



PRIVATE 5G IN WAREHOUSING

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INTRODUCTION: THE ROLE OF PRIVATE 5G FOR ENTERPRISES

The trend toward digitizing production assets and workflows (often referred to as Industry 4.0) promises great opportunities for enterprises across the board, as it lessens the reliance on manual labor, increases efficiency and quality of enterprise operations, and decreases their carbon footprint. The latter becomes particularly important, as increasing energy prices—in response to several geopolitical crises—are continuing to put enterprises under immense pressure to remain profitable.

As warehouses are characterized by a multitude of concurrently running operations and processes, automating these workflows will greatly increase efficiency and enhance productivity per warehouse.

Connectivity will be a main driver behind Industry 4.0, as machines and production assets will need to be connected to transmit data. Connectivity will also be one of the keys for warehouse operators to unlock the benefits and efficiency enhancements promised by automating and digitizing workflows and processes.

In this context, private 5G will be an important building block, as it provides important features that will address warehouse managers' key pain points:



Massive Machine Type Communication (mMTC) capabilities will support the connectivity of up to 1 million devices per 0.38 square mile.



The supported bandwidth of 10 Gigabits per Second (Gbps) in the uplink and 20 Gbps in the downlink (through **Enhanced Mobile Broadband (eMBB)** capabilities will enable automating particularly data-intensive processes.



Ultra-Reliable Low Latency Communication (URLLC), as well as support for Time Sensitive Networking (TSN) and deterministic networking, make 5G particularly useful for mission- or even life-critical enterprise applications.

Private 5G networks enable a diverse set of Industry 4.0 tools specifically for warehouse managers. These include Condition-Based Monitoring (CBM), Real-Time Location System (RTLS)/asset tracking, inventory management, Augmented Reality (AR) glasses, wearables, building automation, robotics, and more.

A CLOSER LOOK INTO LOGISTICS: PAIN POINTS AND DIGITIZATION REQUIREMENTS

The logistics industry has witnessed extraordinary growth over the last 2 years. Although this sector had been experiencing solid growth before 2020, the COVID-19 pandemic triggered an unforeseen surge in demand for orders.

The outbreak of the global COVID-19 pandemic led to important structural and long-lasting changes in the logistics sector. Demand for logistics operations and warehousing services increased, as almost all brick & mortar retail moved to online shopping because of lockdown measures, which is a trend that is expected to continue. ABI Research forecasts that, by 2025, 35 billion packages and parcels will ship in the United States. Facility managers will continue to face the challenge of recruiting and training enough people to meet peaks in demand. This issue is further heightened by labor shortages, port and air traffic congestions, and lockdown and social distancing measures being reimposed around the world. These developments underline the increasing need for digitization and technological solutions in the field of logistics.

The outbreak of COVID-19 and recent geopolitical events have underlined how vulnerable today's warehouses still are to sudden disruptions in global supply chains. A fully transparent supply chain could prevent these disruptions and minimize revenue losses by allowing warehouses to preventively adjust their operations accordingly.

Today's warehouse is characterized by a high degree of technology fragmentation. Automated identification solutions like Radio Frequency Identification (RFID) are often combined with optical identification like barcode readers, supported by a basic connectivity layer—either Ethernet or

Wi-Fi. However, these technologies have important shortcomings. Laying cables to connect workstations not only limits flexibility of the warehouse layout, but also incurs long-term costs as each cable drop costs hundreds of dollars to deploy and requires a high degree of maintenance and replacement. Wi-Fi does not provide the level of reliable network connectivity needed for smart warehousing use cases. This very fragmented technology landscape often leads to inefficient operations within warehouses, as additional resources (either time or personnel) need to be pooled to harmonize the different technologies with each other and ensure seamless interoperability.

PRIVATE 5G USE CASES FOR WAREHOUSING & LOGISTICS

Private 5G lends itself to a range of heterogeneous use cases and is perfectly suited for deployments in a warehousing environment, where the multitude of concurrent processes place stringent requirements on the underlying connectivity technology. Most fundamentally, a private 5G network guarantees a high level of integrity and data sovereignty, meaning that highly critical warehousing data, such as the number and condition of existing workstations, pallet positions, or autonomous vehicles, can remain on the warehousing premises and will not have to leave for external processing. In addition, private 5G will enable a range of more specific use cases for receiving, picking, and packing, machine vision and camera solutions, and robotics applications in warehouses.

RECEIVING, PICKING, AND PACKING

The current setup of warehouses with RFID and Wi-Fi connectivity can lead to inconsistent data and patchy network coverage. With a reliable private wireless network, warehouses are seeing productivity gains without having to hire new staff. New hands-free technologies like voice picking and vision picking can be reliably supported, and mobile push-to-talk devices can be used for efficient team communications throughout the building, dock, and yard. Table 1 provides an overview of how private 5G can address the key pain points.

Table 1: Use Cases, Pain Points, and Private 5G Solutions for Receiving, Picking, and Packing

(Source: ABI Research)

Operational Details	Pain Points	Private 5G Solution
Warehouse operations include a range of different workstations: From truck yards to sorting hubs and individual pallet positions.	No communication between different workstations resulting in inefficient warehousing operations.	Private 5G can provide ubiquitous coverage, allowing the smooth transmission of data between all workstations.
Receiving, Picking and Packing currently involves a high degree of manual labor.	Manual labor is expensive and an increasingly scarce resource as the economy restarts after Covid-19.	Private 5G will allow the automation & remote operations of Receiving, Picking and Packing equipment.
Different workstations use different connectivity / identification technologies.	Technology fragmentation creates inefficiencies, as it makes data transmission and analysis more difficult.	Private 5G will be able to address all different use cases (particularly mission-critical ones) with the same technology.

MACHINE VISION AND CAMERA SOLUTIONS

Connecting cameras can be essential for security, asset management, worker safety, and quality assurance. Cameras are also critical for yard management for gate operations, monitoring dwell times, and achieving regulatory compliance. Table 2 highlights how a private 5G network can address these issues.

Table 2: Use Cases, Pain Points, and Private 5G Solutions for Machine Vision and Camera Solutions

(Source: ABI Research)

Operational Details	Pain Points	Private 5G Solution
Quality control of loading operations is based on manual operation & inspection.	Faulty (un-)loading operations unnecessarily increase the workload and therefore reduce productivity.	Private 5G enabled machine vision can automatically monitor loading operations and minimize faults.
Camera solutions will be an important building block for automating gate operations.	Camera files for remote operations are data-intensive, so transmission requires sufficient bandwidth.	Private 5G will provide large enough bandwidth in the up- & downlink to enable remote operation.
Security & Access Management has become an even more important aspect to warehouses through the Covid-19 pandemic.	Current security & access management at warehouses is not automated and therefore time-consuming.	Private 5G will enable combining camera solutions with Artificial Intelligence (AI) for high-quality access management.

ROBOTICS

Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), collaborative robots, and autonomous forklifts will be important assets for warehouses to realize the benefits of a fully automated and digitized warehouse. By 2025, there will be more than 3,700 robotic warehouses in the United States, according to ABI Research. Table 3 highlights the role of private 5G in enabling enhanced robotics use cases on the warehouse floor.

Table 3: Use Cases, Pain Points, and Private 5G Solutions for Robotics

(Source: ABI Research)

Operational Details	Pain Points	Private 5G Solution
Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) require full mobility across the entire warehouse floor.	Current wireless technologies can not provide robust signal hand-offs between Access Points, requiring AGVs to operate at lower speed.	Private 5G will guarantee consistently low latencies, which will enable warehouse managers to operate AGVs at 30% higher speed.
Robots require a range of visual and sensor data to operate truly autonomously.	Current wireless connectivity technologies do not offer the required bandwidth & low latency for all sensor & visual data.	Private 5G will guarantee enough bandwidth (with constant network availability) that will allow robots & warehousing assets to operate autonomously.
AGVs and AMRs require an emergency stop function in case workers safety is endangered.	Current wireless connectivity technologies can not provide this safety function, as they can not guarantee low enough end-to-end latency.	Private 5G will ultimately bring latencies below 1 millisecond, which will be low enough to enable emergency shutdown functions.

MAKING THE BUSINESS CASE FOR PRIVATE NETWORK DEPLOYMENTS

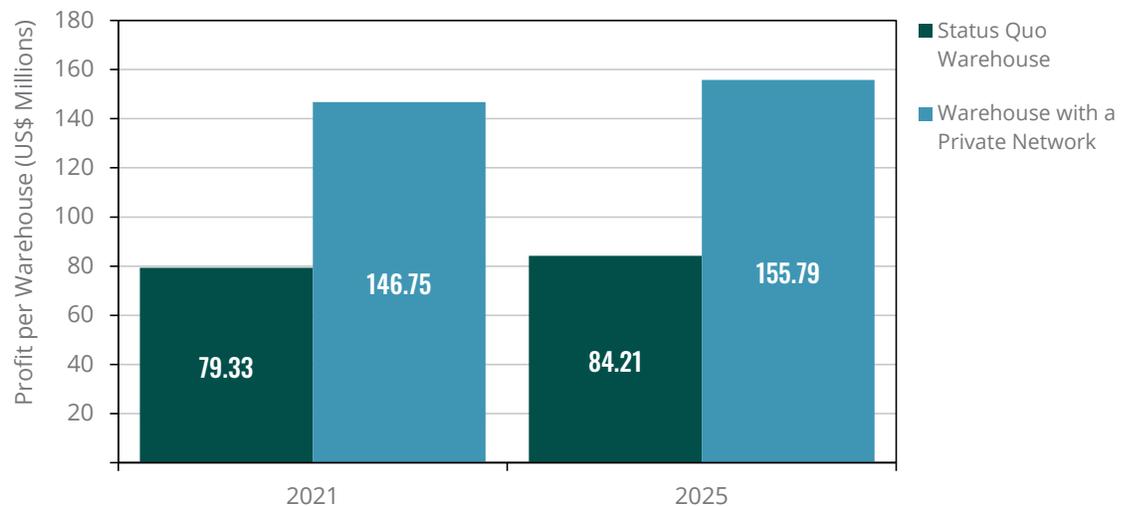
To help warehouse managers understand the value proposition of deploying a private network on their premises, ABI Research has estimated both the Return on Investment (ROI) for deploying and the Cost of Inactiveness (COI) of not deploying a private network for warehousing operations.

Over a 5-year period, an average warehouse in the United States with a private 5G network for smart warehousing applications is expected to experience the following:

-  An 11.9% increase in gross profit margin
-  An operational cost savings of US\$248.17 million
-  An ROI of US\$13.8 for every US\$1 spent

Chart 1: Profitability Comparison between Status Quo and Cellular Connected Warehouse

(Source: ABI Research)



Another way to look at the business impact of deploying private 5G is to look at the COI if warehouse operators decide not to deploy a private network on their premises.

By maintaining the status quo and not deploying a private 5G network, each warehouse in the United States is expected to forgo the following over a 5-year period:

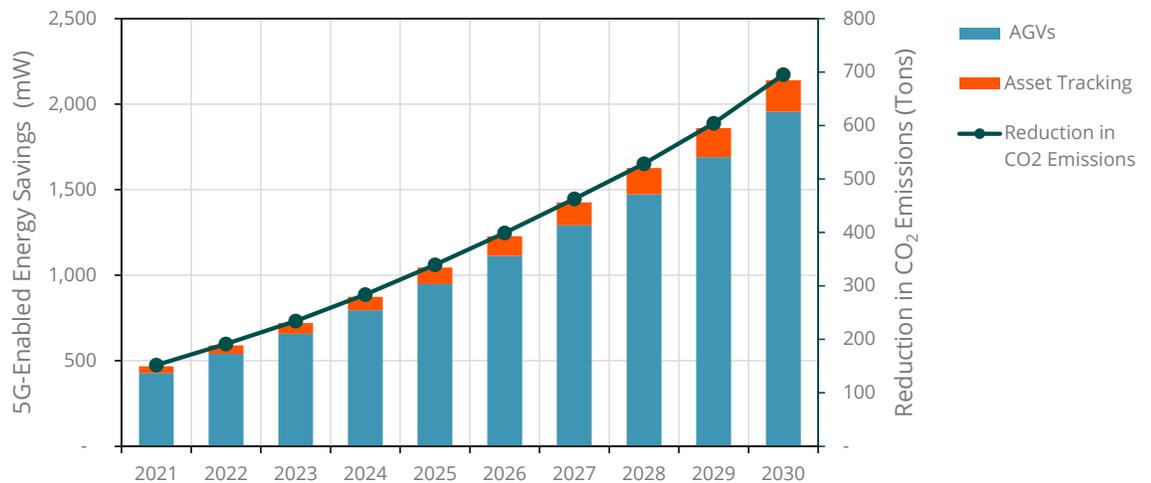
-  US\$231 million of unrealized gross profit
-  6.02 million fewer packages shipped
-  Overall COI to maintain the status quo of US\$243 million

Based on this, the 5-year COI of the entire U.S. warehousing industry stands to be US\$10.2 billion, and the potential loss of packages shipped would amount to approximately US\$1.5 billion.

In the wake of soaring energy prices and the drive toward increasing sustainability, energy efficiency becomes a growing concern. ABI Research also calculated potential reductions in energy consumption and increased energy efficiency. As Chart 2 illustrates, the energy efficiency enhancements of a private 5G network will increase gradually, as 5G technology will mature and be used for more and more use cases. By 2030, each warehouse operator can reduce energy consumption by 2,000 Megawatts (mW) per year. This will increase sustainability of the sector, as it will decrease each warehouse’s Carbon Dioxide (CO₂) emissions by almost 700 tons per year.

Chart 2: 5G-Enabled Energy Savings and CO₂ Emission Reduction per Warehouse United States: 2021-2030

(Source: ABI Research)



CASE STUDY: 5G DEPLOYMENT AT TELTECH GROUP

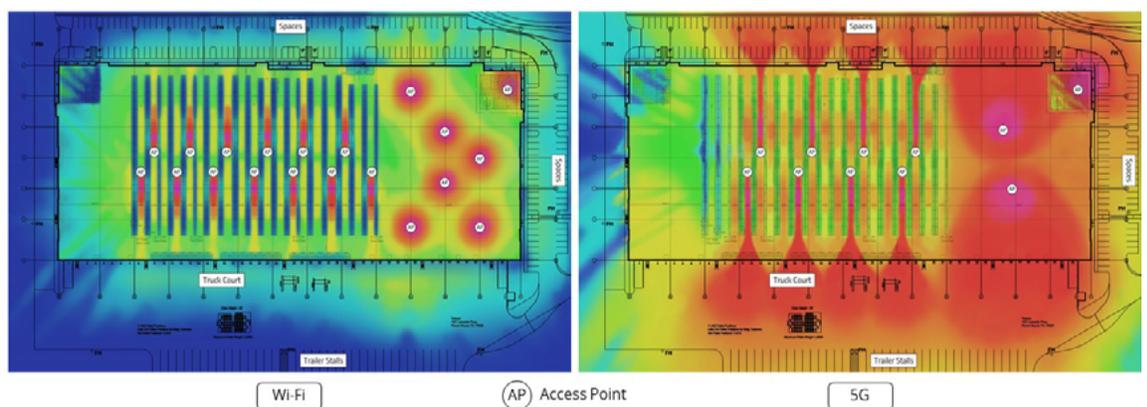
To foster the deployment of new technologies, such as private 5G, within enterprises like warehousing, it is important to develop blueprint deployments and reference designs, as warehouse operators can use them to understand the value proposition of private 5G for their workflows. Struggles in finding qualified manual labor because of changes in the labor force during the COVID-19 pandemic, as well as soaring energy prices fueled by recent geopolitical events, are placing a burden on warehousing companies to guarantee economically-viable business continuity.

The U.S.-based company Teltech Group is one example that shows the benefits of deploying a private 5G network for smart warehousing and logistics use cases. Founded in 1999 as Teltech Communications, the organization has a total of 470,000 square feet (sq. ft.) of scalable warehouse space available in multiple parts of the United States. In 2022, the company decided to deploy a private network in one of its 200,000 sq. ft. warehouses.

Two-thirds of the floor space in this warehouse is racked, resulting in a total of 15,000 possible pallet positions. As Wi-Fi-based connectivity increased the risk of unwanted interference and dead zones, private 4G/5G connectivity was chosen to add smart warehouse applications to the operation. Figure 1 illustrates the coverage areas of both a Wi-Fi and a private 5G deployment. As the right-hand side shows, 20 Wi-Fi APs would have been needed to provide at least a basic level of connectivity for the floor space between individual racks, while other parts of the warehouse remain with poor or no connectivity coverage. Private 5G technology, on the other hand, provides a more even level of connectivity across the entire warehouse floor with only 11 5G APs, each mounted 35 ft. above the ground with a down-tilt of 15°.

Figure 1: Connectivity Coverage Area at Teltech Group by Technology

(Source: Betacom)



To lessen the reliance on manual labor and increase profitability even in uncertain economic times, the private 5G network is used to connect robots, drones, and scanners to their respective workstations for automatic cycle counting. The enhanced bandwidth and high reliability, as well as the availability of the network, allows for the remote operation or even autonomous movement of robots. Autonomous forklifts and fully connected truck yards complete the picture for

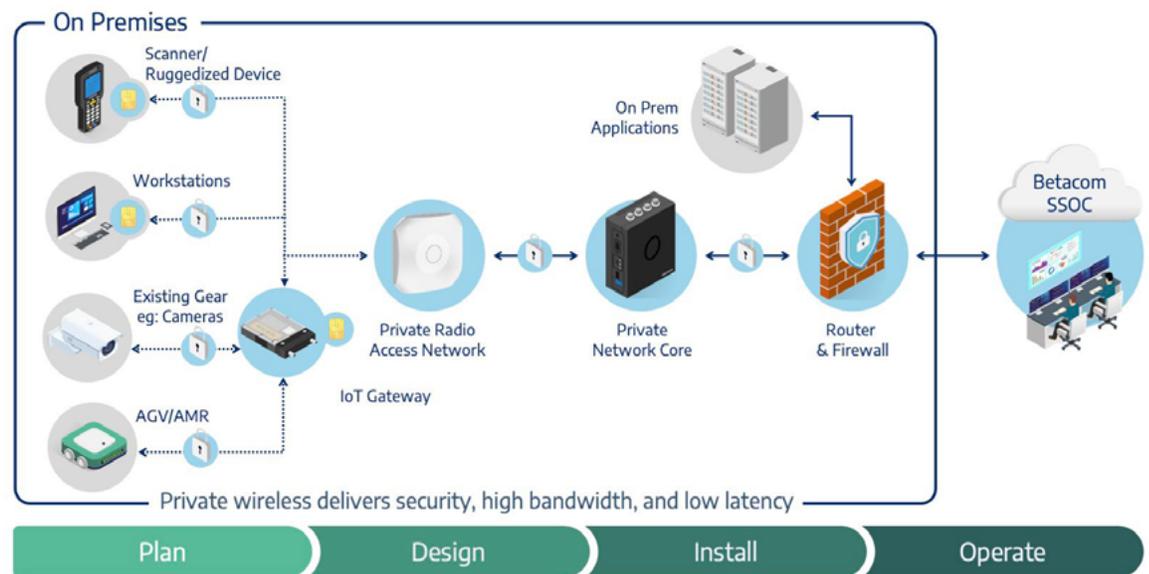
truly end-to-end automated and connected inventory tracking from when goods enter the warehouse until they leave again. While other connectivity solutions result in machine downtime, which can lead to revenue loss of 20% to 30%, the private 5G solution provides 100% uptime and critical profitability enhancements. Private 5G connectivity can provide the much-needed security and network integrity, as it only allows authorized devices to use the network, guaranteeing integrity of all warehouse data.

DEPLOYMENT MODEL

As operational data in a warehouse are highly sensitive, it should not be allowed to leave the enterprise premises. Adequate measures need to be taken to ensure that a private network can be deployed on-site. Figure 2 depicts the simple deployment model that was used to support all the smart warehouse applications that Teltech wanted to deploy.

Figure 2: *Betacom Deployment Model Private 5G Network-as-a-Service*

(Source: Betacom)



For spectrum access, the deployment uses the Citizens Broadband Radio Service (CBRS), which offers enterprises easy access to shared mobile network spectrum at a minimum marginal cost. It minimizes initial upfront investment and provides even small- and medium-sized warehouse operators, which are often governed by tight budgetary controls preventing large upfront investments, with the opportunity to benefit from deploying private 5G in their facility.

CONCLUDING REMARKS AND RECOMMENDATIONS FOR WAREHOUSE MANAGERS

This whitepaper laid out the immense benefits warehousing & logistics operators can gain from deploying a private 5G network on their premises. However, they should not underestimate the complexity of the decision at stake.

Warehouse managers should follow trusted technology suppliers for handholding through the process of deploying a private 5G network on their site to enhance both the efficiency and quality of their operations. To ease their investment decision, warehouse operators should, from a business economic point of view, consider service-based offerings that allow each enterprise to pay for private 5G-enabled services on a long-term basis, rather than as an upfront investment. From a business case point of view, they should consider not only the enhancements from present day private 5G applications, but also consider future use cases that provide further visibility along a product's supply chain. While this is true for any enterprise deployment, it particularly holds true for the logistics industry, as future use cases around end-to-end supply chain visibility will help eliminate unforeseen supply chain disruptions and, therefore, allow all of the different companies within the value chain for a given product to detect irregularities when they occur and allow them to adjust accordingly.



Published August 2022

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