Quantum Corridor: The Commercialized Quantum-Ready Network

Developing the Quantum Internet in the Nation's Heartland

Bruce Chesley, Ph.D.
Patrick Scully, P.Eng. & MBA

Quantum Corridor is a scalable, multi-node, quantum-safe network built for real-world applications and commercialization—delivering a first-of-its-kind Midwest testbed for quantum communications. It is the first quantum-safe commercial network in the Western Hemisphere capable of sending quantum protocols. Following successful inter-state deployment in Fall 2023, the network made history with its quantum communications testbed between Chicago and Northwest Indiana by becoming the fastest bi-state network in the Americas outside of the research networks having successfully pushed 40 Tbs.

Quantum Corridor is ready to expand across the Midwest to support applications across defense, finance, life sciences, automation and more.

Network Background

On October 24, 2023, Quantum Corridor became the first network in North America to achieve a capacity of 40 terabits per second (Tbps), making it one of the fastest Tier One networks on the continent. Connecting the ORD10 Data Center in Chicago (more commonly known as 350 Cermak) to the Digital Crossroad (DX) Data Center in Hammond, IN, Quantum Corridor achieved a round-trip latency of 0.266 milliseconds for information exchange over the redundant 12-mile network. And, because it's built using TAA-compliant components and ready for quantum-safe communications, Quantum Corridor delivers the next level in secure data transmission across the first commercial quantum-safe infrastructure in North America.

Quantum Corridor's programmable coherent optics currently enable encrypted line rates up to 800 Gbps to support a range of high bandwidth applications across defense, financial services, life sciences, chemical companies, automotive companies and educational institutions. For businesses that experience scaling constraints at ORD10 – or those seeking access to interconnected multi-tenant data center in the Midwest – Quantum Corridor's dedicated connectivity from Digital Crossroad puts them one cross-connect and 0.266 milliseconds round trip away.

Following the publication of a paper by JPMC, Ciena and Toshiba on Quantum Key Distribution in early 2023, Quantum Corridor adopted the concept of quantum-safe networking to design a solution making the secure transmission of sensitive and confidential data possible. Quantum-safe communications include the ability to support Post-Quantum Cryptography (PQC), Quantum Key Distribution (QKD), and ultimately quantum entanglement distribution in a common network infrastructure. The Quantum Corridor reconfigurable photonic infrastructure, or optical line system and its coherent optics, bring unparalleled bandwidth to the network. Its 40 Tbps capacity is scalable, as the underlying technology also provides L-band support, enabling almost twice the initial capacity. The nearly instantaneous computing and communications capabilities position Indiana and the Chicagoland region as one of the most quantum-capable regions in the world.

A Commercial Network with Test Capabilities

Quantum Corridor's network is primarily designed to offer high-speed quantum-safe connectivity between its various points of presence. These include data center locations as well quantum sciences research institutions, commercial enterprises and government agencies and facilities.

The high-bandwidth connectivity services are delivered over a modern open line system that supports a flexible grid implementation, allowing for the transmission of today's highest channel rate, 1.6Tbps at 200Gbauds, and is designed to support future line rates with its flexible filter and Reconfigurable Optical Add/Drop Multiplexer (ROADM) technology. All data rates up to 400GbE are supported, and the equipment is ready for 800GbE services.

By default, all connectivity services on the network are delivered encrypted using a quantum-safe implementation ensuring the privacy and security of the transmitted data. The hybrid approach to quantum-safe communication provided by Quantum Corridor is delivered by a complementary use of a quantum-resistant encryption implementation, the migration to Post Quantum Cryptography (PQC) algorithms and the first commercial network in North America leveraging a multi-node Quantum Key Distribution (QKD) system and a trusted node architecture.

The ability to leverage additional fiber strands alongside the ones used to deliver the quantum-safe connectivity services between the different sites, particularly nodes in quantum sciences research institutions like University of Chicago / Chicago Quantum

Exchange, Roberts Impact Lab and Purdue University (initially through the Purdue Northwest (PNW) campus), allows for the second vocation of the network, that of a real-world testbed.

Unlike traditional testbeds confined to controlled labs, Quantum Corridor provides a production-grade environment where commercial users and researchers can test and scale in parallel. Several leading organizations have already committed to projects utilizing the Quantum Corridor network to advance their capabilities and core technologies, including case projects involving:

- Department of Defense applications
- Secure healthcare data transmission
- Financial systems connectivity
- Hyperscale partner integration
- Quantum equipment onboarding

Quantum Corridor is closely integrated with core quantum research institutions. Its quantum hubs also provide access to advanced resources such as quantum computers, AI systems and classical high-performance computing clusters. This infrastructure enables the network to serve a dual purpose: supporting both cutting-edge research and the commercialization of quantum technologies in communication, networking and sensing.

Network Details

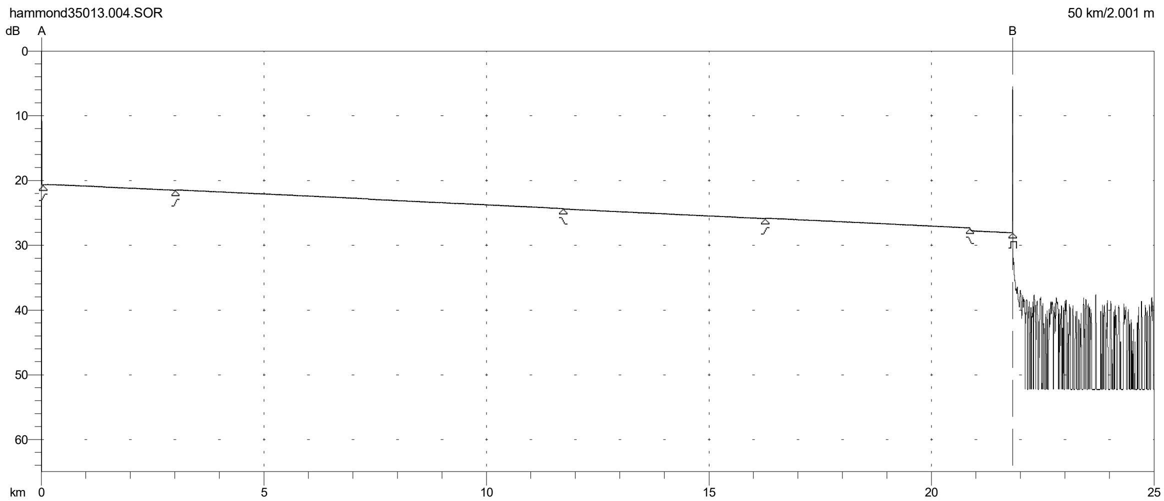
Existing Infrastructure

Initially established between two major Chicago-area data centers, Quantum Corridor's network was architected and built from inception to deliver a state-of-the-art communications network delivering quantum-safe transmission leveraging QKD technology.

At its core is the deployment of new G652D fiber optic cables on the most direct path between the locations. This multi-strand fiber asset gives Quantum Corridor access to 48 strands along that route, allowing for both connectivity services, operational testing and research applications. This new fiber installation also delivers an optical infrastructure providing minimal splicing along the way, providing excellent fiber characteristics, which are essential to quantum applications. As per the OTDR trace below, this 21.8km fiber span delivers a very low 7.25 dB of end-to-end optical loss.

DX Hammond to 350 E. Cermak

Anritsu NetWorks/OTDR - Version 5.0.00
Date: 02/02/2021 Time: 03:52 PM



A: 0.0068 km B: 21.8267 km A -> B: 21.8199 km	Index: 1.467000 2-Point Loss: -4.827 dB Reflectance: N/A	100ns / 10.0m [HR] Avg: 12288 / 0:30 /1310 nm/SM

Analysis Results -- hammond35013.004.SOR

Feature #/Type	Location (km)	Event-Event (dB)	Event-Event (dB/Km)	Loss (dB)	Refl (dB)
1/N	0.0368	-0.08	-2.056	-0.10(2P)	
2/N	3.0123	0.90	0.304	-0.07	
3/N	11.7260	2.89	0.332	0.08	
4/N	16.2638	1.45	0.320	-0.08	
5/N	20.8650	1.51	0.327	0.46	
6/E	21.8221	0.28	0.289	>3.00	>-18.96

Overall (End-to-End) Loss: 7.25 dB

Figure 1 – OTDR trace between 350 Cermak and Digital Crossroad locations

Part of the initial network turnup also included the execution of an industry-standard RFC2544 test suite to measure throughput and round-trip delay (RTD). The following figures include the complete RFC2544 suite results and capture the measured RTD of 266µs, constant across various frame lengths.

Enhanced RFC 2544 Test

Overall Test Result: Pass

Throughput	✓
Latency	✓
Frame Loss	✓

Mode	Symmetric Loopback
Tests to Run	Throughput, Latency, Frame Loss
Customer Name	Quantum Corridor
Technician ID	Doug Schremp / Bob Reinert / Chris Irwin
Test Location	100 Digital Crossroad Drive, Hammond, IN 46320
Work Order	Job Number 29384940
Comments/Notes	Connectivity Test
Instrument	T-BERD5800-100G
Serial Number	WMSE0113470069
SW Version	31.1.1
Start Date	10/25/2023
End Date	10/25/2023
Start Time	2:27:25 PM EDT
End Time	3:16:25 PM EDT

Figure 2 - RFC 2544 Test Suite Executed on October 25, 2023.

The following figure captures the RFC2544 throughput and latency test results across various frame sizes:

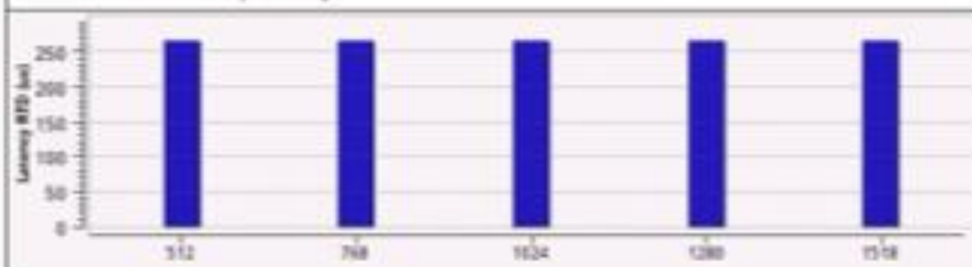
Enhanced RFC 2544: Throughput Test Graph

Enhanced RFC 2544 Report - Part 1: 100GigE Layer 2 Traffic Tests

Enhanced RFC 2544: Throughput Test Results

Pass/Fail	Frame Length (Bytes)	Measured L1 Rate (Mbps)	Measured L2 Rate (Mbps)	Measured L3 Rate (Mbps)	Measured L4 Rate (Mbps)	Measured Rate (frms/sec)	Pause Detect	Cfg Rate (L2 Mbps)
Pass	512	10391.0	10000.4	9492.5	9101.9	2,441,511	No	10000.0
Pass	768	10268.0	9999.6	9661.1	9400.7	1,627,551	No	10000.0
Pass	1024	10195.0	9999.7	9745.8	9550.5	1,220,673	No	10000.0
Pass	1280	10156.0	9999.8	9796.6	9640.4	976,546	No	10000.0
Pass	1518	10132.0	10000.2	9829.0	9697.2	823,477	No	10000.0

Enhanced RFC 2544: Latency Test Graph



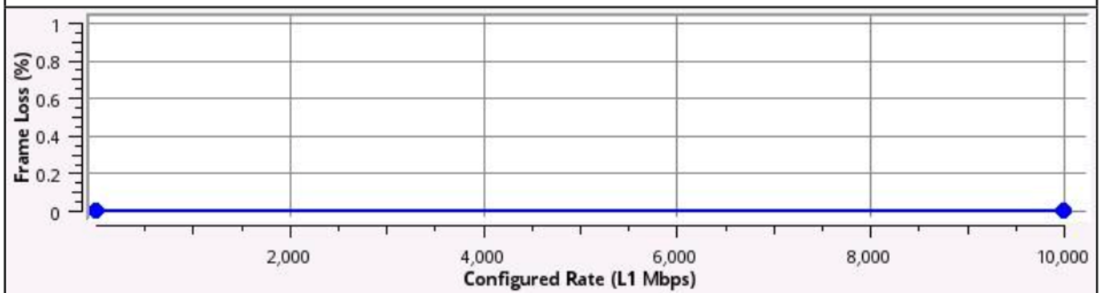
Enhanced RFC 2544: Latency Test Results

Pass/Fail	Frame Length (Bytes)	Latency RTD (us)	Measured L2 Rate (Mbps)	Measured L1 (% Line Rate)	Measured Rate (frms/sec)	Pause Detect
Pass	512	266.35	10000.4	10.391	2,441,511	No
Pass	768	266.35	9999.6	10.268	1,627,551	No
Pass	1024	266.18	9999.7	10.195	1,220,673	No
Pass	1280	266.08	9999.8	10.156	976,546	No
Pass	1518	266.10	10000.2	10.132	823,477	No

Figure 3 - RFC2544 Throughput and Latency Test Results

The following diagrams capture the RFC2544 Frame Loss test results, confirming no frames were lost during the transmission at various frame sizes.

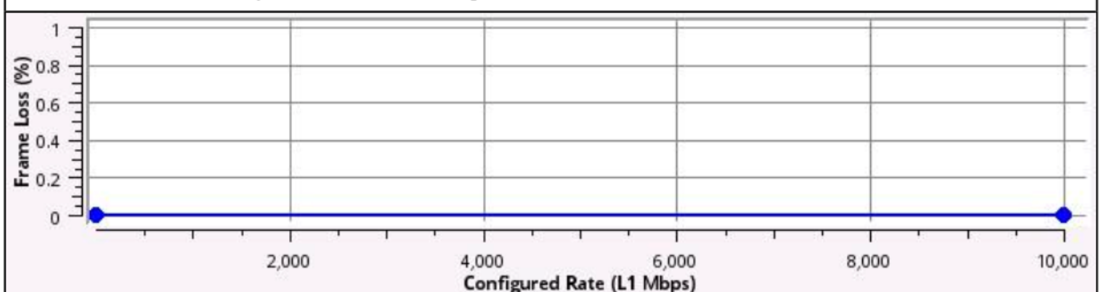
Enhanced RFC 2544: 512 Byte Frame Loss Test Graph



Enhanced RFC 2544: 512 Byte Frame Loss Test Results

Throughput Rate (L2 Mbps)	*Frame Loss Rate (%)*	*Frames Lost*	*Pause Detect*	*Cfg Rate (L2 Mbps)*
10000.4	0.00	0	No	10,000
1.0	0.00	0	No	1

Enhanced RFC 2544: 768 Byte Frame Loss Test Graph

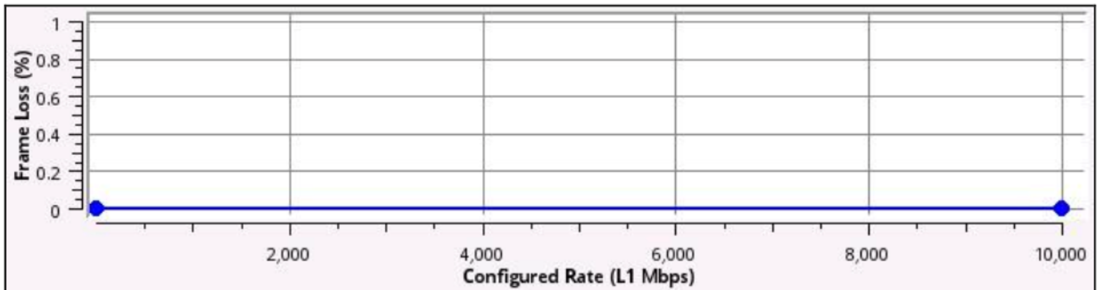


Enhanced RFC 2544: 768 Byte Frame Loss Test Results

Throughput Rate (L2 Mbps)	*Frame Loss Rate (%)*	*Frames Lost*	*Pause Detect*	*Cfg Rate (L2 Mbps)*
9999.7	0.00	0	No	10,000
1.0	0.00	0	No	1

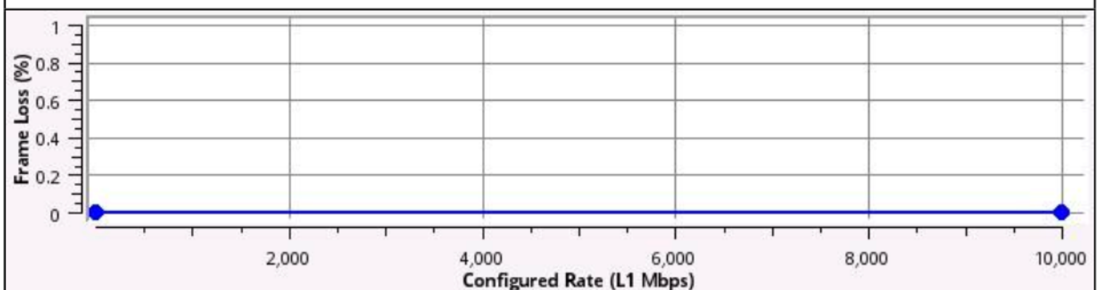
Enhanced RFC 2544: 1024 Byte Frame Loss Test Graph

Figure 4 - RFC2544 Frame Loss Test for 512B and 768B Frames



Enhanced RFC 2544: 1024 Byte Frame Loss Test Results				
Throughput Rate (L2 Mbps)	***Frame Loss Rate (%)***	***Frames Lost***	***Pause Detect***	***Cfg Rate (L2 Mbps)***
9999.7	0.00	0	No	10,000
1.0	0.00	0	No	1

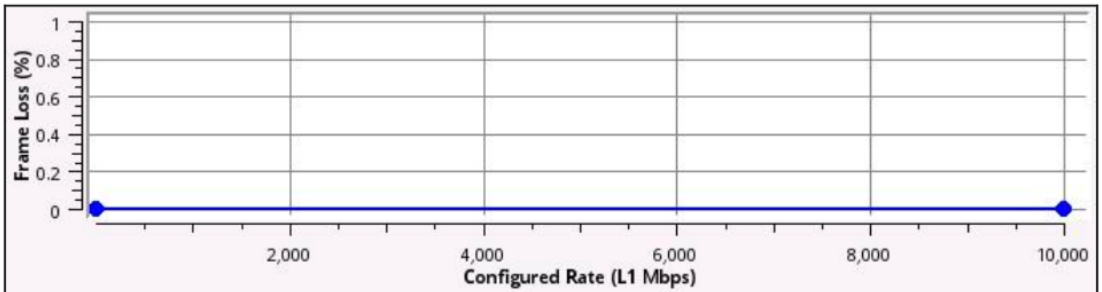
Enhanced RFC 2544: 1280 Byte Frame Loss Test Graph



Enhanced RFC 2544: 1280 Byte Frame Loss Test Results				
Throughput Rate (L2 Mbps)	***Frame Loss Rate (%)***	***Frames Lost***	***Pause Detect***	***Cfg Rate (L2 Mbps)***
9999.8	0.00	0	No	10,000
1.0	0.00	0	No	1

Enhanced RFC 2544: 1518 Byte Frame Loss Test Graph

Figure 5 - RFC2544 Frame Loss Test for 1024B and 1280B Frames



Enhanced RFC 2544: 1518 Byte Frame Loss Test Results				
Throughput Rate (L2 Mbps)	***Frame Loss Rate (%)***	***Frames Lost***	***Pause Detect***	***Cfg Rate (L2 Mbps)***
10000.3	0.00	0	No	10,000
1.0	0.00	0	No	1

Enhanced RFC 2544: Network Configuration	
Frame Type	802.3
Test Mode	Traffic
Encapsulation	None
Loop Type	Broadcast
Source MAC	00-80-16-93-17-09
Auto-increment Source	No
Destination MAC	00-80-16-00-00-00

Enhanced RFC 2544: Test Configuration	
Tests to Run	Throughput, Latency, Frame Loss
Acterna Payload Version	Version 2
Bandwidth Unit	L2 Mbps
Max Test Bandwidth (Mbps)	10000
Frame Lengths Selected (bytes)	512, 768, 1024, 1280, 1518
Throughput Measurement Accuracy	To within 100 Mbps
Throughput Zeroing-in Process	Viavi Enhanced
Throughput Frame Loss Tolerance (%)	0

All Tests Duration (s)	180

Figure 6 - RFC2544 Frame Loss Test for 1518B Frames & Report Summary

All Tests Number of Trials	1
Throughput Pass Threshold	Selected
Throughput Pass Threshold (Mbps)	10000
Configure Max Bandwidth per Frame Size	Not Selected
Latency Pass Threshold	Selected
Latency Pass Threshold (us)	1000
Frame Loss Test Procedure	RFC 2544 Standard
Frame Loss Bandwidth Granularity (Mbps)	10000
Test Protection	0

Figure 7 - RFC 2544 Report Summary (cont'd)

Quantum Corridor's existing fiber infrastructure also extends from Digital Crossroad to the Ohio state line across Northern Indiana. This new optical cable, which is built alongside the Indiana Toll Road (ITR) or I-90, provides an additional 276.8 kms of optical fiber, with 48 available strands, and is readily available for long range quantum research activities. It is planned for connecting additional sites in South Bend, Fort Wayne and other locations to the existing points of presence on the network.

Growing from 2 to 5 Nodes

Three additional fiber spans are being added to the network in 2025, which will bring three new nodes to the network and create a variety of fiber options for research activities.

i. Addition of 288 fiber strands connection between the University of Chicago campus at 5640 S. Ellis Ave and the existing Quantum Corridor fiber route on S. Martin Luther King Drive. This will provide a 14.2 km direct connection between UChicago/CQE and Digital Crossroad, and a 9.2 km direct connection to 350 Cermak. (Fig. 8)

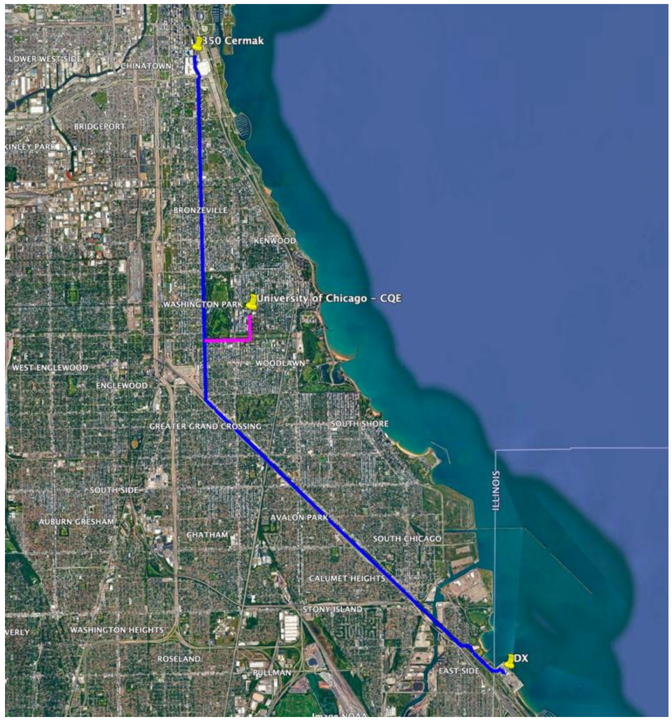


Figure 8 - New fiber to University of Chicago and CQE

ii. A new fiber build with two conduits (each with 288 strands) between the Roberts Impact Lab (RIL) located at 5454 Hohman Ave, in Hammond, IN and the existing Quantum Corridor route along the ITR, resulting in a 13.5 km path between RIL and DX. (Fig. 9)

iii. A new fiber build with two conduits (each with 288 strands) between the Purdue Northwest campus in Hammond, IN and the existing Quantum Corridor route along the ITR, resulting in a 20.4 km path between PNW and DX. Fig. 9)

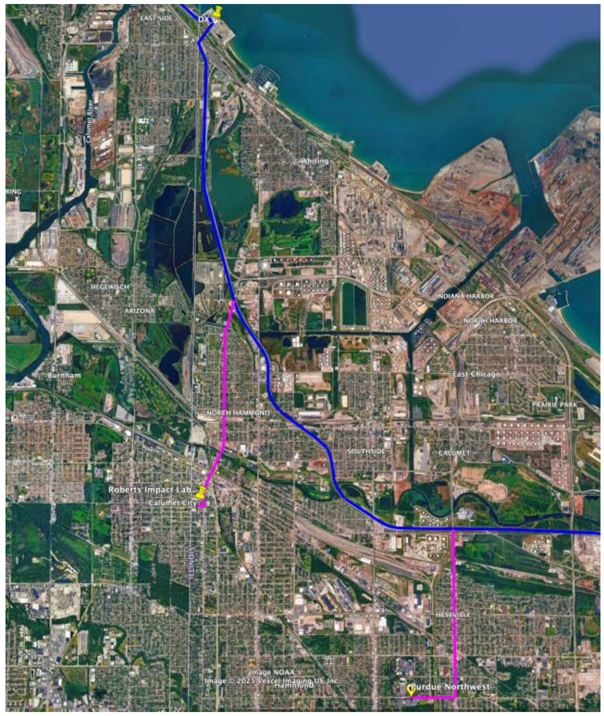


Figure 9 - New fiber routes to Roberts Impact Lab and Purdue Northwest (PWN)

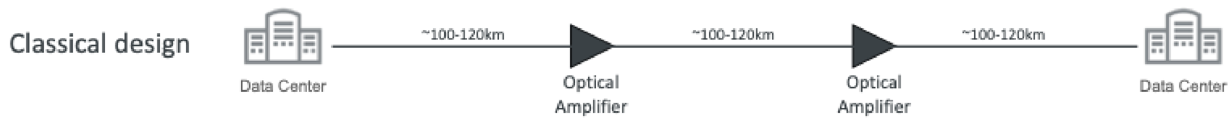
These additional fiber routes will increase the number of fiber span configurations available for research and test activities, with the possibility of combining different routes to extend the overall distances and/or offer intermediate sites for multi-site applications, e.g. in quantum repeater research.

The addition of the UChicago, RIL and PNW nodes to Quantum Corridor's network will create a multi-state network supporting research collaboration between major quantum sciences centers at the University of Chicago and Purdue, as well as research tenants and partners that will establish a presence at the new Robert Impact Lab facility.

A Network Architected for Quantum Applications

Quantum Corridor's network was architected and engineered from Day 1 to support Quantum applications such as Quantum Key Distribution (QKD) and further laying the foundation for entanglement distribution, quantum repeaters and similar future applications. What this means practically is an investment in the network itself and the sites supporting it.

In traditional optical network designs, the spacing between sites is maximized as far as the amplified optical channels will reach to minimize the number of sites and optimize the network costs. This results in a typical network architecture where amplifier sites are located 100-120km or ever further apart.

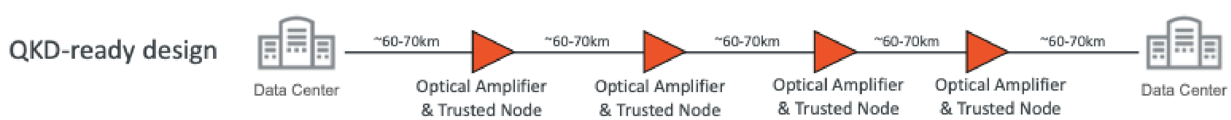


This type of network design is not compatible in most cases, and far from optimal in remaining cases, with quantum applications like QKD. Key considerations are:

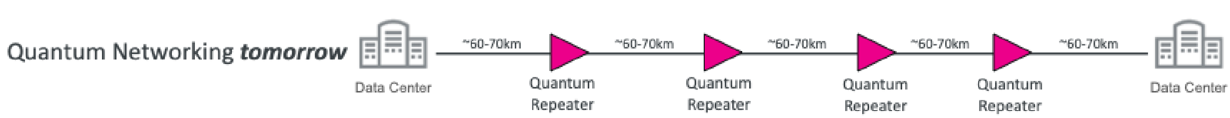
- QKD system leverage single photon transmission
    - These do not have the same optical reach as traditional coherent optical signals which are launched with a lot more energy.
- Based on the non-cloning principle of quantum physics, the QKD signals cannot be amplified
    - The signals cannot go through optical amplifier sites, often called ILA sites.

Given those considerations, it is not practical (and certainly not commercially viable) to retrofit existing networks deployed using classical design considerations.

By contrast, Quantum Corridor's network design took these factors into consideration as part of its default architecture and engineering rules, resulting in a drastically different implementation that limits the distance between sites, and incorporates a trusted node implementation for the quantum signal alongside the amplification for classical signals.



This innovative network design approach not only allows Quantum Corridor to deploy a QKD solution today to deliver a hybrid quantum-safe solution to its customers, but it also prepares the path to the Quantum Internet by laying down the physical infrastructure to deliver quantum communication in the future when relevant technologies like quantum repeaters make their entry into commercial applications.



The Global Quantum Network Landscape

A number of quantum networks have been described across the globe. Commercial and research QKD networks in Korea and Singapore, respectively, as well as existing network infrastructure being used for QKD demonstration or test activities in Europe (e.g. UK, Germany). While the adoption of QKD as a viable solution outside of the U.S. has led to many government-funded research and proof-of-concept activities in Europe and Asia-Pacific, the focus outside some industry-led activities (e.g. JPMC) has been on building a small number of small test networks focused on research and development activities. We'll explore two such examples in this section: the EPB network in Tennessee and the KIRQ network in Quebec.

Specialized Quantum Testbeds

Although the two networks are different, they both share the same approach: building a small research network dedicated to the testing and advancement of quantum sciences. Both networks are co-located with a major university and part of an ecosystem fostering the development on quantum technologies.

Key benefits include a very stable test infrastructure that is fully characterized to help analyze experimental test results and end points built into existing research facilities. While the short distances typically involved can alternatively be viewed as a benefit or a limitation, the environment is better characterized as a large-scale laboratory setting than a real-world network.

EPB Quantum Network, Chattanooga, TN

The EPB Quantum Network in Chattanooga was established as part of the local ecosystem and interconnects different facilities in the region, including the University of Tennessee in Chattanooga and Qubitekk, a private quantum communications company recently acquired by IonQ. Leveraging a subscription-based model, this network operated by a commercial entity offers a three-hub network equipped with a variety of quantum and optical test equipment (such as a source of photonic qubits, all-optical switches and a variety of measuring apparatus) to its subscribers allowing for the development and conduct of research activities.

The infrastructure runs on two 3km fiber paths, each equipped with 12 strands of fiber. The 12 strands are divided in a primary and a secondary path, each with 4 fibers for quantum transmission and a fifth for synchronization purposes. The last pair is used to provide Ethernet connectivity between sites.

KIRQ Network, Sherbrooke, QC (Canada)

Located in Distriq, the Quantum Innovation Zone offers local startups and others a development environment with office, meeting and lab spaces designed for quantum sciences (e.g. equipped with cryogenic cooling apparatus). The Zone also includes Sherbrooke University's Quantum Institute, which focuses on quantum sciences.

Operated as a not-for-profit entity, the network, similar to the EPB network, provides access to a few kilometers of dark fiber between facilities. There is a plan to extend the network connectivity with dark fiber to both Montreal and Quebec City, both ambitious distances of approximately 150 and 225 kilometers, respectively.

Compared to quantum testbeds in Chattanooga and Sherbrooke, Quantum Corridor uniquely integrates research flexibility with commercial-grade infrastructure and a real-world operating environment (see Table 1).

Table 1. Comparison of North American Quantum Networks

Feature/Capability	Quantum Corridor	EPB	KIRQ
Geographic Scope	Multi-state (IL, IN) with Midwest expansion	City scale (Chattanooga)	City scale (Sherbrooke)
Primary Purpose	Commercial + research testbed	Research testbed	Research and startup incubator
Fiber Distance	12+ miles, scalable up to hundreds of km in development	Two 3-km paths	Few km now; some future expansion plans
Fiber Environment	Real-world temperature, vibration, physical infrastructure variation (highways, railways)	Controlled lab-like setting	Controlled testbed environment
Network Capacity	40 Tbps, scalable	Not specified	Not specified
Quantum-Safe Features	Encrypted services, PQC, multi-mode QKD, trusted node architecture	Some encryption; QKD focus	Dark fiber available; QKD experimentation

Commercial Use Support	Built for commercialization	Limited – subscription research model	Limited – research and startup development
Research Use Support	UChicago, Purdue, Roberts Impact Lab (current); expansion to other universities and government research orgs	U of Tennessee Chattanooga	Sherbrooke U
Network Scalability	Scalable with planned new nodes	Limited by design	Planned expansion, but limited scope

A Real-World Application

When Ciena, Toshiba and J.P. Morgan Chase built the first controlled Quantum Key Distribution (QKD) network in a lab setting in 2022, the findings set the table for Quantum Corridor's real-world application. To prove QKD-readiness, researchers transmitted across 70km of spooled fiber between two racks with two splices at each end. Certain variables like artificial tectonic activity were applied, however the lab tests were ultimately highly controlled.

Quantum Corridor built on those findings with its interstate, real-world network. The 12-mile network achieved successful round-trip transmissions via conduit and duct paths that traverse:

- Highways
- Bridges
- Train Tracks
- Waterways
- Splice Cases
- Vaults

Support services at both the Digital Crossroad Data Center and at all future Quantum Hubs/nodes include floorspace, ample power, cooling and computing access for customers linked to Quantum Corridor's network.

Real-World Environments as a Testing Advantage

Temperature

Despite being located on the shore of Lake Michigan, the Chicago-Northwest Indiana region does experience a significant variance in temperature throughout the year. The following graph illustrates the variation in temperature for 2024, along with a view of typical high and lows and seasonal variations.

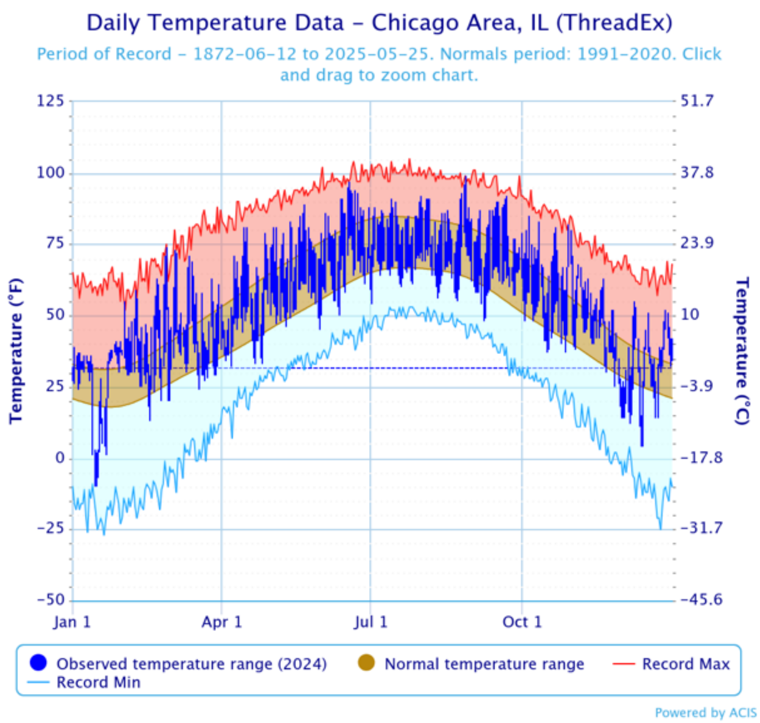


Figure 10 - Chicago-area temperature data – U.S. National Weather Service

While Quantum Corridor's fiber infrastructure is located inside subterranean conduits and thus not experiencing the full variance in daily and seasonal temperatures, the climate does provide for measurable temperature variations during any period. This data can help in the correlation of test results and help better characterize quantum science applications performance over a variety of temperature conditions outside of a lab environment.

Vibration

The Chicago and Northwest Indiana region is served by a dense ecosystem of roadways, highways and railways. The heavy traffic, along with the presence of a significant East-West corridor for transport and hauling companies, creates dynamic environments that are not easily recreated in a laboratory setting. Additionally, when considering that a sizeable segment of the global fiber infrastructure is located alongside railway systems, it is critical for research into quantum communication and sensing applications to take this into account to develop mitigating strategies during the technology development cycle. The impact of rhythmic and other vibrations on coherent signals is a phenomenon that has been characterized and addressed in the past for today modern's coherent optical classical communication systems. While researchers are keenly aware of the probable interference of railway systems on future quantum communication systems, offering a real testbed located alongside existing rail and road infrastructure makes Quantum Corridor's network ideal for characterizing those impediments and help build the required mitigation strategies early in the development cycle.

This temperature and vibration exposure ensures that Quantum Corridor is not only a proving ground for quantum technologies but also a preparation zone for their deployment in operational field conditions.

The following image provides a view of major rail systems in relation to Quantum Corridor's current network assets, offering partners and researchers options depending on the nature of the work being conducted:

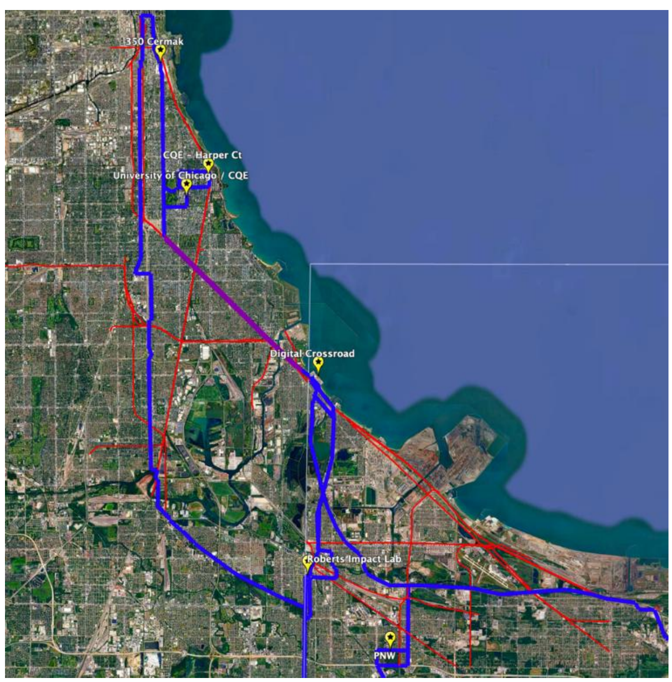


*Figure 11 - The network traverses the complex Chicagoland rail system. Rail lines are indicated in **red**. The current and future Quantum Corridor network is shown in **blue**. The portion of the network that runs beneath rail is marked in **purple**.*

Contrary to testing in a lab setting, Quantum Corridor's routing engine has made the technology commercially viable for customers on the IP session. Researchers are not managed service providers. Quantum Corridor has picked up where research leaves off by taking the theoretical and putting it into the real world to commercialize it.

Conclusion

Quantum Corridor demonstrates what is possible when quantum research meets infrastructure built for real-world deployment. As the first commercial quantum-safe network in North America, it bridges the gap between laboratory science and commercial operations. By enabling both secure commercial applications and advanced research today, Quantum Corridor is accelerating the quantum internet.