

# RUGGED AND RELIABLE SOLUTIONS FOR INDUSTRIAL AND COMMERCIAL TRANSPORTATION (ICT)

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How TE Connectivity and LADD Distribution  
Solve ICT Connectivity Challenges in Ultra-Harsh Conditions



As mobility solutions become more connected, automated and electrified, in-vehicle component connectivity challenges are intensifying. However, robust power and signal connectivity solutions for transportation systems can meet the demands of connectivity in ultra-harsh environments, providing the reliability and availability these applications require.



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Passenger vehicle applications are increasingly crossing over into industrial and commercial transportation (ICT) applications. Features such as adaptive braking and steering, onboard diagnostics, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, and cameras that provide a 360-degree view of their environment are now becoming basic customer requirements and are being broadly implemented across the ICT industry.

At the same time, regulators and consumers are demanding cleaner, quieter alternatives to gasoline and diesel-powered engines. The ICT industry is responding with increasingly

electrified vehicle architectures. So, why can't ICT apply solutions developed for passenger cars to these new purposes?

Not so fast! Industrial vehicles operate in harsh environments, and as such, require more rugged and robust connection systems than passenger cars need. Sensors, connectors and relays must withstand dirt, moisture, salt, shock and vibration at industrial sites and during long-haul operations. Underhood applications operate at extreme temperatures, requiring that connectivity solutions deliver performance that far exceeds that of passenger cars. Interrupted or failed connections can lead to a host of ills. These issues include lost time, dissatisfied customers, reduced productivity, lower revenues, increased repair and maintenance costs, and safety risks for operators and other staff.

As if these factors aren't challenging enough, commercial vehicles are expected to provide exceptional performance across hundreds of thousands of miles (or more) and multiple decades of operation.

TE Connectivity (TE) develops and delivers reliable connectivity and sensing products designed to withstand harsh environments in heavy-duty truck and off-highway applications where failure is not an option.

***But how harsh is harsh?*** Let's explore this further.



*Result From A Harsh Operating Environment*



Figure 2: Industrial vehicles experience harsh environmental and operating conditions every day, across years of use.

**ICT Vehicles Must Withstand Harsh Environmental and Operating Conditions**

What sets ICT connectivity applications apart from passenger vehicles? There are two principal differences. First, the harsh operating conditions and applications that ICT vehicles are subjected are much more severe than those experienced by passenger vehicles. Second, the ramifications for a failed connection in a commercial or industrial setting are immense and costly. Whereas a passenger car’s failure may inconvenience consumers and result in costs in the hundreds or low thousands of dollars, an ICT vehicle’s failure could bring site operations to a stop and create business losses into the millions of dollars.

So, just how harsh are these environmental operating conditions? Temperature extremes for connectivity components can be as low as -40°C and as high as +150°C. Connections for ICT applications must be able to guard against solid particle intrusion by being dust-tight. They also must withstand liquid intrusion, including powerful high-temperature water jets. Think of a dump truck or concrete mixer that needs frequent intensive cleaning or a piece of mining equipment

that’s operating below the earth’s surface. That’s why connectivity solutions for ICT applications are designed to meet the requirements of IEC Standard 60529 Ingress Protection IP69K. Connectivity solutions must also be able to withstand contact with caustic and corrosive materials, whether from on-board systems like batteries and transmissions, or from external sources found in industrial settings.

These conditions described are just some of the more obvious environmental factors. Connectivity solutions in ICT applications may encounter explosive environments where any type of spark could potentially have catastrophic consequences. They also can be subjected to far noisier electrical environments than passenger cars. A sampling of harsh environmental conditions that are unique and/or extreme for ICT connectivity applications can be found in figure 2.

New ICT applications and architectures are driving the need for connectivity solutions that can thrive in harsh environments and fulfil other critical technical requirements.

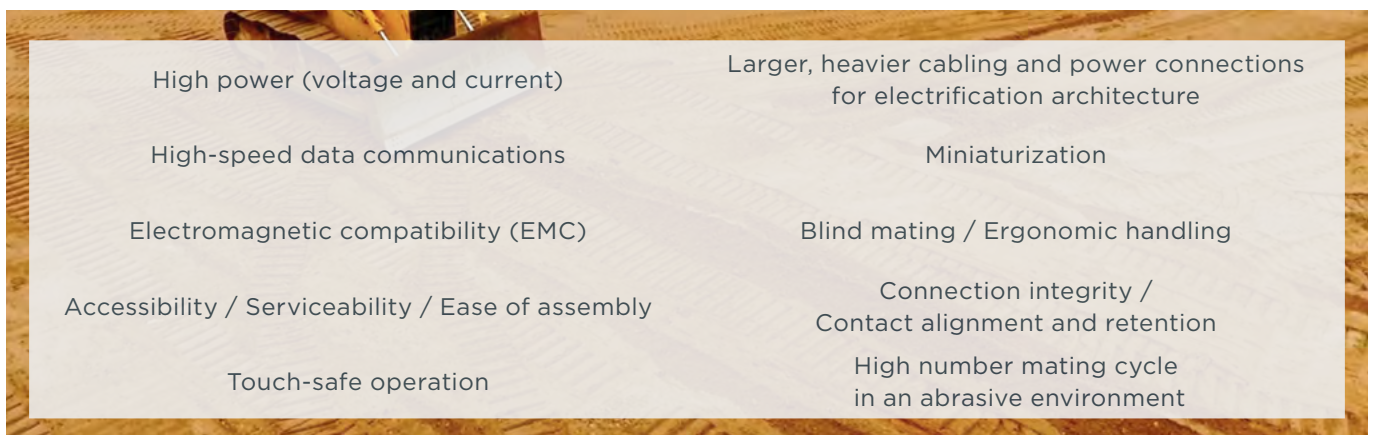


Figure 3: ICT implementation challenges

Today's trucks and industrial machinery are typically powered by internal combustion engines driving two or more wheels through a transmission. They primarily use gasoline, diesel fuel, or in some cases, compressed natural gas. While industry manufacturers have taken steps to improve fuel consumption and reduce emissions, including introducing 48V mild hybrid approaches, more improvements are needed.

Regional, national and state legislation, as well as diesel bans around the world, are providing the business case for the industry's drive to reduce emissions. As a result, vehicle manufacturers are accelerating development away from internal combustion engines (ICEs) and focusing more on architectures incorporating electric motors. The four primary architectures are conventional hybrids, plug-in hybrids, battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles.

As passenger and commercial vehicle architectures become increasingly electrified, with operating voltages as low as 48V and as high as 850V, commercial applications are experiencing unique implementation challenges. More electric power means bigger and heavier cables. In addition, cable runs must be longer given the greater size of commercial vehicles.

These cables may experience extensive shock and vibration. Construction machinery or long-haul trucks will typically have multiple operators, operate across extended workdays and experience operating conditions that can exact significant abuse on internal systems.

A similar story exists for applications relying on in-vehicle high-speed data connections. As sensors and intelligence increase in vehicle architectures to ensure efficient and safe operation, so does the need for high-speed data connec-

### Connectivity Challenges for In-Vehicle High Voltage Components

One perceived constraint in the adoption of electric vehicles is slow refueling. To meet consumers' expectations, electric vehicles need to charge in minutes, not hours. At the same time, vehicle-to-world connectivity means more sensors, displays and antennas. Increased automated and safety-critical control means more computing power as well as more power to drive electronic actuators for steering, braking, and suspension. This power also needs to be efficiently distributed. In-vehicle power and thermal management requirements are growing while in-vehicle components are shrinking. Designers are creating innovative solutions in smaller form factors that deliver exceptional performance while freeing up space under the hood. All of these trends present challenges and opportunities for providing robust, reliable in-vehicle power and signal connections.

Material improvements and innovations are needed to address the forward-looking requirements of all-electric powertrains. For example, a charging inlet will be subjected to thousands of mating cycles, well beyond typical automotive applications. The metal contacts, over their entire operation lifecycle, need to be highly conductive, with high wear resistance and low friction.

TE Connectivity is developing a suite of contacts that optimize strength, improve conductivity and reduce friction using various copper base alloys

and unique structured surfaces. One challenge as we design components, which include plastic parts, is to meet the industry-lagging Standard ISO 60664 which defines required dimensions for a certain voltage (the creepage and clearance distances) only up to 600V.

Newer fast charging requirements now specify voltages up to 1500V, widening the gap between ISO 60664 and proposed standards. System designers and component suppliers thus need to possess a deep understanding of how electricity interacts with various base resins and fillers, as well as work together to match solution materials to current charging profiles in terms of timing and peak power.

More demanding high-power charging requirements, when combined with size constraints for in-vehicle components, push the boundaries of physics. Where there's power, there's heat, so proper thermal management is another key challenge. TE possesses in-house electro-thermal modeling and simulation capabilities, enabling our teams to optimize the design of components and subsystems that experience high charging voltages. We work with our customers, at the component and system level, to account for size, material and cabling requirements to optimize their performance.

tivity. As a contrast, running camera video from the rear of a passenger car is far simpler than running the same information from the rear of a tractor trailer. Signal integrity, distortion and noise susceptibility challenges increase exponentially in ICT applications.

Electrification and data connectivity trends are just two of the examples that increase the complexity of designing high-performance ICT vehicle architectures. Miniaturization, ergonomics, ease-of-assembly and serviceability are a few other examples of issues that need to be fully thought through as designers create new solutions and components for ICT vehicles. Figure 3 summarizes a few examples of these challenges.



### TE Designs for Harsh Environments

TE Connectivity is solving the industry's harshest technical and operational challenges. In heavy industries, electrical systems must stand up to rigorous conditions and all-weather environments. Electrical system failures can be expensive to diagnose, as well as cause costly equipment outages. As equipment becomes increasingly sophisticated and reliant on electronic packaging and diagnostics, it's more important than ever to choose environmentally sealed electrical connectors that are capable of holding up to extreme conditions.

Many manufacturers count on TE Connectivity's Industrial and Commercial Transportation electrical connectors to maintain their electrical connections, day in and day out, in truly punishing operating conditions.

Our **DEUTSCH** industrial environmentally sealed electrical connectors are for critical applications and are designed to withstand the harshest and most challenging environments. They are designed for critical applications where dust, dirt, moisture and vibration can damage electrical connections.

Our **AMPSEAL** connectors provide rugged reliability, ease of use and superior environmental sealing. They are available in cable plugs and PCB mount headers that are designed to stand up to high-temperature underhood applications.

Our **AMPSEAL 16** high temperature connectors are the newest addition to our well-established AMPSEAL 16 connector product portfolio. This wire-to-wire and wire-to-device connector line was designed to meet the rigorous demands of an industry that requires the highest standards in performance.

Our **Heavy Duty Sealed Connector Series** offers several cavity arrangements and mixed wire sizes. The rugged, thermoplastic connectors have a secondary lock with a poka-yoke feature and can be used for in-line or flange mount applications. They are available in five housing sizes and four keying options.

Our **LEAVYSEAL** products use a lever lock system for mating. These ruggedized connectors are multi-pin, accept multiple wire sizes, and are available in several mounting styles and keying options. The housings come in six sizes and feature an integrated cable attachment.

No matter how harsh your industrial application, we have connectivity solutions that will exceed your requirements. Our in-house application tooling developers at TE Connectivity ensure that our customers can apply and service all of our product offerings.

**TE and LADD: Trusted and Reliable Partners for Demanding ICT Applications**

**About LADD Distribution**

LADD Distribution is a TE company, focused on customer fulfillment of TE Connectivity’s DEUTSCH, AMPSEAL and AMPSEAL 16 electrical connectors and accessories. LADD provides both distribution and technical support, to ensure customers have an exceptional experience with TE products.

LADD teams strive to exceed customer expectations by providing knowledgeable, personalized customer care. Our highly trained customer service associates deliver targeted support, guiding our customers through the process of placing orders, obtaining quotes and receiving technical assistance.

LADD can assist customers from initial design to final assembly of industrial environmentally sealed connectors. Our application consultants are available to provide on-site design-in assistance, technical support and product training. LADD’s goal is to help you find, procure, receive and apply the right solutions for your specific applications.

LADD Distribution has been serving customers in the off-highway, marine, trucking, construction, agricultural and engine industries for more than 30 years.

**About TE Connectivity**

TE Connectivity is a system-knowledgeable connectivity solutions supplier with electronics architecture and physical integration expertise. We speak our customers’ technical language, working closely with ICT organizations to develop solutions based on the latest standards, technologies and materials innovations.

We support our customers with a comprehensive product portfolio of robust solutions for high-power and high-data rate applications and technical design, manufacturing and application tooling know-how. Only TE provides the engineers and scientists, co-creation capabilities and local presence to serve you in every market and industry and ensure you have a reliable source of high-performance products when and where you need them.

From concept to design, through manufacturing to field support, TE harnesses our more than 75 years of deep industry experience to support our customers every step of the way. We measure our success by our customers’ success.

**Because trusted connections count.**



Figure 4: LADD Distribution offers a host of value-added services

## About TE Connectivity

TE Connectivity is a global industrial technology leader creating a safer, sustainable, productive, and connected future. Our broad range of connectivity and sensor solutions, proven in the harshest environments, enable advancements in transportation, industrial applications, medical technology, energy, data communications, and the home. With more than 85,000 employees, including over 8,000 engineers, working alongside customers in approximately 140 countries, TE ensures that EVERY CONNECTION COUNTS. Learn more at [www.te.com](http://www.te.com) and on LinkedIn, Facebook, WeChat and Twitter.

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## Connect with us

We make it easy to connect with our experts and are ready to provide all the support you need. Visit [www.te.com/support](http://www.te.com/support) to chat with a Product Information Specialist.

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