CASE STUDY

Transforming Open-Pit Mining with IEI Rugged Panel PC

Delivering automation, visibility, and resilience in dust, shock, and temperature extremes of open-pit mining.

At a glance:

A global mining company needed a rugged in-vehicle system to support its open-pit automation goals, but harsh terrain, unstable power, and extreme environments made conventional solutions unsustainable.

IEI partnered with a mining system integrator to deploy a 12-inch rugged Panel PC as the central HMI across haul trucks. Powered by an Intel® Core™ i3 processor, the solution delivered real-time monitoring, intelligent dispatching, and semi-autonomous operation- resulting in a 40% reduction in idle time and a 35% decrease in maintenance hours. Engineered with MIL-STD-810H durability and ignition delay control, the system runs reliably in dust, vibration, and temperature extremes.

The mining industry is undergoing a rapid transformation toward digitalization and automation. Frequent hardware failures, idle equipment, and inefficient dispatching in harsh mining environments can cost operations millions annually in lost productivity and fuel waste. As open-pit mines race to automate, the lack of rugged, reliable computing platforms remains a major roadblock- especially in remote regions where extreme temperatures, dust, and vibration are constant threats.

To overcome these challenges, a global mining solution provider partnered with IEI and its system integrator to deploy a 12-inch rugged Panel PC across its haul truck fleet. Acting as the central human-machine interface (HMI), this solution enabled real-time monitoring, smarter dispatching, and remote or semi-autonomous operation- all while withstanding the industry's toughest conditions. The result: a 40% reduction in idle time, improved operator safety, and measurable productivity gains.

Close coordination among all stakeholders and clearly defined responsibilities were essential to the project's success. As open-pit mines continue scaling and automating operations, this case reinforces a critical insight: the foundation of successful digital transformation lies in deploying rugged, high-reliability computing systems designed to endure the industry's harshest environments.

> *"UPC is the keystone of our smart truck conversion. Its durability and delayed power-on/off feature let us capture every data point without fear of power cuts. Downtime is down, production is up, and our operators feel safer."*
>
> *- Maintenance Manager, Open-Pit Mine*

Challenges

Digitalizing mining operations offers significant promise, but implementing such strategies in open-pit environments presents real-world challenges. Most mine sites are located in remote and harsh terrains where IT infrastructure is limited or underdeveloped. This makes it difficult to establish stable data pipelines for real-time communication, monitoring, and analytics.

Reliable equipment operation is also a key technical hurdle. Mining vehicles and machinery must function under extreme environmental conditions - such as high temperatures, airborne dust, and persistent vibration. These stressors not only shorten equipment lifespan but also lead to frequent hardware failures, unplanned idle time, and fuel inefficiencies. Standard display systems often underperform or break down entirely in such settings, increasing the frequency and cost of reactive maintenance.

Beyond hardware resilience, operational visibility is a persistent issue. Without real-time system data, field teams struggle to track vehicle locations or coordinate dispatch efficiently. The lack of situational awareness compromises both safety and productivity, making it harder to optimize fleet movement and minimize delays.

Seamless Integration Through Strategic Partnership

Given the demanding operating conditions of open-pit mines and the technical intricacies of fleet digitalization, the project was best approached through close collaboration rather than isolated efforts.

IEI partnered with a system integrator experienced in deploying rugged solutions for heavy-duty machinery in mining industry. This integrator had an established relationship with the mining technology provider and played a key role in customizing and adapting the solution for real-world deployment.

Working hand-in-hand, the two teams jointly optimized key aspects of the system. One critical customization was the adjustment of the ACC (ignition) delay time - ensuring that the panel PC powers up and shuts down safely in sync with vehicle engine behavior, thereby preserving data integrity during power transitions.

In addition, the system leverages M12 I/O connectors with flexible cabling configurations, allowing internal ports to be flexibly mapped to external interfaces without requiring changes to the mainboard layout. This cable-based design enabled rapid customization of I/O functions based on deployment needs, ensuring secure, vibration-resistant connections within mining trucks. By decoupling hardware I/O definition from the board itself, the integrator achieved faster configuration, simplified maintenance, and greater scalability across different vehicle models.

UPC-F12M1-RPLP

Rugged, Intelligent Hardware Designed for Field Operations

- Intel® Core™ i3-1315URE Processor
  Efficient multi-core computing optimized for in-vehicle performance and low power usage.
- IP66-Rated Aluminum Enclosure
  Dust-tight and water-resistant against high-pressure spray; ideal for rugged outdoor conditions
- Custom M12 Connectors
  Industrial-grade power and I/O interfaces designed to resist vibration and secure field wiring.
- Optically Bonded High-Brightness Touchscreen
- Sunlight-readable (≥ 600 nits), glare-resistant, and suitable for outdoor visibility and usability.
- -20 °C to +60 °C Operating Temperature Range
  Wide-temperature components ensure reliable performance across varied mining climates.
- Ignition Delay (ACC Control)
  Smart power-on/off sequencing preserves data integrity during vehicle start-ups and shutdowns.

Built to Withstand Harsh Mining Environments

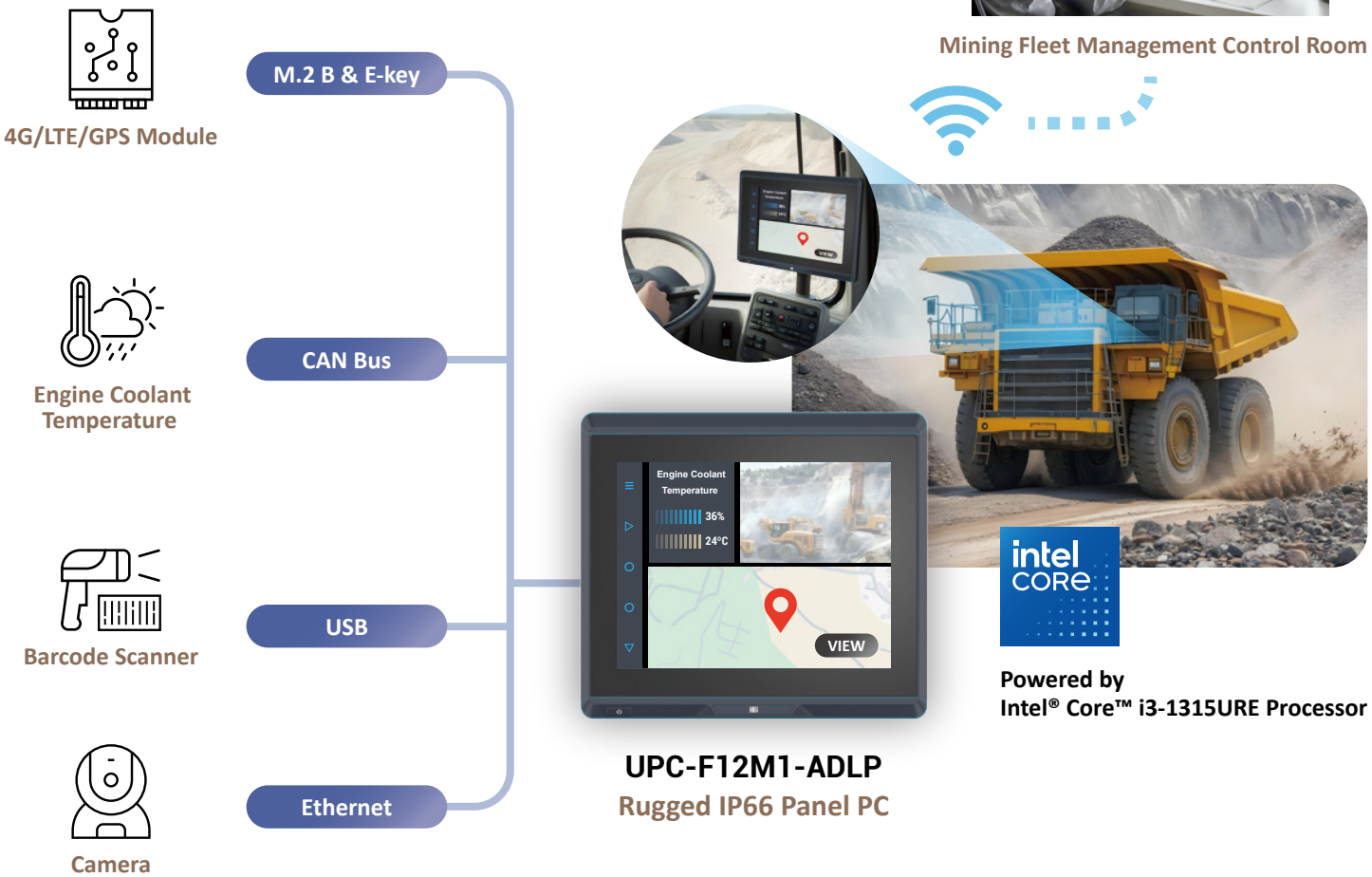
Because the solution was destined for deployment in open-pit mines across regions with extreme environmental conditions, the panel PC had to meet industrial-grade durability standards and ensure long-term operational reliability.

The device meets MIL-STD-810H, withstanding 7.7 grms vibration levels across 5-500 Hz under full load, proving its durability under real-world transport and in-cab field vibration scenarios typical of haul trucks operating on uneven terrain.

To support daily operations, the rugged 12" HMI plays multiple mission-critical roles inside the vehicle:

- **Vehicle Monitoring & Data Collection:**
  The panel PC interfaces with in-vehicle protocol, CAN Bus to collect real-time data on engine status, fuel usage, hydraulic pressure, lighting, voltage, and more. This data is displayed live, logged locally, and synchronized with backend systems to support predictive maintenance and operational transparency.
- **Vehicle Control Interface:**
  It acts as the front-end interface for various automated control systems, enabling functions such as engine start/stop, remote throttle/brake control, and driver-assisted operations. In some deployments, it integrates with positioning and path-planning modules to support semi-autonomous driving and route execution within the mining site.
- **On-Site Task Visualization:**
  The display provides real-time maps, job assignments, routing updates, alerts, and task schedules- helping drivers stay aligned with operational goals. By consolidating multiple displays (camera feeds, machine status, task reports) into one screen, the system improves visibility while reducing cabin clutter.
- **Communication & Logging Hub:**
  Acting as a communication bridge between the field and the control center, the system supports data transmission via 4G/LTE. It automatically uploads event logs, diagnostics, and alarm reports to backend systems- enhancing fleet coordination, safety, and decision-making.
- **Durability for Harsh Conditions:**
  Designed for industrial vehicles, the system features IP66-rated protection, wide-temperature operation, anti-vibration structure, and glove-friendly touch screen. It also supports vehicle-grade power input ranges, ensuring compatibility across mining truck platforms.

Mining Fleet Management Control Room



UPC-F12M1-ADLP
Rugged IP66 Panel PC

Powered by
Intel® Core™ i3-1315URE Processor

Proven Results in the Field

Since deployment, the solution has delivered measurable operational improvements across the mining fleet. Real-time monitoring has enabled site managers to continuously track the status and location of each haul truck, enhancing visibility and control. With predictive analytics powered by edge-collected data, the system now supports proactive maintenance, allowing teams to identify and address potential issues before failures occur- resulting in a 35% reduction in maintenance time.

Operational efficiency has also seen significant gains. By eliminating unnecessary idle time and streamlining dispatch coordination, the fleet achieved a 40% decrease in vehicle downtime, contributing to a marked increase in annual production output. These tangible improvements reflect the value of a reliable, integrated HMI platform tailored for the unique demands of open-pit mining.

> *At IEI, our heavy industry Panel PCs are designed with adaptability in mind - making 'them ideal for rugged applications like smart mining trucks. This architecture allows us to rapidly tailor features such as ignition delay control, vibration-resistant connectors, and communication interfaces based on customer needs. Because we handle everything from board-level design to system integration in-house, we significantly shorten the development cycle and reduce deployment risks. Whether adapting existing platforms or building fully customized solutions, our engineering team draws on deep industry experience to help customers accelerate their digital transformation in even the harshest environments.*
>
> *- Bill Yeh, Product Manager, IEI*

IEI Integration Corp.

IEI Integration Corp. builds up the business as a leading industrial computer provider, and turns to artificial intelligence and networking edge computing. IEI's products are applied in computer-based applications such as factory automation, computer telephony integration, networking appliances, security, systems, and in fields like AI, IoT (Internet of Things), national defense, police administration, transportation, communication base stations and medical instruments. IEI continues to promote its brand products as well as serving ODM vertical markets to offer complete and professional services.

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