, 2020-2024* (IDC #US47085720, December 2020).

Source: IDC, 2020

While we expect private LTE to remain the predominant portion of that spend through the forecast period, private 5G spend will eventually grow to surpass spending on private LTE and drive new spending among verticals that were not interested in leveraging cellular networks in the past, particularly those in the industrial markets.

Indeed, private LTE is already deployed globally, particularly in instances where dedicated and reliable communications are required across large outdoors areas or distributed operations requiring wide area networks. For instance, mining, utilities, and transportation sectors have been deploying private LTE solutions for the past several years, albeit on a limited basis. This is in part due to the maturity and broad rollout of LTE coverage and a more mature device ecosystem. While 5G represents an evolution for mobile communications in many areas, LTE is expected to remain a viable solution, particularly across use cases where LTE devices are readily available and where LTE can meet the needs of the organization. Said differently, many organizations are expected to continue to deploy LTE as a private WAN solution for some time.

As such, when planning for a private cellular implementation, a converged solution may present the optimal approach, which could include deploying a converged LTE/5G core, and multi-RAT radios for backward and forward compatibility. Said differently, taking an either/or approach may result in organizations needing to spend more over the longer term, particularly if there is an interest in deploying LTE and 5G together.

Private 5G In Focus

The reasons for the interest in private 5G are many, but they can be summarized into a few key value propositions discussed in the sections that follow.

Superior Performance in Comparison to LTE

- **Superior reliability:** 5G NR delivers ultrareliable connectivity, whereas LTE, while generally sufficient in many cases, leverages older QoS parameters, making it potentially less reliable for ultrasensitive use cases.
- **Ultralow latency:** For industrial and time-sensitive use cases, 5G can deliver sub-10ms round-trip latency, critical for emerging time-sensitive and edge-based use cases. When combining with ultra-reliability, 5G can provide ultrareliable and ultralow-latency networking.
- **Ability to address industrial IoT use cases, particularly those deployed using edge infrastructure:** Combined with time-sensitive networking (TSN), 5G can provide a more deterministic networking solution, using 5G as the wireless connectivity bridge.

Future Proof for Ultradense Sets of IoT Endpoints

- **Massive IoT and M2M communications**. 5G is designed to accommodate ultradense, high-capacity sites, making it an ideal solution for a high volume of deployed IoT endpoints.

Architectural Advantages That Expand Deployment Models

- **Flexibility of 5G architecture**. Some of the private 5G components can be deployed as cloud-native functions (e.g., SA 5G core), enabling portions of the solution to be hosted in the cloud, at the edge, or on premises.
- **5G network slicing:** While this concept, which includes pervasive automation, has been championed by communications service providers, organizations consuming private 5G will

also be able to "slice" the network for use cases or applications. However, this will take more planning on the part of organizations, with particular dependence on where and how they deploy the 5G core functions, whether in the cloud, on premises, or in a hybrid cloud model. Deploying one model over another may alter the ability of the organization to "control" how and where 5G slicing is applied, which is likely to be a "must-have" for many organizations. In addition:

- 5G slicing requires device dependencies and is more tuned for advanced scenarios. Overall, we expect the application of network slicing as part of a private cellular deployment to require careful consideration on the part of the enterprise.

Potential TCO Gains and Improved Time to Market When Deploying Network Infrastructure

- **Cost advantages to deploying wireless solutions in lieu of wired solutions, particularly in greenfield builds.** Some organizations have justified the initial spending on private LTE and 5G due to the ability to save up-front costs and improve time to market as opposed to running new wires, particularly indoors.

Overall, private 5G attempts to blend the technological advances of 5G with an improved commercial and business model for organizations as well.

SETTING REALISTIC EXPECTATIONS AROUND PRIVATE 5G CAPABILITIES, MARKET ADOPTION, AND TIMING

While private 5G is indeed entering the commercial phase, the reality is that it remains a technological work in progress. Whether public or private 5G, the 3GPP standards body dictates a multiyear evolutionary path for 5G features. Said differently, the 5G that was deployed in 2019 (e.g., Release 15) will hardly resemble what 5G can offer in 2023 and beyond (e.g., Release 18 and beyond). As a result, enterprise and industrial adoption assumes a timely resolution and agreement among industry stakeholders to achieve the proposed features and timelines shown in Figure 2.

FIGURE 2

3GPP Releases 16, 17, and 18 Will Impact Enterprise and Industrial Adoption Plans for Private 5G

Feature	Release 15 — Dec 2018	Release 16 — July 2020	Release 17 — June 2022	Release 18: TBD
Data rate/area traffic capacity (20Gbps)	Complete	Complete	Complete	Complete
Spectrum efficiency (3x LTE)	Complete	Complete	Complete	Complete
Network energy efficiency	Complete	Complete	Complete	Complete
Connection density (1,000,000/km^2)	Partially	Partially	Complete	Complete
Latency (<10ms)	None	Partially	Complete	Complete
Reliability (99.999% under 10ms)	None	Partially	Complete	Complete
Mobility (roaming with 500km/h)	Complete	Complete	Complete	Complete
Localization (Phase 1:1m accuracy)	None	Partially	Partially	Complete
Nonpublic networks (private networks)	None	Partially	Complete	Complete
Industrial IoT (TSN support)	None	Partially	Partially	Complete
Network slicing	Complete	Complete	Complete (+ more)	Complete (+ more)
Sidelink (direct communications between end devices)	None	Partially	Partially	Complete

Source: IDC, 2021

For example, while 5G has been around for several years, the use cases it has initially supported are generally linked to enhanced mobile broadband (eMBB), which includes improved mobile app performance across existing apps but also the ability to potentially unlock newer apps including augmented reality/virtual reality (AR/VR), cloud gaming, and connected car. Even so, many of these apps have yet to see mainstream adoption. Assuming 5G advancements remain on track, it will still be a couple of years before 5G incorporates more advanced features, including industrial IoT, localization, and direct communications between end devices, called sidelink (SL). In focus, these features are expected to be what drives private 5G adoption within the industrial space, beyond 2022.

5G Smartphones Are Widely Available, But Requisite Availability of Enterprise- and Industrial-Grade 5G Devices Remains a Work in Progress

Compounded by supply chain shortages on a global level, devices that incorporate 5G SIMs in both handheld and embedded devices, particularly for enterprise use, remain relatively sparse. This is to be expected in any new cellular technology era. However, for private 5G to see any meaningful uptake in the short term, the broader industry will need to tackle this problem head-on. To some extent, tactical cooperation between 5G technology suppliers and upstream embedded device makers is beginning to expand. This cooperation is leading to early examples of 5G-embedded devices in healthcare, manufacturing, and public sector; however, actual commercial volume will take time to accrue.

We expect that in addition to readiness, 5G-embedded device price points will need to hit key milestones before organizations purchase at volume. This is normal in any new mobile era, but one that will likely slow adoption.

As such, organizations evaluating private 5G today should understand what it is that 5G can offer from both a technology and device perspective today, and in the next couple of years. In conclusion, without

a pervasive and rich 5G device ecosystem to justify investment in the infrastructure, private 5G is expected to see select rollouts in the interim.

UNDERSTANDING PRIVATE 5G'S COMPONENTS: UNLOCKING PRIVATE 5G'S FULL VALUE WILL REQUIRE EXPANDED SOLUTION SET

For this section, while we focus on private 5G, many of these components can be included as part of a private LTE solution as well. In fact, we expect private LTE and 5G to be sold as a combined solution, where LTE and 5G hardware and software can be applied to certain use cases to start and where advanced 5G features can be "turned" on via software upgrades over time. Other organizations may opt to start directly with 5G as well.

Direct Components

Direct components consist of the infrastructure and device layer. To design, deploy, and launch private 5G, each system will require a fully functioning set of devices that interact with the network infrastructure layer. Indeed, many early private 5G solutions are offering both infrastructure and 5G SIMs as a package, if only to ease adoption in the early days. Further:

- **Radio access network:** Comprises macro, small cell (indoors and outdoors) running on licensed and unlicensed spectrum
- **NSA and SA 5G core:** Generally, made up of the SA 5G core, the User-Plane Function (UPF) deployed at the edge, to include additional 5G core functions (e.g., NEF, NWDAF) (In the early days, however, the combined use of LTE and 5G will likely include the use of the NSA 5G configuration, whereby a vEPC [LTE] core is deployed as a converged core solution alongside 5G.)
- **Edge server:** Compute resource deployed to house 5G network software and other edge applications
- **Transport layer:** Includes IP/optical, microwave, and other wireless connectivity for transport functions (This could also include 5G cellular routers in instances where 5G is used as a WAN backhaul.)
- **5G devices:** As previously noted, mostly includes handheld devices today but will evolve to include embedded and other 5G IoT devices over time

Indirect Components

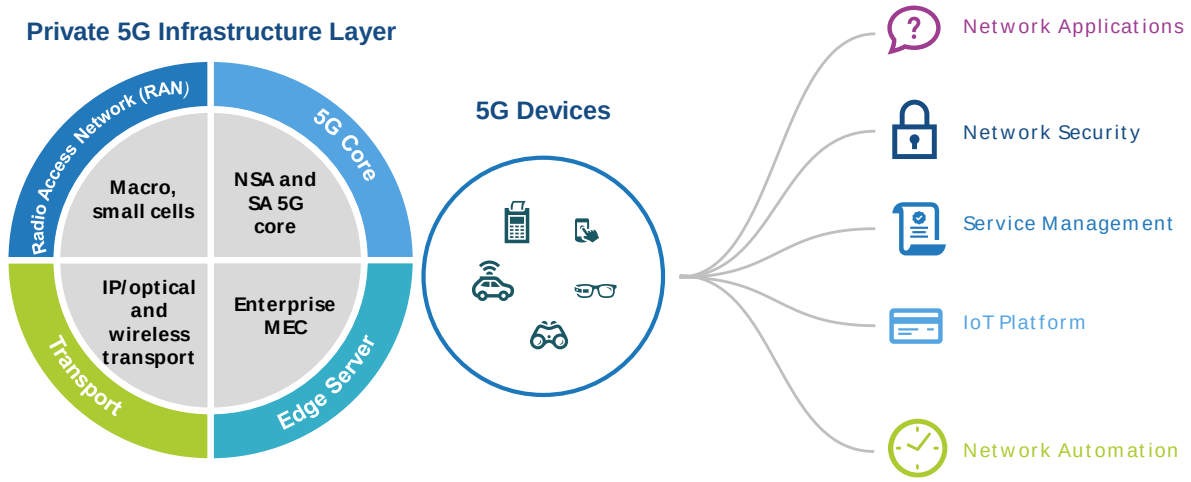
- **Network applications:** Includes applications such as PTT, MC-PTT, and video, or AR/VR running on a private 5G network
- **Network security:** Includes next-generation firewalls (NGFWs), gateways, network monitoring and visibility tools, and other security software designed with 5G traffic in mind
- **Service management:** Unified life-cycle management spanning device, network, and policy management designed to simplify the rollout and management of 5G, often alongside already deployed network access
- **IoT platform:** Platform layer consisting of connectivity, device, provisioning, and data management related to 5G
- **Analytics platforms:** Analytics solutions that track KPI metrics to ensure production efficiency (With private 5G, more data can be transacted faster and across a more diverse set of fixed and mobile endpoints.)

- **Network automation:** Includes 5G network and MEC orchestration but deployed for enterprise consumption, as opposed to solutions deployed for mobile operators (Network automation in the context of both private LTE and 5G will make it easier for enterprises to use and maintain.)

While direct components will be what is required to initially deploy a private 5G solution, indirect components represent an opportunity to add value to the deployment in the form of specialized security applications (see Figure 3). Integrating these solutions as part of a private 5G will likely require third-party integration expertise but could also be carried out by the enterprise or industrial organization itself. Whatever the approach, IDC expects most organizations to deploy one or several of these features as part of a private 5G implementation, and which adds value to the solution outcome overall.

FIGURE 3

Private 5G Components (Direct and Indirect)



Source: IDC, 2021

PRIVATE 5G ADOPTION: WHAT IS THE VERTICAL AND USE CASE OUTLOOK?

Even as private 5G remains in the early days, a diverse set of enterprise and industrial verticals are moving to test, trial and, in select cases, commercially deploy private 5G as part of ongoing operations. This section provides thoughts on where IDC expects private 5G adoption will be highest, the expected predominant cloud model, and which use cases it can reasonably address.

In addition, as part of IDC's market evaluation, we differentiate between enterprise and industrial verticals, with industrial widely recognized as verticals pursuing Industry 4.0 use cases. These generally include a focus on extreme process automation, digitalization, and evangelization of advanced technologies including big data/analytics, machine learning/artificial intelligence, MEC, and 5G.

In focus, we expect industrial or operations-based use cases spanning multiple verticals (e.g., manufacturing, government, mining) to generate the bulk of interest and requisite spend in private 5G in the short term. This is in part due to these industries recognizing the value of private 5G because of

a strong alignment between what 5G networks offer in performance (e.g., feature sets) and the alignment with targeted use cases, as listed in Figure 4. Over time, we expect other verticals, including those better defined as traditional "enterprise" organizations (e.g., retail and education) to also deploy private 5G for their own use. However, the broader enterprise space will require additional support, a simplified consumption model (e.g., NaaS), and a deeper and broader channel evangelization.

FIGURE 4

Enterprise and Industrial Verticals Private 5G Adoption Outlook

Vertical	Expected Adoption	Expected Predominant Cloud Model	Use Cases
Manufacturing	**High**	On premises	Real-time automation/process automation, monitoring, AGVs, industrial controls, smart factory, digital twin
Government and public sector	**High**	Hybrid	Video apps, monitoring, site automation, LMR modernization (e.g., public safety)
Mining	**High**	On premises	Remote monitoring, digitize operations, data curation and management, AGVs, automated extraction, digital twin
Energy (oil and gas, etc.)	**Moderate**	On premises	Remote monitoring, digitize operations, data curation and management, AGVs, automated extraction, digital twin
Utilities	**Moderate**	On premises	Substation digitalization, sensor connectivity, monitoring, predictive maintenance, IoT
Healthcare	**Moderate**	Hybrid	Video, hazard sensing monitoring/tracking, embedded intelligence
Transportation	**Moderate**	Hybrid	Monitoring and tracking, hazard sensing, surveillance
Education	**Moderate**	Hybrid	R&D and innovation lab enablement, data privacy, campus connectivity, network standardization across campus footprints
Retail	**Moderate**	Mostly public cloud	Video apps, tracking and monitoring, POS devices, smart signage
Others	**Low**	Mostly public cloud	Enterprise communications, multicloud apps, collaboration

Note: This chart aligns with the time frame and assumptions as part of IDC's Worldwide Private LTE/5G Infrastructure Forecast, 2020–2024, which includes market developments through 2024, or the next three years. We expect pervasive private 5G, or mainstream adoption across many verticals, to occur more broadly in the second half of the decade.

Source: IDC, 2021

Considering Cloud Models and the Impact on Private 5G Use Cases

As briefly discussed, 5G marks the beginning of the shift to a cloud-native solution. In particular, the software components (e.g., SA 5G core, cloud RAN, and other select software) can be deployed across a mix of cloud models spanning on-premises, hybrid cloud, or public cloud infrastructure.

This fundamentally changes the way enterprises can consume and deploy private 5G across the organization. Like other network technologies, including SD-WAN, cloud strategies can play a role in how private 5G can be used for purely internal use cases (e.g., manufacturing) or in a B2B implementation, whereby the private 5G network plays a direct role in a customer-facing service (e.g., retail). Furthermore:

- **On premises (private or dedicated cloud):** This model considers deploying the total private 5G solution on premises, which could include a set of private or dedicated cloud infrastructure to host the 5G network software as part of a closed-loop system. Verticals can expect to gain more control over security, data privacy, and performance. Downsides include the likely need to invest in specialized skill sets, and potentially spectrum, associated with deploying, integrating, managing, continuously updating, and supporting telecom and cellular

infrastructure. For many organizations, this reality will be a nonstarter for this model. However, select early adopters today, which include multinational manufacturers and a few other automation-focused customers, have embarked down this road. Even so, we expect this model to make up a smaller portion of the overall market over time.

Note: We define the term *on premises* loosely, as it could include deploying the entirety of the solution on premises (e.g., RAN, core). Another scenario envisions deploying the UPF of the 5G core on premises, while the remaining 5G network functions are hosted in the cloud.

- **Impact on use cases:** Deploying select components, including the SA 5G core on premises, can provide a boost in latency, performance, and customization. Select verticals spanning government, defense, manufacturing, and others that require mission-critical reliability for use cases spanning robotics, auto-guided vehicles, and precision toolsets are expected to gravitate toward the on-premises model, in conjunction with the extreme reliability and low-latency characteristics that private 5G will support.

- **Hybrid cloud:** This model assumes select portions of the private 5G solution are deployed both on premises (e.g., private cloud) and in a public or shared cloud. Examples of this include decomposing the SA 5G core into select functions that are hosted on premises (e.g., UPF) and other functions that can be hosted off premises. This can help organizations grapple with concerns around flexible consumption models, opex concerns, and limited space to deploy IT and network resources on premises. In addition, organizations can more easily receive software upgrades via the cloud.
  - **Impact on use cases:** Leveraging third-party cloud infrastructure can help organizations scale use cases faster, which could be internal use cases or those designed to support a B2B model. Indeed, the hybrid cloud approach is likely to be a more desired approach for most organizations, enabling to align applications and use cases, business, and technology decisions for superior outcomes.
- **Public or shared cloud:** This model assumes that the majority of the private 5G solution, excluding some radio hardware, is deployed off premises in a public or shared cloud configuration. In many cases, this model will support the end-to-end managed service approach, whereby a managed service provider, mobile operator, or systems integrator can manage the solution on behalf of the organization. Conversely to the fully on-premises model, certain regulatory and privacy requirements are likely to limit which verticals will be able to deploy this model. Select verticals, including the previously mentioned government, defense, and manufacturing, are a few but could also include healthcare, depending on regulatory guidance for handling data.
  - **Impact on use cases:** While this model simplifies adoption for the end organization, it does require organizations to carefully consider their managed service partner and to what degree the service is managed. If it is fully managed end to end, the organization will be putting significant trust into the services partner that it will be able to deliver customized service level, provide a robust innovation pipeline to grow with the organization, and achieve the "private" or "dedicated" level of the solution as defined by the customer. This is one reason the hybrid model is likely to be the predominant model, as it enables the customer to define which workloads are performed on premises and which are deployed in the public cloud.

Emerging Private 5G Channels: Choosing the Best Option for Your Needs

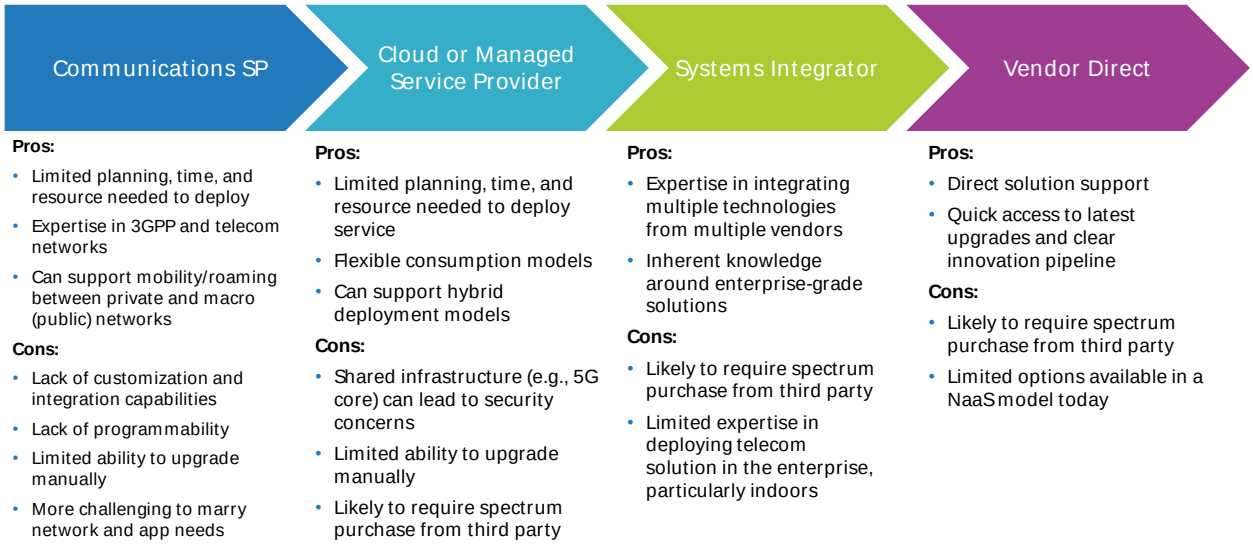
As previously noted, private 5G remains a somewhat niche approach to enterprise communications, with the expectation that it will be more pervasive in several years. While this paper describes the present-day limitations in technology, ecosystem, and enterprise readiness, channel readiness is also

a key consideration. Even so, channel models for private 5G continue to emerge, ranging from communications SPs, managed or cloud providers, systems integrators, and vendor-direct models as well. Like the cloud discussion, organizations need to carefully consider channel and its alignment with the desired business, technology, and organizational outcomes.

Figure 5 outlines some of the potential pros and cons associated with choosing a specific channel considering today's market conditions. However, we note that each of the respective channels are actively working to address shortfalls. For example, a select set of communications SPs are now able to deploy private LTE/5G in a way that enterprises do retain the ability to customize enterprise policies. Said differently, Figure 5 reflects common perceptions today, assuming the broader market will course correct and address in the future. Further, while enterprises can evaluate and choose their best fit, regulatory requirements, including privacy mandates related to GDPR, may force enterprises into a choice.

FIGURE 5

Evaluating Channel Models for Best Fit



Source: IDC, 2021

EVALUATING PRIVATE 5G AS AN ENTERPRISE-GRADE SOLUTION

While many assumed it would be the communications service providers that will consume the majority of 5G infrastructure for their B2C and B2B WAN services, it has become clear that 5G solutions will be consumed not only as part of the carrier network but also as an enterprise-grade LAN solution akin to Ethernet-based switching or Wi-Fi. As such, private 5G will need to be more than simply a better pipe but incorporate many of the enterprise-grade features that organizations expect, including:

- Integrated security features
- Comparable pricing metrics to other enterprise solutions

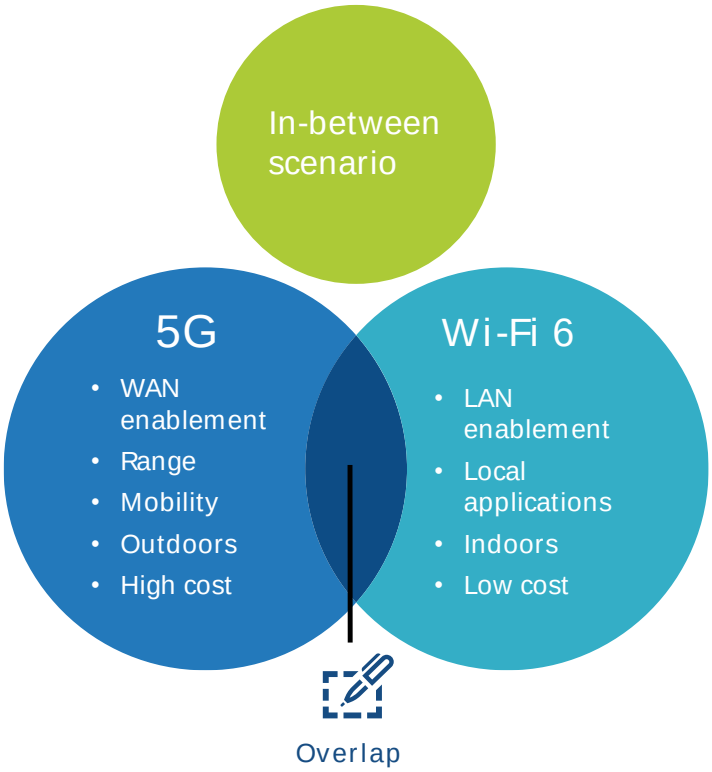
- Multicloud compliance
- Simplified and flexible consumption models
- Ease of integration with other enterprise technologies
- Service management features accessible through self-service portals
- Application-driven policy enablement
- Embedded intelligence for better decision making
- Analytics to provide KPI metrics and ensure SLA and efficiency goals are met

Further, select industry stakeholders continue to champion 5G as a 1:1 replacement for enterprise network solutions, particularly Wi-Fi. In IDC's view, this is an unlikely outcome. Private 5G should be viewed as an adjunct network tool that can be deployed to support certain applications, including those requiring clean spectrum, dedicated infrastructure, and high-performance wireless. Enterprises should not assume that private 5G can address the totality of their connectivity needs. However, IDC does expect some overlap, particularly in the area of enterprise wireless, namely, 5G and Wi-Fi 6.

While Figure 6 showcases the historical strengths of each solution, the "overlap" of these two technologies has somewhat increased with the advent of both 5G and Wi-Fi 6. While 5G enhancements are enabling it to move beyond consumer wireless broadband to include the ability to connect enterprise IoT endpoints, Wi-Fi 6 already leverages enhancements (e.g., OFDMA, MU-MIMO) to lay claim to the enterprise and industrial IoT space as well. As such, enterprise IoT deployments represent a potential overlapping use case. Further, the outdoor Wi-Fi market represents an area where private 5G may be as viable, if not more so. Think of a port connecting ships, containers, and mobile logistics equipment over relatively long ranges and with high-performance and reliability needs. In those cases, it may be better to consider private 5G.

FIGURE 6

5G and Wi-Fi 6 May Overlap, But Should Generally Be Considered Complementary for Enterprise Use



Source: IDC, 2021

However, in many cases, it will be a "judgement" call whether to deploy private 5G or 4G/LTE or Wi-Fi. Consider a low-range yet ultradense indoor site, perhaps connecting enterprise IoT endpoints. In this case, Wi-Fi 6 may provide the requisite coverage and capacity needed while private 5G may be unnecessary. At the end of the day, there will be many considerations as to where and how to deploy both technologies. We expect Wi-Fi to reasonably retain its role in day-to-day operations and see additional uptake for enterprise IoT implementation. Private 5G, on the other hand, may be better suited for mission-critical applications than Wi-Fi, where the application requires always-on, clean spectrum and ultra-reliability.

In areas where both technologies perform adequately, the deciding factors may not be the technology at all, but the device ecosystem, enterprise-grade functionality, TCO/ROI metrics, and ability to consume the solution on the enterprises' terms may be what drive decision making.

Indeed, the correct approach in many instances is more or less to view both solutions as complementary, as opposed to competitive. IDC expects Wi-Fi shipments to remain robust over the 2020s fueled by Wi-Fi's continued use as a mainstay enterprise LAN solution. We do not expect 5G to displace Wi-Fi in its day-to-day role but act as an overlay to address specific use cases where Wi-Fi

may not be the optimal solution. As such, focusing on how to efficiently deploy both solutions as part of broader strategy is likely to make more sense.

PRIVATE 5G AS MORE THAN JUST A PIPE: EMBEDDING ENTERPRISE-GRADE INTELLIGENCE FOR GREATER VALUE

While 5G networks can certainly deliver on better network KPIs, including capacity, latency, and throughput, it is fair to state that many communications SPs continue to struggle to overcome the notion that their 5G networks provide value beyond connectivity. Indeed, for communications SPs, vendors, or any 5G supplier to successfully bring 5G to the enterprise, those solutions will likely need to offer more than base connectivity.

One area where the network can rise above this notion is by leveraging embedded intelligence, where private 5G networks embed intelligence gathering tools that collect data in real time and provide actionable insights for optimization. In practice, the network transforms from a passive participant in the value chain to an active enabler of value.

For example, embedding intelligence can enable enterprise IT teams to tweak network parameters across device policy and security, driven by deep-packet inspection. Networks can also become proactive using network visibility tools to enable machine learning models to quickly identify anomalies and network patterns and address issues before they impact a customer. Further, embedding intelligence can unlock the ability to build a pattern of behavior for the groups of devices and start enabling heuristics profiles that can potentially identify issues and take intelligent actions prior to human detection or intervention, if chosen.

While these approaches are not necessarily new in the enterprise space, many early private 5G solutions lack embedded support as part of the solution. In short, enterprises should expect any private 5G solution to include embedded intelligence features to not only improve overall productivity but also ensure the network itself can run both efficiently and reliably.

Along those lines, private 5G becomes an enterprise-grade tool, whereby enterprise IT teams can define intelligent rules based on their known devices, providing the customization and beyond connectivity value that private 5G will need to deliver on.

IN SUMMARY

Overall, enterprise and industrial verticals should be excited that they are on the cusp of a new mobile network generation designed for enhanced performance, to deliver operational efficiencies, and to accelerate their path to DX. Even so, the reality is private 5G, and 5G in general, is a work in progress, particularly as an enterprise-grade tool.

Further, while it has initially been wielded by the communications SPs for the consumer market, we believe 5G will ultimately by judged by its efficacy in the enterprise and industrial space. To evaluate private 5G fairly, organizations should align what private 5G can do today against what it will be able to provide over time. Overlaying private 5G's timeline, capabilities, and deployment models with organizational needs across strategy, technology, devices, consumption model, and preferred channel presents the best case scenario for healthy development of the private 5G ecosystem. Misalignment in any of these areas risks issues when deploying, and, ultimately, for the business outcomes of the customer.

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