Use Case and Technology Evaluation Criteria – Construction Site

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1. Introduction

1.1. Vision

The construction industry faces persistent challenges that compromise safety and operational efficiency. Workers encounter hazardous conditions, while remote locations and a shortage of skilled labor worsen project delays and cost overruns. Traditional on-site inspections further strain resources, necessitating extensive travel and resulting in increased downtime.

IOWN technologies offer a groundbreaking solution: an ultra-high-capacity, low-latency network for real-time, data-driven construction management. By capturing and analyzing vast amounts of site data, IOWN enables AI-driven risk prediction, enhanced safety monitoring, and seamless progress tracking throughout and beyond the construction phase.

Scalable and cost-efficient, IOWN's solutions connect multiple construction sites, remote offices, and data centers, ensuring streamlined collaboration among contractors and clients. The result is faster project delivery, reduced risk, and optimized infrastructure lifecycle management, fostering a safer and more productive environment for all stakeholders.

1.2. Scope

This document describes the following two points:

- The Use Case and its key requirements
- The Technology Evaluation Criteria

While applicable to various construction sites, this document focuses on tunnel construction. Tunnel projects face many geological uncertainties and high activity near the tunnel face, making advanced network infrastructure particularly beneficial. As a result, the advantages of utilizing IOWN Technologies in this context are substantial.

2. Use Case

Enabling remote and data-driven tunnel construction enhances safety and efficiency, allowing for easier project management. Utilizing the IOWN-All Photonics Network (APN) enables an end-to-end workflow for acquiring data from multiple construction sites, delivering acquired data to various remote offices and data centers, analyzing data for anomalies, remotely instructing construction work, and monitoring deterioration over time after the construction is complete. This workflow incorporates AI-driven insights, benefiting both construction contractors and their clients.

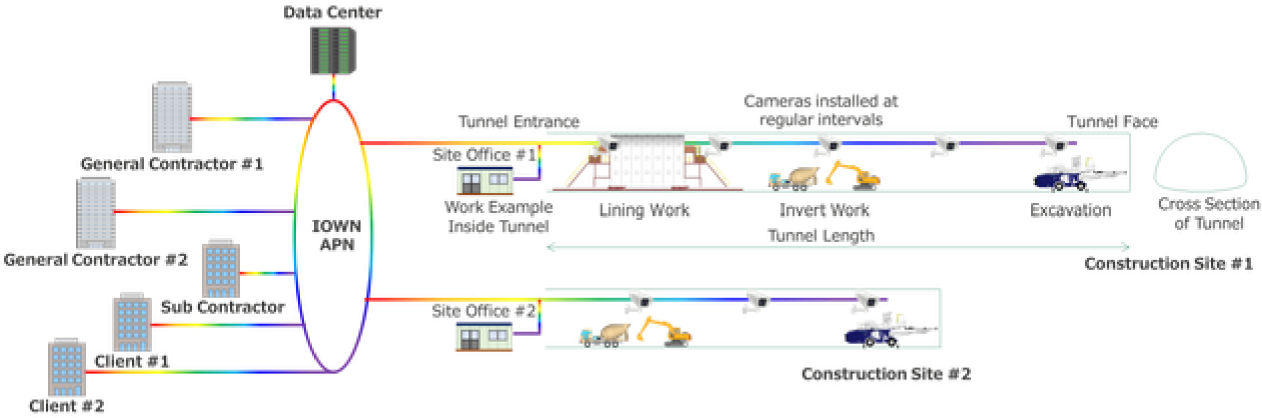

Figure 2.1: Overview of Construction Site Use Case

2.1. Continuous Surveillance and Data Acquisition

High-precision stationary monitoring data is continuously collected from image, vibration, water quality, thermal, and gas concentration sensors across multiple construction sites. This data is transmitted to data centers and general contractor offices for work process inspections, anomaly detection, safety confirmations, and work process improvements, all of which require a high-capacity and low-latency network. AI-driven automation enhances the accuracy and efficiency of these tasks, primarily benefiting general contractors.

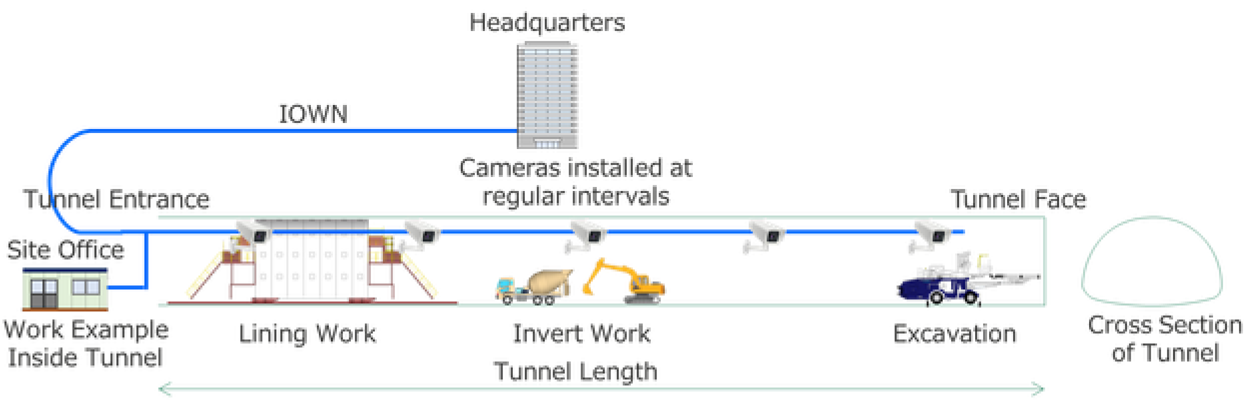

Figure 2.2: Camera Installation in the Tunnel for Continuous Surveillance

2.2. Event-Driven Monitoring and Data Analysis

At the tunnel face, various machinery is employed to perform specific tasks according to the construction phase. Observations are conducted at each phase using various sensors to gather data on the tunnel surface, including high-resolution imaging, high-resolution point cloud data, vibration analysis, thermal readings, and gas concentration measurements. This enables early detection of abnormalities, ensuring safety during these tasks and mitigating risks to workers. Based on geological conditions and excavation results, the next steps are determined, allowing for efficient project management. This event-driven monitoring enables time-sharing of network connections, reducing operational costs and primarily benefiting subcontractors.

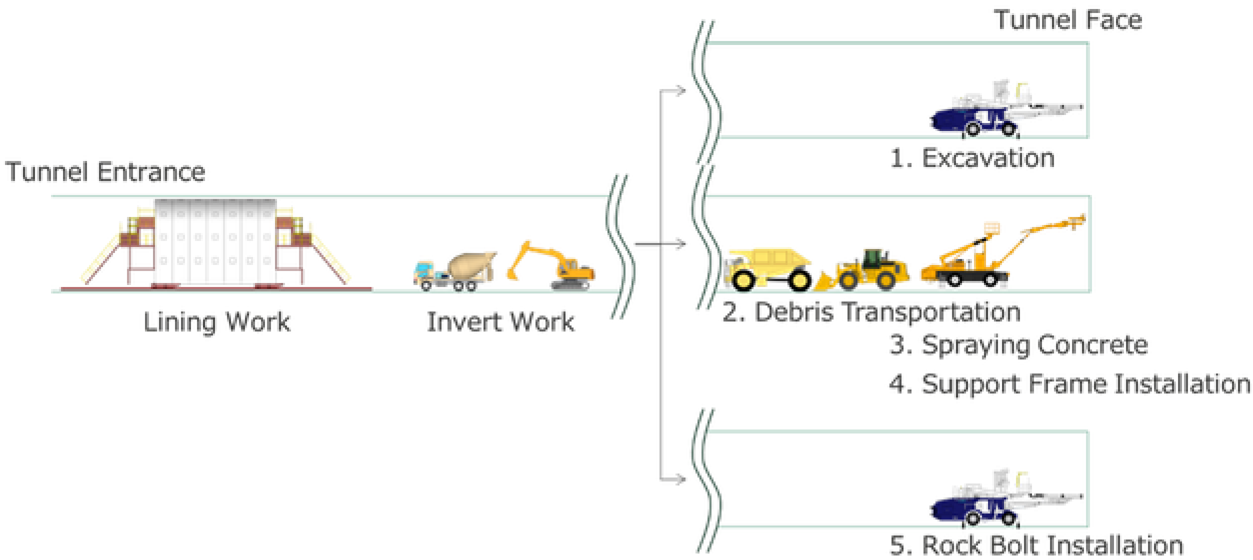

Figure 2.3: Construction Cycle at the Tunnel Face

2.3. Mobile Inspection

Inspections are conducted after each construction phase by the client and general contractors to ensure compliance with specifications and quality standards. These inspections target pinpoint and occluded areas that are not visible to stationary monitoring, focusing on detecting cracks and water leaks. Using a wireless or mobile camera with interactive remote communication enhances efficiency. Inspections are event-driven, so constant connection is unnecessary, and time-sharing of connectivity is preferred to reduce operational costs.

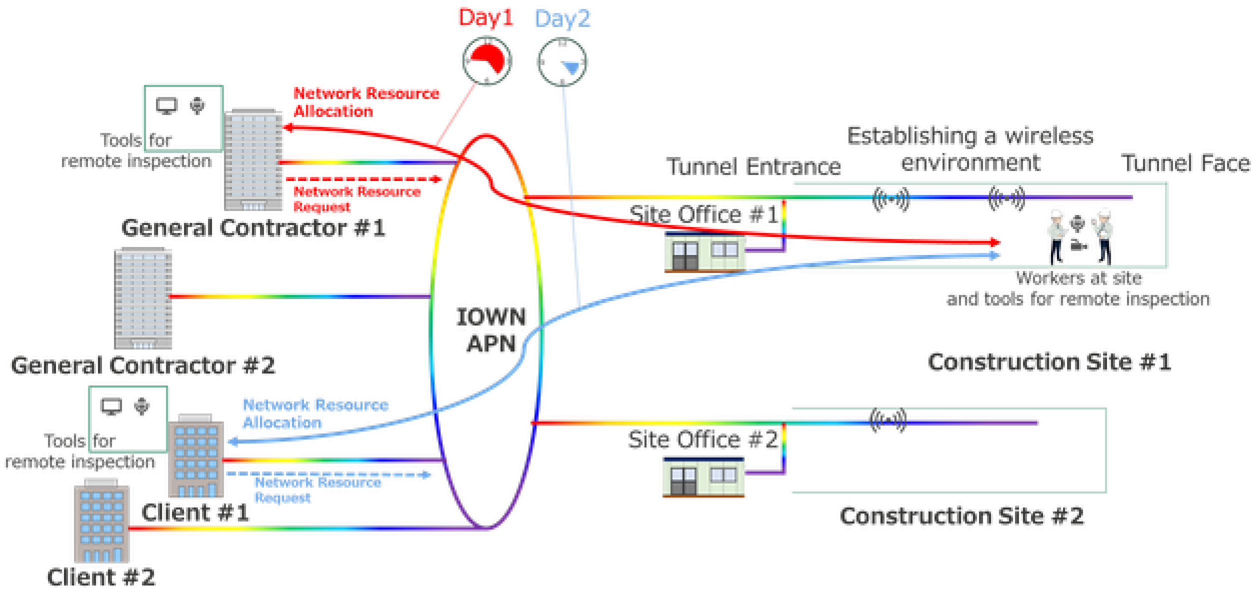

Figure 2.4: Mobile Inspection

2.4. Remote Maintenance Leveraging Embedded Infrastructure

Managing a network of tunnels that require regular maintenance to ensure safety and operational efficiency involves utilizing fiber sensors and network infrastructure installed during the construction phase. These resources are connected to a centralized control center, allowing remote monitoring and management of tunnel operations. This approach makes maintenance processes more efficient, ensures safety standards are met, keeps detailed maintenance records, and reduces ownership costs for the client.

3. Key Requirements

For each of the four sub-use cases, the Key Requirements are presented.

3.1. Continuous Surveillance and Data Acquisition

Table 3.1: Key Requirements for Continuous Surveillance and Data Acquisition

Item	Value	Note
Movie Transmission Bitrate	100 Mbps per unit	Install 8K cameras at approximately 100m intervals within the tunnel to continuously transmit movie to the site office or headquarters. The bitrate for the 8K cameras is set to 100 Mbps, including compression.

3.2. Event-Driven Monitoring and Data Analysis

Table 3.2: Key Requirements for Event-Driven Monitoring and Data Analysis

Item	Value	Note
Transmission Delay Including Data Processing	60 s	In tunnel construction, image data and shape data are measured at the end of work segments to decide the next work method. The acquired data is transmitted to a data center for image processing and point cloud processing, and the results are returned to the construction site. The transmission delay here refers to the time from data acquisition to data processing and back to the site. Since work must be stopped during processing, smaller delays are preferable to maintain the schedule. A permissible time of 60 seconds is set.

3.3. Mobile Inspection

Table 3.3: Key Requirements for Mobile Inspection with Network Time-Sharing

Item	Value	Note
Transmission Delay Including Wireless Section for Remote Inspection	0.1 s	In remote inspection, a general contractor employee moves within the tunnel construction site with a handheld device, focusing on areas instructed by a remote inspector. Since inspections are conducted continuously at arbitrary locations, communication is wireless. To change focus areas based on the inspector's instructions, bidirectional communication is necessary, and a delay of less than 0.1 seconds is set for seamless conversation. Images taken from a distance of 1m must be able to detect cracks of 0.2mm.

3.4. Remote Maintenance Leveraging Embedded Infrastructure

Table 3.4: Key Requirements for Remote Maintenance Leveraging Embedded Infrastructure

Item	Value	Note
Reuse of Optical Fiber Cable	--	Fiber cable used during construction can be reused during operation.

4. Technology Evaluation Criteria

To evaluate the effectiveness and merits of adopting IOWN Technologies to realize the use case, we define the Reference Case and Metrics below.

4.1. Reference Case for Continuous Surveillance

Table 4.1: Benchmark Conditions: Continuous Surveillance and Data Acquisition

Item	Value	Note
Tunnel Length	1,500 m	Average tunnel length for one section.
Communication Distance	1,000 km	Distance from the site in Hokkaido to the headquarters in Tokyo.
Number of Sites	Max 20	Number of mountain tunnel sites in Japan.
Monitoring Time	24 h	Communication is conducted all day due to day and night shifts.

4.2. Reference Case for Event-Driven Monitoring

Table 4.2: Benchmark Conditions: Event-Driven Monitoring and Data Analysis

Item	Value	Note
Bitrate	450 Mbps	Assuming 350 Mbps for 3D scanners and 100 Mbps for cameras.

4.3. Reference Case for Mobile Inspection

Table 4.3: Benchmark Conditions: Mobile Inspection with Network Time-Sharing

Item	Value	Note
Bitrate	100 Mbps	Assuming detection of 0.2mm cracks from a distance of 1m with 8K cameras.

Item	Value	Note
Communication Distance	1,000 km	Distance from the site in Hokkaido to the headquarters in Tokyo.
Number of General Contractors	5	Number of general contractors in a joint venture.
Inspection Time	1 hour	Switching connection destinations every hour.

4.4. Metrics

The following metrics will be measured when evaluating the developed system;

- Latency (for UC #1, #2, #3)
- Strain measurement accuracy (for UC #4)
- Spatial resolution (for UC #4)

5. Conclusion

This document presents the use case of remote inspection at construction sites, utilizing IOWN technologies, to revolutionize workflows in the construction industry. As a solution to the industry's challenges in safety and efficiency, IOWN's ultra-high-capacity, low-latency network enhances AI-driven risk prediction and safety monitoring. By connecting multiple construction sites, it facilitates seamless collaboration, aiming to achieve faster project completion and reduced risk.

This document outlines the first step of IOWN GF's activities to engage early adopters in the construction industry, evaluating the feasibility of this vision through the development of Reference Implementation Models and Proof-of-Concept (PoC) demonstrations.

History

Revision	Release Date	Summary of Changes
1.0	July 24, 2025	Initial version