



# S.1 Electrical Study Group Position Paper: 2024-3

## *Recommendations Regarding Technical Needs for Next Generation Tractor/Trailer Electrical and Data Connectivity*

Developed by the Technology & Maintenance Council's (TMC) S.1 Electrical Study Group  
Next Generation Tractor/Trailer Electrical Interface Task Force

### **ABSTRACT**

The SAE J560 Tractor/Trailer Electrical Interface has served as the industry's standard means of connectivity for more than 60 years. However, market-ready advancements in technologies that enable improved safety, efficiency, and durability cannot be applied due to the low-bandwidth and relatively low conductor count of the J560 connector. TMC's S.1 Electrical Study Group and its Next Generation Tractor/Trailer Electrical Interface Task Force developed this position paper to provide a set of technical characteristics to facilitate advancement of trailer technology through modernizing the truck/trailer interface in a way that minimizes the burden on fleets and individual owner/operators, and allows for the best opportunity for successful industry adoption without causing unnecessary business disruption yet still provide the necessary expansions to accommodate future truck/trailer functionality. TMC recommends that the industry consider these criteria in development of TMC Recommended Practices and design and testing norms by industry standards organizations.

### **INTRODUCTION**

The SAE J560 Tractor/Trailer Electrical Interface (J560), and its revisions, has served the industry well for more than 60 years. This standard has allowed the transportation industry in North America to prosper by ensuring that almost all tractors — regardless of owner, operator, manufacturer, make, model and age — are capable of connecting to almost all trailers in order to power brake and lighting systems

and provide limited communication capability for antilock braking system (ABS) safety and compliance. The transportation industry in North America would look significantly different than it does today without the standardization brought about by SAE J560.

The current design standard (revised in February 2020, is SAE J560\_202002, *Primary and Auxiliary Seven Conductor Electrical*

*Connector for Truck-Trailer Jumper Cable*, which provides the minimum requirements for primary and auxiliary jumper cable plug and receptacle for the truck-trailer and converter dolly jumper cable systems for 12-volt direct current (DC) nominal applications. It includes the test procedures, design, and performance requirements. TMC recognized the SAE J560 standard as the referenced performance criteria for its Recommended Engineering Practice TMC RP 107C, *Seven Conductor Truck-Trailer/Converter Dolly Jumper Cable and Connection Selection*, as the industry benchmark for the electrical and data interface.

However, the J560 interface must be modernized to meet new market recommendations and allow for the advancement of technologies now available to the trailer market. The application of technologies vetted in the automotive and tractor markets that promise improved safety, efficiency, and durability cannot be applied due to the low-bandwidth and relatively low conductor count of the J560.

Attempts to modernize the J560 interface are not new. SAE J2691, *15-Pole Connector Between Towing Vehicles and Trailers with 12-Volt Nominal Supply*, last revised in 2020, was meant to replace J560 and included the additional communications and extra conductors to allow the trailer to advance at a similar rate to that of the tractors in the industry. However, the J2691 interface has not seen significant market penetration. This is generally understood to be because it is not backward compatible with the J560 interface and truck/trailer retrofits would require significant investment and industry-wide coordination. By and large, the industry wants a safer, more efficient and overall “smarter” trailer. Generally, it is agreed that one important step to achieving this is updating the existing J560 interface.

TMC's S.1 Next Generation Tractor/Trailer Electrical Interface Task Force was created to support the advancement of the effort to

update the existing tractor/trailer interface in North America by working with the industry professionals that will be responsible for the design of the interface, its implementation, and eventual standardization. Participants in TMC's S.1 Task Force include original equipment manufacturers (OEMs), component and systems suppliers, service companies and fleets. At the time this writing, the Task Force included more than 175 individuals. A number of the Task Force members are also active in standards development task forces at SAE and other organizations that are also considering various aspects of the tractor trailer interface.

A second Task Force, created by TMC's S.7, Trailers, Bodies and Material Handling Study Group, was established to evaluate the architectural needs for a next generation (NextGen) interface. This Task Force completed its work with the publication of TMC Position Paper, *TMC PP 2023-1: Design Recommendations for Next Generation Trailer Electrical Architecture*. TMC's S.1 Task Force has taken these “guiding principals” into account as it developed this document.

This position paper is based on significant research done to determine a set of technical performance needs for a NextGen tractor/trailer interface that can garner the support of fleets, independent operators, and other implementers, while satisfying the technological needs of manufacturers, upfitters, and aftermarket suppliers looking to advance trailer technology. The findings presented herein are intended for one or both of the following objectives:

- Development of a TMC Recommended Engineering Practice for selection/design criteria for currently existing or as-yet-to-be developed interface solutions. Once adopted through TMC's RP development process, these criteria could then be referenced by those interested in vetting and presenting actual interface solutions to the industry—a benchmark to use that gauges the industry acceptance

one would expect based on the number and criticality of recommendations being met. These recommendations could also be used by those interested in developing a new interface to meet the industry demand.

- Use by an engineering organization (e.g. SAE and/or ISO) in development of new design, testing and performance standards. These recommendations can be used to understand the needs/desires of the interface implementers and users when updating or creating new benchmarks related to the modernization of the truck/trailer interface for North America.

This position paper provides a general description section that details the scope of the needs assessment exercise engaged upon by TMC's S.1 Task Force and the resulting findings regarding the technical needs for a NextGen Interface. These technical criteria detail the Task Force's consensus on the description of each of the criteria identified, as well as clarifications and justifications for each. The intent is to communicate how the Task Force came to the determination to include each criteria. These findings are arranged in a multilevel list for clarity and ease of reference.

## **GENERAL DESCRIPTION FOR A NEW INTERFACE CONCEPT**

The findings presented herein describe technical needs for any new interface between a truck and a trailer, referred to as the "NextGen Interface" or just "NextGen" when appropriate. The NextGen Interface is a concept for a new interface connecting heavy-duty Class 7-8 power units (i.e., tractors) and trailer(s), including converter dollies in longer combination vehicles. It is not meant to represent any specific product or idea that already exists in the market.

While it is possible that one or more interfaces capable of meeting all the technical criteria described herein already exists, the intention

of the Task Force was to describe an "ideal" interface and not be constrained by existing art. However, significant consideration was given to available and yet-to-be available technology, since the interface is desired to be backward compatible, yet expandable. The Task Force also determined that in order to garner support from the implementers, the interface should be designed so to last at least twice the expected service life of today's assets.

The following describes some of the constraints considered during this exercise:

### ***a. Expandability to Carry Forward until 2055***

— The Task Force agreed that the NextGen Interface should include enough future expandability to accommodate for technologies expected to emerge up to 2055. In general, the Task Force relies on the increased baud rates of the included communication interfaces to protect for this. However, additional electrical loads on the trailer are also expected and addressed. In the event that new lights, cameras and other sensors and ancillary devices are required, the Task Force took the approach of encouraging Controlled Area Network (CAN) or Ethernet-controlled devices that are supplied power from common sources, as opposed to attempting to protect for separate conductors for each. Adding conductors makes a physical connector more bulky, complex, expensive and difficult for a driver to manage, so emphasis was placed on only adding conductors when absolutely necessary.

### ***b. Exclusion of Autocoupler Considerations***

— The Task Force agreed that the NextGen Interface is not necessarily meant to be an interface used for or by fully automated coupling systems (FACS) — also known as auto coupling systems. Although technologies capable of automatically coupling the tractor to the trailer without the need for driver intervention are exciting, the state of development and adoption time frame are unknown at present. Exclusion of FACS allows for the

advancement of the NextGen Interface to move forward without having to wait for development of these technologies.

**c. Wireless Solution Considerations** — Although a completely wireless NextGen Interface should be considered if such a solution may be presented, the Task Force agreed that the current challenges associated with a safety critical systems (e.g., trailer braking and others) receiving input and sending output through wireless means are not likely to be overcome to the satisfaction of SAE or ISO in the near future. For this reason, wireless interface solutions were not considered during the construction of these recommendations.

## TECHNICAL NEEDS

After exhaustive discussions over multiple meetings to assess the technical needs to be fulfilled by a NextGen Connector, the Task Force decided to issue a set of recommended high level and detailed technical criteria.

### High-Level Criteria

The following high-level considerations have been identified for the NextGen Interface:

- SAE J560 compatibility.
  - This assumes the pins related to SAE J560 backward compatibility will remain 12 volt.
- A minimum of two additional power pins, compared to the J560.
  - One of these additional power pins to be dedicated for 24-volt functionality
- One CAN network dedicated for ISO 11992 compliant operation for trailer braking and safety systems.
- One CAN FD “capable” network for other CAN communications.
- Two Ethernet connections capable of a minimum 1.0Gb/s speed.

### Detailed Criteria

The following are the detailed technical criteria for a NextGen Interface agreed upon by the Task Force and its representative clarifications

and justifications. All references related to SAE, ISO or other relevant industry standards are based on the current version of the publication available at the time this position paper was published.

## 1. Compatibility

**1.1. Backward Compatibility** — The proposed NextGen Interface must remain backward compatible with SAE J560 as described in all sub recommendations of this section.

### 1.1.1. Connector Housing Compatibility (Trailer Side):

**1.1.1.1.** The NextGen connector, when installed on a tractor, must allow a trailer equipped only with a compatible J560 socket to mate with it.

### 1.1.2. Socket Housing Compatibility (Tractor Side):

**1.1.2.1.** The NextGen socket, when installed on a trailer, must allow a tractor equipped only with a compatible J560 connector to mate with it.

### 1.1.3. Connector Housing Compatibility (Tractor Side):

**1.1.3.1.** The NextGen connector, when installed on the trailer, must mate to a tractor that has only an SAE J560 compatible socket on it.

### 1.1.4. Socket Housing Compatibility (Trailer Side):

**1.1.4.1.** The NextGen socket, when installed on a tractor, must mate to a trailer equipped only with a compatible J560 connector on it.

### 1.1.5. J560 Interface (pin configuration):

**1.1.5.1.** The NextGen connector and

socket must maintain all existing pin configuration functionality as described in the latest version of SAE J560 standard. This includes (but is not limited to) pin size, shape, length and geometric configuration.

#### **1.1.6. J560 Interface (Electrical Capabilities):**

**1.1.6.1.** The NextGen connector and socket must maintain all existing electrical capabilities as described in latest version of SAE J560 standard. This includes (but is not limited to) the voltage capability and current capability.

#### **1.1.7. J560 Locking Mechanism:**

**1.1.7.1.** The locking mechanism of the NextGen connector and socket, when mated to a legacy SAE J560 connector or socket, must behave in a manner consistent with the latest SAE J560 Standard.

#### **1.1.8. J560 PLC Communications (SAE J2497):**

**1.1.8.1.** Pertaining to PLC communications as described in SAE J2497: only the MID 10 and 11 lamp messages, MID 125 J2497 identification, and MID 87 active ABS event shall be permitted on new tractor and trailer equipment having CAN or Ethernet available in the tractor trailer interface. All other messages described within J2497, J1587 and J1708 including diagnostic commands via J1587 Data Link Escape messages over J2497 are discouraged from continued use on new tractor

and trailer equipment having CAN or Ethernet available in the tractor trailer interface. New trailer equipment having CAN or Ethernet available in the tractor trailer interface shall implement sending of MID 10 and MID 11 lamp messages, dropping any and all messages on ingress. For both new trailer and new tractor equipment having CAN or Ethernet available in the tractor trailer interface all other functions previously used on J2497 will be migrated to CAN or Ethernet now available in this new interface.

**1.1.8.2.** For protection of older trailer equipment from J2497 attacks: new tractor equipment having CAN or Ethernet available in the interface to the trailer will include at least one attack mitigation.

### **1.2. Compatibility Recommendations Clarifications and Justifications:**

The following section details clarifications and justifications related to the recommendations in this section.

**1.2.1.** An interface that utilizes multiple electrical connectors to meet the recommendations in this section is still considered backwards compatible with the J560 interface.

**1.2.2.** An interface that utilizes an or multiple adapters to meet the recommendations of this section is still considered backwards compatible with the J560 interface.

**1.2.3.** Harmonization with the European Union (EU) was purposely omitted from the finding presented here. It is the opinion of this TMC Task Force that although worldwide (or North American/

EU) adoption of a single truck/trailer interface would be ideal, the coordination required would delay a J560 replacement for an unacceptable amount of time for the following reasons:

- 1.2.3.1. The EU currently utilizes several connectors, all of these would have to be considered in the design of the NextGen Interface.
- 1.2.3.2. Both 24-volt and 12-volt systems would need to be coordinated. This also adds complexity to potentially include discussions of other voltage levels.
- 1.2.3.3. The current EU standard is more modernized than North America, and there does not appear to be as much pressure in EU to change the standardized interface there.
- 1.2.4. Further to the item above, although it is not a recommendation that the new NextGen Interface be harmonized with Europe, it should not be discouraged during the selection process.
- 1.2.5. The J2497 databus is susceptible to remote write of J2497 messages in certain trailer configurations c.f. CVE-2022-26131. Trailer and tractor equipment to this day reacts to diagnostics and other commands over J2497 that is at risk of being compromised by attacks. The introduction of the new tractor-trailer electrical interface is the key moment to deprecate the continued use of the dangerous practice of command and control over J2497. Any and all functions presently implemented over J2497 other than the MID

10 et. al. captured in 1.1.8.1 can be migrated to the new interfaces proposed where modern security controls can also be implemented and the decades-old implementations can be dropped, particularly diagnostics. Furthermore, given the long service lifetime of the trailers it is important that the new tractor equipment include mitigations for J2497 attacks on older trailer equipment which is the rationale for 1.1.8.2.

## 2. CAN Networks and Related ABS/Electronic Braking System (EBS) Bus

**2.1. CAN Networks and Related ABS/EBS Bus Recommendations:** The proposed NextGen Interface must include at least two (2) CAN networks.

- 2.1.1. The interface must include one (1) ISO 11992-1/2 compliant CAN bus.
- 2.1.2. The interface must include one (1) CAN bus dedicated to communications not already considered with ISO 11992-1/2. This CAN network must allow for future expandability similar to that offered by CAN FD.

**2.2. CAN Networks and Related ABS/EBS Bus Recommendations, Clarifications and Justifications:** The following section details clarifications and justifications related to the recommendations in this section.

- 2.2.1. The Task Force agreed that segregating a separate CAN bus specifically for brake system use would allow for braking manufacturers to quickly adopt CAN protocols similar to those

achieved with ISO 11992-1 and ISO 11992-2 in EU.

**2.2.2.** The addition of the second CAN bus was determined to be a necessity for the following reasons:

**2.2.2.1.** Utilization of the ISO 11992-1/2 protocol on any single CAN bus essentially closes the bus to any new traffic or future expansion until brake manufacturers/SAE are able to expand the bus.

**2.2.2.2.** The Task Force thought it prudent to segregate an entire CAN bus to braking function so that safety-related functions that require significant testing and review do not necessarily have to slow the expansion of a separate bus carrying non-safety critical data.

**2.2.2.3.** The segregation of a single CAN bus specifically identified as a dedicated braking system CAN bus allows nearly immediate adoption of the ISO 11992-1/2 protocol by braking manufacturers and the fleet return on investment (ROI) that comes with it.

**2.2.2.4.** The adoption of the ISO 11992-1/2 protocols for braking systems allows at least some level of shared functionality between North American and EU trailers and reduces workload on trailer braking system manufacturers. Essentially beginning the homogenization process for a global tractor/trailer interface.

### **3. Ethernet Networks**

**3.1. Ethernet Network Recommendations:**  
The proposed NextGen Interface must include at least two (2) Ethernet networks.

**3.1.1.** The proposed NextGen Interface must include at least two (2) Ethernet Networks that allows for a minimum of 1Gb/s.

### **3.2. Ethernet Network Recommendations Clarifications and Justifications:**

The following section details clarifications and justifications related to the recommendations in this section.

**3.2.1.** The Task Force believes (2) Ethernet networks are required for sufficient redundancy for safety critical systems that intend to utilize Ethernet for communication.

**3.2.2.** Although the Task Force feels additional bandwidth is desirable for each bus, certain technological barriers including (but not limited to) silicon production and availability, ohmic losses and supply chain issues make it unreasonable to raise the minimum bandwidth for this section and still expect a timely release of a new interface.

### **4. Additional Pins**

**4.1. Additional Pins Recommendations:**  
The proposed NextGen Interface must include at least (2) additional pins beyond that accounted for per SAE J560 and all other section of this document to accommodate auxiliary loads from the tractor to the trailer:

**4.1.1.** The interface will incorporate at least one additional constant power pin that can accommodate a load similar to that described for the AUX pin per SAE J560.

**4.1.2.** The interface will incorporate at least one additional constant power pin that can accommodate a 24-volt load similar to

that described for pin 9 per ISO 12098.

#### **4.2. Additional Pins Recommendations Clarifications and Justifications:**

The following section details clarifications and justifications related to the recommendations in this section.

- 4.2.1.** The additional 12-volt pin is included in order to allow for a dedicated brake system power circuit.
- 4.2.2.** These additional pins are meant to support ancillary and after-market power recommendations such as, but not limited to liftgate charging, sensors, additional CAN-based lighting and telematics systems.
- 4.2.3.** The additional 24-volt pin is included in order to allow for brake controller supply voltage in road train applications where voltage loss on the 12-volt circuit would result in insufficient operating voltage on rearward trailer units of a road train.
- 4.2.4.** The additional 24-volt pin is included in order to allow for adapters to be developed that allow for SAE (North American) standard trailers to be electrically coupled to ISO standard (EU, Australian and South American standard) trucks and visa-versa.

### **5. Intellectual Property (IP)**

#### **5.1. IP Recommendations:**

The design of the NextGen Interface must include at least the following elements that are free of IP restrictions that limit their use.

#### **5.1.1. General Geometry:**

**5.1.1.1.** The general geometry of the interface connector and socket including, but not necessarily limited to the shape, size, connection procedure (if applicable), locking feature orientation and overall positioning.

#### **5.1.2. Pin Configuration:**

**5.1.2.1.** The orientation, size shape and length and purpose of the pins used in the design.

#### **5.1.3. Locking Features:**

**5.1.3.1.** Features included in the geometry of the design that allow for a standardized locking system for the NextGen Interface from manufacturer to manufacturer.

### **5.2. IP Recommendations, Clarifications and Justifications:**

The following section details clarifications and justifications related to the recommendations in this section.

**5.2.1.** Overall, the spirit of this section is to promote an environment where manufacturers are free to compete with designs of varying concept and feature, but all are able to interface with one another. Similar to the current environment created by the SAE J560 standard.

### **CONCLUSIONS**

With the findings detailed herein, TMC's S.1 Electrical Study Group now has set of benchmarks by which to systematically evaluate current and future proposals for the NextGen tractor/trailer interface(s). Additionally, TMC hopes that this position paper will serve as a guide that provides individuals and/or organizations insight into the needs of the industry



and the desires of the implementers of a new tractor/trailer interface in the North American trucking industry.

TMC anticipates that the industry will decide for itself through organic implementation of NextGen Interface(s) that is vetted and accepted by a small number of fleets at first, then more as time goes on. As with the implementation of the J560 connector to become the standard interface nearly 60 years ago, market forces will drive any widespread adoption of a single NextGen connector.

## NEXT STEPS

TMC's S.1 Electrical Study Group will continue its work to evaluate multiple proposed solutions to the development of a common NextGen Interface, some of which are conceptual and some of which exist in the current market or in prototype phase. TMC notes that most, if not all of the proposals identified to date meet all the technical criteria identified in this paper. This continuing process will include a significant effort to involve a input from fleets into the evaluation of the various proposals that have or may be presented.

As consensus develops into one or more preferred solutions, perhaps from consolidation of various concepts, TMC's Study Groups and Task Forces will, as appropriate, develop a Recommended Engineering Practice for the specifications of a NextGen Interface to succeed TMC RP 107C, in parallel with standards organizations (SAE and/or ISO) as engineering and testings standards may be developed.

## REFERENCES

TMC RP 107C, *Seven Conductor Truck-Trailer/Converter Dolly Jumper Cable and Connection Selection*. <https://tmc.trucking.org>.

TMC Position Paper, *TMC PP 2023-1: Design Recommendations for Next Generation Trailer Electrical Architecture*.

ISO 7638-1:2018: *Road vehicles — Connectors for the electrical connection of towing and towed vehicles — Part 1: Connectors for braking systems and running gear of vehicles with 24 V nominal supply voltage*. International Organization for Standardisation (ISO), Chemin de Blandonnet 8, CP 401 - 1214 Vernier, Geneva, Switzerland (<https://iso.org>)

ISO 11992-2:2014: *Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles — Part 2: Application layer for brakes and running gear*.

ISO 12098:2020: *Road vehicles — Connectors for the electrical connection of towing and towed vehicles — 15-pole connector for vehicles with 24 V nominal supply voltage*.

SAE J560\_202002: *Primary and Auxiliary Seven Conductor Electrical Connector for Truck-Trailer Jumper Cable*. SAE J2497\_201207: *Power Line Carrier Communications for Commercial Vehicles*. SAE International, 400 Commonwealth Drive, Warrendale, PA 15096, [www.sae.org](http://www.sae.org).

SAE J2691\_202002: *15 Pole Connector Between Towing Vehicles and Trailers with 12 Volt Nominal Supply*

[CVE-2022-26131](https://cve.org): Power Line Communications PLC4TRUCKS J2497 trailer receivers are susceptible to remote RF induced signals, U.S. Department of Homeland Security, Cybersecurity Vulnerabilities Evaluation Program, <https://cve.org>. □