Private Cellular Networks: Enterprise ROI in an Evolving Marketplace

An IMAGINE WIRELESS thought-leadership paper

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Executive Summary

This white paper examines the impact of Private Cellular Networks (PCN) in delivering business benefits and generating attractive financial returns for enterprises. Use cases for PCNs are highlighted across multiple industry verticals, demonstrating their broad applicability to solve both long-standing and emerging operational challenges. Emerging use cases related to digital transformation represent additional opportunities for value creation.

Enterprise PCN deployments are still maturing but gaining strong momentum with more than 300,000 private cellular access points and 900 networks deployed by the end of 2022 according to the OnGo Alliance. In this current state of enterprise adoption, financial models for total cost of ownership (TCO) are well understood. However, understanding of the expected financial return is still evolving.

Interviews across the PCN ecosystem reveal that initial use cases have delivered the desired results for Digital Transformation initiatives where legacy technologies such as public cellular or Wi-Fi failed to provide the required wireless performance. Enterprises are deploying PCNs to solve specific coverage, reliability, security, latency, and mobility needs for an initial specific business-critical use case. The measured or projected business value is not usually quantified ahead of the capital outlay due to the urgency to solve the connectivity issue that is critically limiting the enterprise.

We see significant return on investment (ROI) opportunities as more and more use cases are deployed on private cellular networks. Wireless has proven to give more organizations the flexibility to say, "what if" and bring ideas that can provide business insights and productivity through connectivity.

PCN Definition and Overview

A private cellular network provides enterprise connectivity using 3GPP spectrum (typically 4G or 5G) in the cellular frequency bands and is operated and managed distinctly from Communication Service Provider (CSP) public networks. From the perspective of an enterprise, PCNs enable the connectivity of people, places and things leveraging business-critical applications within a network framework designed to meet the unique needs of the organization. Private cellular networks enable enhanced reliability, mobility, coverage, capacity, security, and reduced latency to overcome technical limitations for use cases where legacy public cellular, Wi-Fi, or wired ethernet are not sufficient.

Benefits of PCN

Innovate or die. This phrase crystalizes the business and strategic imperative for enterprises operating in dynamic market conditions. Increasingly, the ability to innovate relies heavily on having network connectivity that matches current and future organizational needs. To that effect, the inherent benefits PCNs enjoy, as a result of evolving 3GPP standards, for reliability, mobility, connectivity, and enterprise control offer advantages that public cellular, Wi-Fi, and wired ethernet networks cannot match. The technology advancements inherent to PCN and 4G/5G networks have been well documented by academics, industry practitioners, and the OnGo Alliance.

Wireless connectivity is fundamental to executing an enterprise Digital Transformation strategy with the general goals of increased efficiency, greater business agility and, ultimately, the unlocking of new value for employees, customers, and shareholders. Use cases span machine learning, artificial intelligence (AI), video analytics, IoT, cloud, and near-edge computing to support real-time decisioning making. PCNs are enabling manufacturers to use digital automation that can enhance business performance use case at a time. Other vertical markets are using PCN-based networks to enable connected worker, physical security, IoT, and autonomous guided vehicles (AGVs) with a focus on the use of real-time data analytics to reduce downtime and help operations run more efficiently.

The ROI for PCN

Through extensive industry interviews, we have found that most PCN early adopters were motivated by imperatives to resolve critical issues in their current network architecture that prevented desired capabilities. Their network improvements were executed without extensive business cases or expected returns on their capital investments, and to a large extent, this strategy has been successful to date.

Fortunately, this lack of well understood ROI modeling has proven not to be a barrier to the early enterprise adopters of PCN. These pioneers have been driven by the need to solve immediate, acute connectivity pain points rather than waiting for comprehensive financial analysis for business justification. As a result, we have observed that most enterprises today are buying PCNs based primarily on technology needs (e.g. reliability, mobility, security, coverage) and not based on a full business case or known business economic value.

This practical approach of using PCNs to solve immediate connectivity problems provides a roadmap for the industry. Over time, expansion into new use cases will promote a greater understanding of the value creation enabled by private cellular networks and will accelerate industry adoption.

While many of the PCN deployments to date were not thought to have involved a comprehensive understanding of potential returns on the required capital investment, we believe that as this technology becomes more mainstream, up front ROI analysis will also become more common. Understanding the financial profile of a PCN deployment requires delving into the total cost of ownership for an enterprise in relation to the expected financial benefits. On the cost side, divergent business objectives of the numerous OEMs, application providers, and Managed Service Providers (MSPs) vying for early market wins have produced varied pricing and service models.
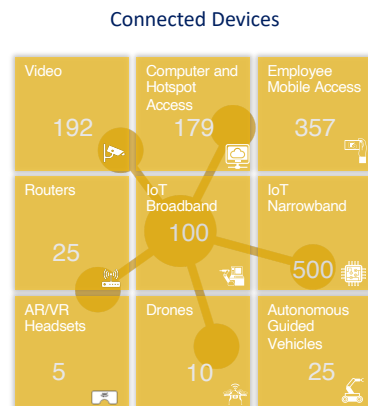
As a reference point, our industry interviews reveal that a PCN deployment for a typical 250k sq. ft. warehouse with a high availability architecture, monitored 4G CBRS network, and dimensioned for 1,000 - 1,500 simultaneous connections, can have a 5-year TCO range from $800k - $1.2M. For most network installations, there will be additional use case specific software applications running on top of the PCN that would add incremental costs that sometimes eclipse the PCN network costs.

Large Warehouse Customer Profile

Warehouse Floorspace (Indoor) (sq.. ft) [9]	230,667
Total Warehouse Coverage (sq.. ft.)	461,333
Indoor/Outdoor (%)	50/50
Number of Employees [9]	714
Number of connected devices	1,303
Number of Indoor Access Points	15 (High Availability Architecture)
Numbers of Outdoor Access Points	4 (High Availability Architecture)
Total Number of Access Points	19

[9] US Energy Information Administration Commercial Building Energy Consumption Survey

Coverage Area

Outdoor – Primarily vehicle yard and loading docks or incoming and outgoing distribution vehicles including cars, trucks, trains and boats.

Indoor – Typically wide-open areas with extensive shelving and distribution equipment (conveyors, belts). Minimal office space. Exterior construction is largely brick, stone, stucco, concrete or metal.

Enterprise Types

Target: Warehouses > 100k sq. ft., including distribution, fulfillment and shipping centers; non-refrigerated warehouses, refrigerated warehouse, and ports

Not targets: Warehouses < 50k sq. ft., self storage

Example Customers
- Ingram Micro, Chef's Warehouse, CVS, CommScope

Architecture Considerations (one or more of the following)
- ✓ Hybrid EPC - SGw and PDGw Local
- ✓ Local Breakout – Date Center or Edge
- ✓ High Availability (fully redundant)

Connected Devices

Video 192	Computer and Hotspot Access 179	Employee Mobile Access 357
Routers 25	IoT Broadband 100	IoT Narrowband 500
AR/VR Headsets 5	Drones 10	Autonomous Guided Vehicles 25

Imagine Wireless estimates – illustrative use cases

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Large Warehouse 4G Cost Model – Expected Enterprise Pricing

	Year 1 2022	Year 2 2023	Year 3 2023	Year 4 2024	Year 5 2024	5 Yr TCO
Vertical: Warehouse **Frequency Band:** CBRS						
RAN						
CBRS Access Points	$56,500					
CBRS Installation H/W, e.g., cabling, brackets	$9,500					
TOTAL RAN	**$66,000**					**$66,000**
CORE						
Device fees (by type, device H/W cost not incl.)	$6,346	$5,601	$5,601	$5,601	$5,601	
Core S/W License and upgrades	$72,000	$72,000	$72,000	$72,000	$72,000	
TOTAL CORE	**$78,346**	**$77,601**	**$77,601**	**$77,601**	**$77,601**	**$388,749**
MEC						
MEC Servers	$18,272					
MEC Orchestration Layer, Mgmt	$10,800	$10,800	$10,800	$10,800	$10,800	
TOTAL MEC	**$29,072**	**$10,800**	**$10,800**	**$10,800**	**$10,800**	**$72,272**
PROFESSIONAL SERVICES	**$243,692**					**$243,692**
- Design, install, system integration, test						
MANAGED SERVICES	**$52,908**	**$52,908**	**$52,908**	**$52,908**	**$52,908**	**$264,538**
- System Monitoring, NOC, Tier 1-4 support						
- Software licenses and upgrades (except core)						
TOTAL	**$470,018**	**$141,308**	**$141,308**	**$141,308**	**$141,308**	**$1,035,251**

Upfront Cost
$417,110
Monthly Re-occurring Cost
$11,775
5 Year Total Cost
$1,035,251

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We have observed that industry pricing models for PCNs are highly variable as the market searches for the best way to demonstrate the value of PCNs relative to legacy technologies. Deal structuring appears to be flexible to accommodate enterprise needs for classifying cash outlays between upfront costs (CapEx) versus ongoing costs (OpEx). Choice of network architecture (e.g. fully integrated similar to Wi-Fi APs, or distributed) results in differential support requirements for various use cases and also drives different cost and value profiles. Deploying PCNs at multiple facilities or campuses can also yield scale benefits and cost efficiencies.

Enterprises across all verticals are adopting PCNs by the need to solve their immediate, acute connectivity pain points rather than waiting for comprehensive financial analysis for business justification. Point-solution ROI's are emerging as described below.

Warehouse and Logistics facilities are undergoing significant industry disruption due to competitive pressures and intensifying customer needs. As a result of greater automation of processes enabled by PCN (e.g. software applications that enable scanners, pickers, smart glasses, AGVs, packing conveyers, etc.) an actual warehouse customer was able to reduce total employees from 500 to 100 over a 5-year period, while maintaining consistent service levels. At an average annual wage of $33,000 per warehouse employee (2023 national salary average per Talent.com), that labor reduction translates into a $13M reduction in annual payroll costs or a $65M labor reduction over a five-year period. In addition, there are quantifiable benefits around increased productivity in fulfillment rates, less fulfillment errors, etc.

Industrial Manufacturing facilities are undergoing a significant digital transformation due to the Industry 4.0 global initiative. In the next five years the number of sensors will soar within this complicated environment along with the full automation of the manufacturing process. This transformation is predicted to improve productivity between 5-10% and can quickly sum up to $30M, based on industry feedback on forecasted results of early deployments.   There will be a complicated set of edge-based use case software applications that require real time analytics and AI to enable decision making processes on the manufacturing line. Today, manufacturing plants are constrained by thousands of feet of cabling which has become a huge issue/cost when reconfiguring or changing the manufacturing process, and PCNs can reduce this infrastructure load with fewer higher power access points.

Entertainment and Sports Venues are reaping the rewards from improved customer experiences and increased revenues as a result of upgrading venue connectivity. Macro public cellular and Wi-Fi networks can suffer severe service degradation due to overloading and congestion at stadiums on game day. For example, a major NFL stadium deployed a PCN to offload their internal operations data from the Wi-Fi network. This relieved congestion for ticket authentication, reducing the time to wirelessly authenticate tickets from an average of 30-35 seconds to less than one second, resulting in up to 30 minutes less wait time per ticket holder to enter the facility. This has resulted in increased pre-game concession sales and improved fan experience (i.e. enabling customers to enter the stadium faster to spend more time purchasing concessions and merchandise). Other software applications are being evaluated for the PCN to improve fan experience such as concession line queuing services to reduce in-venue wait times. Future incremental value levers are tied to the venue's monetization of the PCN to tenants along with the potential to replace the traditional legacy Distributed Antenna Systems (DAS) by sharing the PCN (i.e. Neutral Host Network).

Commercial Buildings and Campuses have traditionally been restricted to carrier-based DAS and corporate liable contracts. With the advent of Citizen's Broadband Radio Service (CBRS) and the opening of device ecosystems and low-cost enterprise CBRS access points (APs) and Evolved Packet Core (EPC) equipment, any enterprise can become its own Mobile Virtual Network Operator (MVNO). Think about an enterprise building a CBRS-based Neutral Host Network (NHN), getting its own PCN for internal use cases, eliminating corporate liable contracts, and managing all the devices and data on the enterprise LAN. Some larger campuses with ~50k corporate liable devices can spend up to $200M over five years for their carrier contracts. By deploying a PCN (CBRS NHN) plus adding costs for 50k new devices and roaming out fees we have seen a 40% potential savings in telecom costs over five years.

The following table summarizes potential current point-solution ROIs across vertical markets.

Industry Vertical	Point-Solution Use Cases	Value Levers	Value Potential *
Warehouse/ Logistics	• AGVs • Pickers • Drones • Asset Tracking	• Lower defects • Less downtime • Labor reduction • Lower shrinkage • Increased fulfillment rates	• $13M savings in labor over 5 years = $65M • $20M increase in revenue • $5M defect reduction • $2M faster inventory turns
Industrial Manufacturing	• Sensors • AGVs • Quality Control • Asset Tracking	• Reduced downtime • Faster line reconfigurations • Preventative equipment maintenance • Fewer escaping defects • Lower labor costs	• 5-10% productivity increases (~$30M) • 1% vs 3% downtime due to equipment failure • Decreased plant downtime for line reconfiguration
Entertainment Sports Venues	• Wireless ticketing • Mobile (in-seat) Commerce • Wireless POS • Mobile parking payment apps • Fewer APs than Wi-Fi • Replace PTT systems and devices • Future NHN	• Increased concession sales • Reduced parking staff costs • Improved fan experience • Reduction in wireless network installation • Stadium liability for connectivity uptime • Reduction in high cost LMR networks and devices • Monetization of PCN (tenants, media, subcontractors, etc.)	• Average 30 min extra time fan spends in stadium pre-game • 4:1 reduction in PCN installation vs Wi-Fi • $500k damages for 15 min of wireless network downtime
Buildings and Campuses (CRE)	• Corporate Liable Devices • Replace DAS	• Reduction in telecom expenses (MNO fees) • Reduction in CapEx for DAS deployment	• $200M spend reduction in MNO telecom over 5 years • Significant cost in new smartphone replacement can be spread/financed over time • @40% MNO savings • Added Digital Transformation platform

Footnote: Figures are illustrative based on interviews and industry estimates.

While most enterprises are deploying PCNs as point-solutions to solve immediate Digital Transformation challenges, we have analyzed the long-term ROI for a complete transformation strategy and estimated the following (all examples are multi-campus, Fortune 500 companies).

<u>Enterprise ROI (5 Year)</u>

The following high-level ROI calculations are based on the PCN TCO of ~$1M over 5 years plus the use case specific application costs which are more representative of the value being delivered.   As a reminder, the PCN is required for coverage, capacity, security and low-latency and is the key enabler for the digital transformational applications that solve use case specific problems with their own value proposition and ROI.

Each of the below industry verticals have their own use case specific applications that require differing amounts of investment in software, hardware, and ecosystem devices. Without going into the detailed analyses for each use case, we are confident that our ROI estimates should be viewed as a realistic goal by the key stakeholders in each enterprise organization. Also, the value returned is quite conservative and based on the primary driving benefit. Even with this conservative approach, it shows that the ROI associated with deploying PCNs is substantial.

1. Warehouse/Logistics Company: Invest $5M (PCN + ~Apps), $13M Return = 160% ROI
2. Industrial Manufacturer: Invest $12M (PCN + ~Apps), $30M Return = 150% ROI
3. Entertainment & Sports Venues: $20M (PCN + ~Apps), $30M Return = 50% ROI
4. Corporate Campus Liable Devices: Invest $120M, $200M Return = 66% ROI

    Note: Apps costs are use-case specific and include a range of hardware, software, and devices required to achieve the value on top of the PCN itself.

<u>Summary and Conclusions</u>

PCN deployments are in an early stage of adoption, but promising financial returns for these initial deployments point the way to an acceleration in the adoption curve. Current motivation for enterprises to deploy PCNs largely appears to be driven by improving or fixing business critical use case performance rather than by financial projections or business cases. In this environment where ROI analyses are still evolving and based primarily on solving single-point problems, PCN suppliers and MSPs have resorted to different TCO and pricing strategies to incentivize enterprise adoption.

Our analysis shows that the ROI associated with private cellular networking is significant and should not slow down deployments that are approached on a per use-case basis. Start small

with solving a specific business problem and then keep adding incremental use cases to realize greater ROIs on the initial PCN installation cost.

Through a broad set of industry expert interviews, we are confident that there is a significant 5-year ROI opportunity for enterprises that install private cellular networks, to offload or replace legacy public cellular or Wi-Fi solutions, thereby unlocking the maximum potential of their business-critical use cases.

About Imagine Wireless

From Telecoms to Enterprises to Private Equity Funds, Imagine Wireless helps clients realize the potential of digital business models and emerging technologies. Our field-tested tools approach brings immediate value to clients without the need for 'learn by doing' like traditional consulting firms.

About Cradlepoint

Cradlepoint enables the freedom to connect people, places, and things that drive more experiences, more ways to work, and better business results — anywhere. The company is a pioneer in Wireless WAN, offering advanced 4G and 5G routers and adapters — controlled through Cradlepoint NetCloud™. Enterprise businesses and public sector agencies rely on Cradlepoint and its Cellular Intelligence to build a reliable, secure network wherever they need it, connecting fixed and temporary sites, vehicles, IoT devices, and remote employees. Headquartered in Boise, Idaho, Cradlepoint is wholly owned subsidiary of Ericsson (NASDAQ: ERIC) and part of their Business Area Enterprise Wireless Solutions. It has international offices in Asia Pacific, Canada, Europe, India, and Latin America. www.cradlepoint.com