NTEA

THE WORK TRUCK ASSOCIATION

OEM CHASSIS CONSIDERATIONS GUIDE

Features strategic recommendations from NTEA operating divisions and other industry stakeholders, with sections on:

Ambulances | Articulating Cranes | Cargo Van Interiors

Dump Bodies | Mid-Size Buses | Propane Trucks

Service Bodies and Telescopic Cranes | Snowplows | Van Bodies

FOREWARD

Building on the history and success of Chassis Design Considerations for the Service Body Industry, this comprehensive guidebook captures experience from the perspective of a broad array of manufacturers and upfitters of vocational bodies and equipment. Unlike mass-produced assembly-line passenger cars and trucks, work trucks are primarily designed and produced individually or in small numbers, on a custom-order basis. Their diverse applications, limited volume and nearly infinite body and equipment variations dictate this method of production; as such, the chassis is the foundation of a countless variety of commercial vehicles.

This guide is intended to help inform OEM product development communities of the work truck industry's needs from their chassis products, both now and into the future. In their partnership role of turning chassis into the ultimate vehicle tool for the common end-user customer, it is the hope that this material will help preserve and multiply industry experience as much of this knowledge base transitions out of the workforce.

This resource should not be viewed as a how-to guide for chassis design and construction — rather, it is based on insight directly from various vocational vehicle manufacturers to describe an ideal chassis for the applications they serve as well as highlight the needs and rationale behind their unique vocational specifications. It's also intended to spark questions from the chassis design and product development communities, along with OEM system and component suppliers, facilitating dialogue between these groups and NTEA's vocational manufacturers and upfitters. Additionally, this guide is designed to highlight chassis features, options and needed OEM information common to multiple vocational applications.

Each section features background on the market and challenges associated with each vocational body and equipment represented, as a backdrop for the detailed chassis recommendations on a system-by-system approach to the desired features, functions and options. Unless otherwise noted, content can be assumed to be propulsion-neutral, applying to a chassis product, regardless of powertrain type. In addition to the chassis, OEM informational needs are described from a forward-looking perspective.

This initial publication forms the foundation for a living document that will continue to be refined and grow in content. NTEA wishes to acknowledge all of the **contributing organizations** for giving their time and experience, without which this guide would not be possible.

For more information, visit **ntea.com/chassisguide** or contact NTEA at **info@ntea.com** or 248-489-7090.

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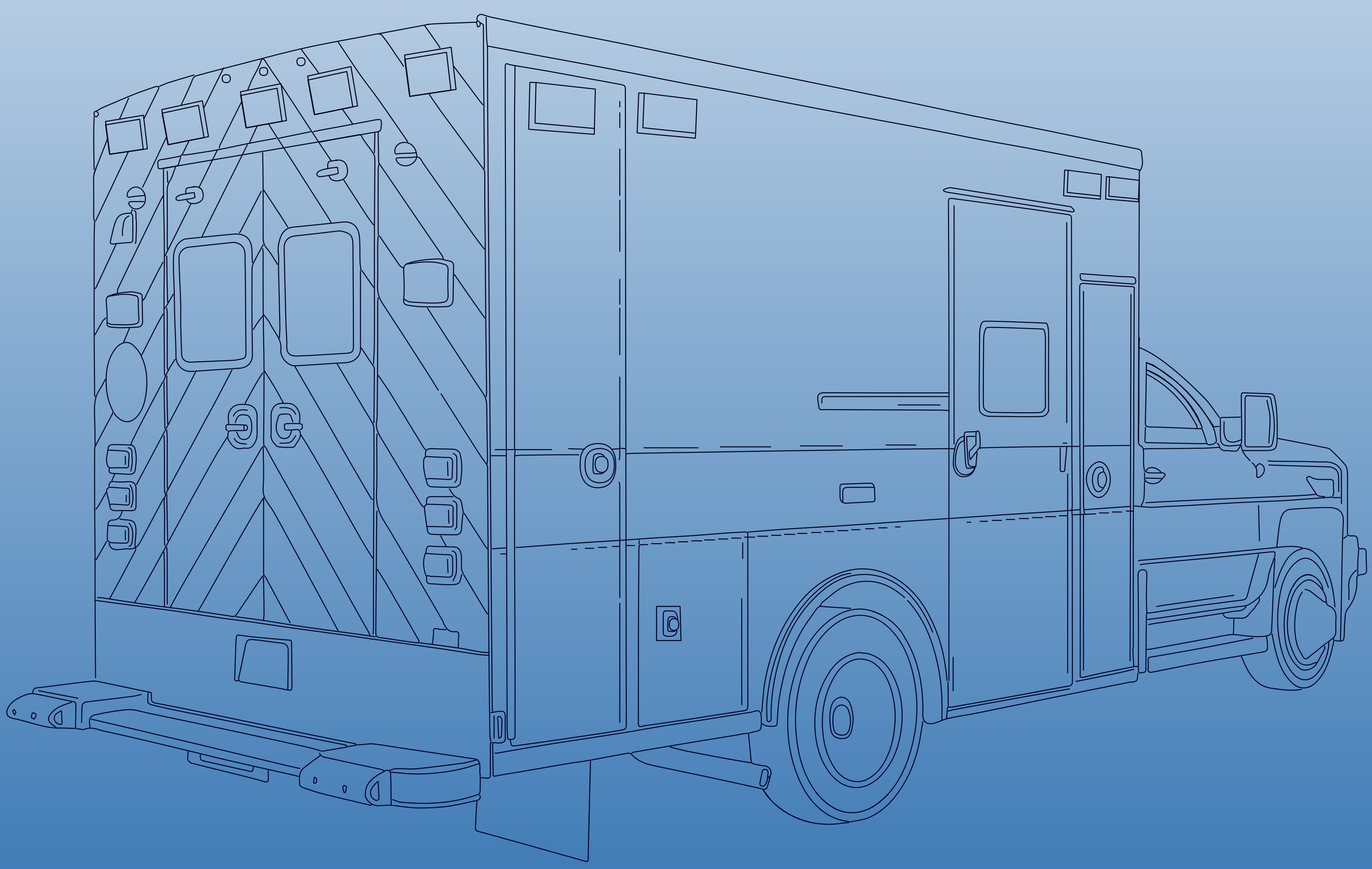
About NTEA

Established in 1964, NTEA – The Work Truck Association™ a 501(c)(6) organization, represents more than 2,100 companies that manufacture, distribute, install, sell and repair commercial vehicles, truck bodies, truck equipment, trailers and accessories. Buyers of work trucks and the major commercial truck chassis manufacturers also belong to NTEA. The Association provides in-depth technical information, education, and member programs and services, and produces Work Truck Week, Green Truck Summit, Commercial Vehicle Upfitting Summit and Executive Leadership Summit. The Association maintains its administrative headquarters in suburban Detroit and government relations offices in Washington, DC, and Ottawa, Ontario, Canada. Learn more at ntea.com.

AMBULANCES



INTRODUCTION

Ambulance Manufacturers Division (AMD)

AMD, an NTEA operating division founded in 1986, consists of manufacturers of ambulance, rescue and emergency vehicles and equipment, as well as related distribution and service providers. The group strives to grow and enhance its market segment; gain and share details on emergency vehicle functionality; build connections with other industry segments; encourage product innovation; and support progress of industry safety requirements and programs.

AMD has addressed many initiatives in the emergency vehicle and medical services industries, including continued occupant and vehicle safety research criteria advancements and execution with governmental organizations like National Institute of Occupational Safety and Health (NIOSH), General Services Administration (GSA), National Institute of Standards and Technology, and Department of Homeland Security, and partners such as National Association of State EMS Officials (NASEMSO). AMD members participate in ambulance and related standards committees of SAE International, NASEMSO, National Fire Protection Association and Commission on Accreditation of Ambulance Services.

AMD maintains strong relationships with many chassis manufacturers and greatly appreciates their ongoing support and product updates to their emergency vehicle chassis.

The Ambulance Industry

The ambulance industry plays a critical role in providing emergency medical services and patient transportation. Ambulances are essential vehicles used by healthcare providers, emergency medical services (EMS) agencies, hospitals and government entities to respond to medical emergencies, accidents and other urgent situations. The vehicles are equipped with medical devices, life support systems and trained medical personnel to provide pre-hospital care and transport patients to medical facilities.

The Market

Ambulance vehicles fall into several design categories: Type I, II and III. Types I and III are modular-bodied units (separate patient compartment body), mounted to a chassis cab and cutaway chassis, respectively. Type II are van-based units outfitted from OEM cargo van variants. The vehicles also vary in mission and designation by the amount and type of equipment they carry, known as BLS (basic life support) and ALS (advanced life support). Modular units are larger and generally carry more equipment, where Type II units offer efficiencies for maneuverability in congested urban areas for shorter transport distances to hospitals in areas of service.

Another market categorization involves vehicle customer base (i.e., the ambulance service providers, often referred to as public and private EMS). Public EMS providers are primarily fire department-based operations, and others are private companies that generally serve areas not readily covered by public EMS operations. Other market variations of vehicle mission include non-emergency medical transport for patient movement to/from hospitals and other care facilities, as well as rapid response vehicles that can more readily serve congested urban areas to provide scene triage ahead of additional ambulatory care.

As with many other essential vehicles in the work truck industry, ambulance demand is stable and continuous. Industry volumes over the last five years have been approximately 6,000 per year, produced by several higher volume manufacturers, with a number of others throughout North America producing the balance.

The Challenges

Ambulance manufacturers face a unique set of challenges when upfitting truck chassis and vans to create functional and efficient emergency medical vehicles. With their role, ambulances have unique features not found in other vehicles. They transport medical devices for use by their occupants in the treatment of other occupants, all in non-standard orientations. They also require agile weight distribution and solid braking and handling in operation. Additionally, ambulances are one of the most electronically complex vehicles with various power levels required, along with the added draw from more lighting than traditional work vehicles, as well as on-board equipment and medical devices. The ability to maintain systems between shifts through shore power adds another dimension to the system architecture, and ambulances have been among the early adopters of multiplex technology.

In addition to the full complement of Federal/Canada Motor Vehicle Safety Standard (F/CMVSS) that apply to multipurpose passenger vehicles, several industry standards contain other requirements used as build specifications by end-users contracting their vehicles. The Federal Specification for the Star-of-Life Ambulance, which is used by the federal government to procure ambulances for different agencies, has served as a de facto industry governing standard since its inception in the early 1970s. This specification is used by many states and other entities for not only the build and operational characteristics of the vehicle and its equipment, but also for licensing and/or operational qualification by states. Since 2004, several other groups have developed standards similar to those of the Federal Specification, with requirements that cater more specifically to public or private EMS customer needs. AMD also maintains a set of Standardized Test Methods used to validate the performance requirements contained in the Star-of-Life specification, as well as those of other governing standards. This unifies the methods used to validate performance of common ambulance vehicle systems, such as HVAC, electrical and oxygen delivery so that the various governing standards do not contain additional or conflicting procedures for the same test.

Another set of advanced test methods have been created by the industry to dynamically evaluate the performance of seating, restraints, patient litter systems, modular ambulance body integrity, and equipment and cabinets attached within them. These advanced test methods are the result of more than a decade of research and development through an industry consortium involving NTEA, AMD, NIOSH, GSA, National Highway Traffic Safety Administration, SAE International and many other organizations. The tests are published and maintained by SAE International. These advanced test methods provide a comprehensive improvement to the safety of EMS workers and their patients, and require ambulance manufacturers and their suppliers to employ advanced engineering and manufacturing techniques to incorporate new systems complying with these tests. View **additional information and background** on the tests and research involved in their development.

Ambulance manufacturers constantly integrate new advances in vehicle and medical device technology produced by other companies that support the industry, while maintaining compliance to federal and customer requirements. These vehicles can house a wide range of medical equipment, such as heart monitors, ventilators, IV systems and communication systems for transmitting pre-hospital medical information. Integrating these devices securely and ergonomically within the limited space of the ambulance requires careful planning and design.

Patient compartment layouts must provide ready access to medical equipment and the patient, allowing EMS workers to efficiently provide patient care while safely restrained. EMS customers often have individual preferences for many aspects of patient compartment design and layout, which lead to heavy customization challenges for ambulance manufacturers while meeting all other requirements and standards associated with contractual obligations. Patient compartment interiors must additionally be capable of being disinfected of numerous pathogens, providing additional design constraints through material options and configurations that lend themselves to this essential maintenance.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insight from the ambulance manufacturer's perspective in depiction of ideal chassis products for these vehicles. Some desires may overlap in an effort to emphasize the importance of features in different, but related sections/chassis systems. In general, these considerations are chassis and propulsion neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

Chassis Features and Functions

Second Unit Body Attachment, Cutaway and Chassis Cab

- **Chassis Cab (Type I):** Guidance is provided for the cutout and removal of the back panel of the chassis cab for walk-thru applications.
- **Cutaway Chassis (Type III) Rear Flange with Weld Nuts:** To ensure efficient attachment of the body to the cab, the rear face of the vehicle features strategically placed weld nuts in the rear-facing flange of the cab structure. These threaded inserts provide secure connection points for joining the body to the cab, enhancing overall stability and reducing the risk of structural issues from alternative means of body attachment.
- **Flat Rear Face and Accommodating Floor Edge:** The rear face of the chassis is flat and seamlessly accommodates the floor edge of the cab. Following cab flange attachment desires, this design consideration facilitates alignment and attachment of the body to the cab, so the floor edge of the rear face of the cab is designed to accommodate the transition to the body, promoting a seamless connection. Matching the cab floor height relative to the ambulance body floor is ideal and factors the frame kickup behind the cab and height of the ambulance body mounts relative to the frame.

- **Chassis Frame Dimensional Tolerances:** The chassis design considers dimensional tolerances to ensure proper alignment between the cab and chassis frame. Maintaining accurate orientation and trueness of the cab to the frame is critical to ensure proper alignment with ambulance body mounts.

Cab

- **Air Horns:** Ideally, air horns are positioned under the cab to prevent them from being roof-mounted. However, if roof-mounted air horns are unavoidable, the design specifies consistent height and positioning for a given chassis model.
- **Additional Cable Length for Antennae:** For scenarios involving roof cutouts or relocations, the chassis design accommodates additional cable length for shark fin antennae on the cab roof. This ensures relocation can be performed without compromising signal reception or functionality.

Body Attachment and Frame Design

- **Second Unit Body Attachment:** For different types of chassis, including cutaway (Type III) and chassis cab (Type I), the design includes guidance on attaching second unit bodies effectively and securely to the frame. Traditional methods include OEM puck mount provisions.
- **Clear Space Designation:** The design allows for clear space in and around the frame of units to be designated in the order system, enabling installation of various equipment components. This design consideration ensures upfit components, such as HVAC systems and auxiliary suspension systems, can be integrated without encroaching on valuable compartment space.

Frame/Chassis Understructure

The design of the chassis frame includes numerous features that support efficient body attachment and equipment integration.

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how these modifications can be made while maintaining structural integrity and compliance with vehicle safety standards.
- **Parallel Rails:** The frame features parallel rails with a flat top surface, ensuring a consistent section height for the entire length behind the cab. This design element promotes ease of upfit installation and compatibility with different body types.
- **Clean CA/Top of Frame Design:** The preferred design aims for a clean cab-to-axle (CA), where no OEM equipment protrudes above or outboard the frame for the entire length behind the cab. Except for tires, the chassis design ensures no suspension or other protrusions extend above the top surface of the frame. This design feature eliminates obstructions and simplifies body installation. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, aiding compatibility with mounting designs and reducing potential interference.
- **C-Channel Frames:** Traditional C-channel frames rails are the preferred shape and designed with adequate material thickness, strength and clearance around the frame rails to aid in mounting body components.
- **Complete Chassis Information:** OEMs are required to provide comprehensive and firm chassis information before the chassis arrives at upfitter facilities. This enables body builders to source long lead time body components in parallel with chassis production and delivery, streamlining the overall upfit process.
- **Universal Hole Patterns:** The design includes a universal hole pattern and location at the rear of the frame that is consistent between manufacturers. This ensures compatibility with various upfit components and attachment methods.
- **Desired Wheelbase, CA and Aft Frame Length (AF) Dimensions:** The Star-of-Life Ambulance Specification limits body length to be no more than two times the CA dimension to prevent the combined center of gravity (CG) position of the body and equipment from locating behind the centerline of the rear axle. Changing the chassis CA dimensional offerings can negatively impact the patient compartment layout for the end user, as well as weight distribution and departure angles. Extra aft frame length is desirable, but with no crossmembers/components, just a bare frame rail, after tank (if present). This facilitates the addition of rear mounts, components and step bumpers.

Vehicle Class 1–8	Body Length (Inches)	Cab-Axle (Inches)
Cutaway	160 max	80
Cutaway	200 max	100
Chassis Cab	168 max	84
Chassis Cab	208, 212, 216 max	104, 106, 108

Mounting/Equipment Attachment and Chassis Dimensions

The chassis design includes several considerations to facilitate the attachment of mounting equipment for ambulance upfit applications. These features ensure upfitters can efficiently and securely attach various components and bodies to the chassis while adhering to industry standards.

- **Outside Frame Rail Width:** The outside width of frame rails is standardized, with chassis cabs featuring a width of 34 inches and cutaway chassis a width of 42 inches. While these are unofficial legacy dimensions, preserving them will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it's critical to preserve those that the industry has used for many decades of development.
  - Further, maintaining these dimensions is critical in that a wider frame will reduce patient compartment and internal cabinet space, while a narrower frame brings stability/torsional rigidity concerns. These dimensions currently offer an advantage over European chassis for ambulance applications.
- **Inside Tire-Inside Tire Dimension:** A companion to the frame width is the inside tire-inside tire dimension at the rear axle. On a 34-inch frame width, the preferred dimension on a chassis cab is 55 inches. On a 42-inch frame width, the preferred dimension on a cutaway chassis is 59 inches.
- **Minimum Inboard Clearance Along Frame Rails:** The chassis provides a minimum clearance of 2 inches along the inside of the frame rails, preventing interference with items like fuel cells or batteries and allowing for proper body attachment, while providing access for technicians and tools.
  - If frame clearance is not available for attaching bodies, OEMs ensure body attachment points are provided. Ideally, these attachment points follow an industry-standard spacing from a defined datum point, such as the axle center line or back of the cab. This standardization allows for universal compatibility, enabling bodies to be produced with mating mounting surfaces pre-installed.
- **Unifying Body Mounting Methods:** The chassis design aims to unify body mounting methods by incorporating the same features across different models. This consistency simplifies the upfitting process for various vocational applications.
- **Floor Mounting and Reinforcement Options:** The chassis design includes provisions for floor mounting equipment and reinforcement options, along with a load rating. This allows upfitters to securely attach and reinforce floor-mounted items within the cab, particularly for meeting dynamic test requirements that exist for ambulance equipment mounts.

Auxiliary Power

- **For Internal Combustion Engine (ICE):** An auxiliary fuel port is integrated into the fuel sender assembly. This feature allows for convenient access to auxiliary fuel sources, and catering to applications that require additional fuel supply beyond the main tank for heaters, generators, etc.
- **Electrical Access – 12V, 24V, etc.:** While 12V is currently preferred for compatibility with a wide range of auxiliary equipment, 24V is also supported to accommodate specific applications that require higher voltage levels, offering the benefit of reduced wire gauge. A 48V chassis electrical system would be supported by the industry in the future, but not until such a voltage level (24V or more) is standardized with a transition period by OEMs and the rest of the industry. A coordinated period of transition is critical for the supply base manufacturing electrical components that are powered by the chassis low voltage electrical system, including emergency lighting, radios and a wide array of powered accessories.
- **Availability of Reconditioning Circuit:** The chassis design includes a reconditioning circuit that allows for remote access to power on or warm up the vehicle. This feature enhances convenience and efficiency in preparing the vehicle for operation.
- **Automatic High Idle and Higher Output Alternator:** ICE chassis rely on an automatic high idle function that increases engine RPM when the vehicle is stationary. This feature ensures sufficient alternator power generation to recharge auxiliary batteries and power additional equipment without draining the main vehicle battery while operating on scene.
- **High Amp Provisions and Categories:** To accommodate various power needs, chassis can offer high amp provisions with clear categorizations. These categories can be defined as 30A and lower (or similar designations), along with provisions for power needs over 30A. This simplifies the installation of high-power auxiliary equipment and ensures safe and efficient operation.
- **High Amp Power and Ground Feed for Body:** Chassis electrical provisions can provide high amp power and ground feed for powering the body and auxiliary equipment. Providing 300A (12V) power or more for large inverters, with a ground feed for power to the body, located behind the cab or underhood.

Fuel

- **Fuel Fill for ICE Chassis:** For ICE chassis, provisions are made for fuel filling, ensuring upfitters have easy access to the fuel tank. If the fuel system uses a capless fuel fill, the OEM provides a standardized fuel cup with an integrated cover/fuel door to prevent dirt/debris from entering the fuel fill cavity.
- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 7 vehicles, aim for a standardized diesel exhaust fluid (DEF) fill location. Ideally located under the hood or at the back of the cab, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.
- **Electrical Charge and Adapters for Hybrid/Electric Vehicle (EV):** The chassis is equipped with the necessary infrastructure to support electrical charging and includes electrical charge and adapters to support compatibility with various power levels and charging connections. This feature ensures compatibility with different charging stations.
- **Off-Gas Protection/Provisions During BEV Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common upfits. The design should be such that large distances of clearance underneath bodies/equipment are not necessary to preserve proper ventilation function. This safeguards against potential hazards with gases becoming trapped or concentrated under/within the vehicle and ensures safe charging operations, contributing to the overall safety of the vehicle and its surroundings. Details on preventing interference with the off-gas provision must be provided in body builder information.
- **Hybrid/EV Battery Isolation:** Electrical architecture provides a safety feature for a crash-triggered isolation of the high-voltage systems, conforming to new/future industry standards.

Exhaust for ICE Vehicles

- **Exhaust Considerations for ICE Vehicles:** The chassis design addresses exhaust packaging constraints to ensure compatibility with upfit installations. Detailed guidance is provided for exhaust modification, within limits of emissions compliance, and discharge location to avoid interference with other components. Additionally, a defined clearance area (zone) around the exhaust is communicated in body builder information, with considerations for heat shielding.
- **Discharge Location and Tailpipe Length:** ICE chassis exhaust discharge is angled/positioned to project exhaust away from the door(s) and is positioned such that it terminates within 1 inch beyond the vertical edge of the body. This requirement ensures effective heat dissipation and minimizes the risk of exhaust system intrusion into the patient compartment, while preventing the tailpipe from becoming an external impediment. Tailpipe length is determined based on the widest body configuration to accommodate various upfit designs. On modular vehicles (Types I and III), the tailpipe outlet shall not terminate within 12 inches of the vertical axis of the fuel tank filler opening(s) when located on the same side.
- **Environmental Protection Agency (EPA) Provisions (Diesel Powertrains):** The exhaust system incorporates the EPA's provisions for emergency vehicles from certain elements of the 2010 diesel emission requirements for diesel particulate filter regeneration and DEF inducement strategies.

Heating, Ventilation and Air Conditioning (HVAC)

- **Auxiliary Heat/AC Provisions and Additional Capacities:** The chassis design includes provisions for auxiliary heat and air conditioning (AC) systems. These provisions include taps that allow upfitters to integrate supplementary heating and cooling capabilities as required by different vocational applications. Further, the chassis design considers the potential need for additional HVAC capacities in patient compartments. The ability to continue to utilize the chassis AC and heating systems will remain a critical need for ambulance upfits on ICE chassis in the future.
- **Auxiliary Compressor and Condenser Capability/Packaging:** The chassis design acknowledges the need for an auxiliary AC compressor on the high-voltage (HV) system. This feature, available as an OEM option as part of ambulance prep or other prep packages, enhances the overall cooling capacity and ensures efficient operation of the HVAC system. Otherwise, ICE vehicles need to simplify the installation of a second AC compressor, or have a larger capacity OEM compressor for AC system tie-in.

Axles/Suspensions

- **Suspension Travel:** The OEM provides detailed suspension profiles in CAD (computer-aided design), including maximum effective and metal-to-metal/full jounce limits. Detailed tire clearance envelopes for each model are also needed. This envelope represents the arc of suspension travel more comprehensively, ensuring tire movement is accounted for in various scenarios. These profiles are supplied before start of production, at the point of design freeze, to facilitate design and engineering integration by suspension system manufacturers. This information is needed to develop auxiliary suspension products and features noted below.
- **Air/Hydraulic Suspension Systems:**
  - **Adaptability:** The suspension design allows for the adaptation of air or hydraulic suspension systems based on specific vehicle needs. This adaptability enhances ride quality, load handling and overall performance that are not typically offered in the original chassis products. Additional package space is needed to facilitate installation of aftermarket suspension components, such as tanks, pumps and compressors. A current battery electric vehicle (BEV) chassis trend is to have reduced package space around rear axle/suspension, which may reduce the ability for ambulance adaptation.
  - **Lateral Adjustment:** The OEM suspension design provides a method for compensating body lean without affecting crucial systems like electronic stability control (ESC), brakes and alignment.
  - **Kneeling Function:** Additionally, the suspension accounts for kneeling functions required to lower the floor height for patient loading. Brake lines and jounce hoses are designed with additional flexibility to accommodate auxiliary suspension travel necessary for the kneeling feature.
  - **Dual Leveling Valves and Tire Clearance:** The chassis design incorporates dual leveling valves that do not interfere with stability controls (ESC). A minimum of 9.25 inches of clearance is needed between side of chassis frame to inside of rear tire to accommodate these components.
- **Automatic Chain Deployment Device and Tire Chain Clearance:** The design additionally accommodates installation of automatic chain deployment devices, along with air/hydraulic suspension systems. Consideration is given to tire chain clearance requirements with or without automatic deployment systems. Bus applications require these same special provisions.
- **Wide Track Axles:** OEM options for wide track rear suspensions are necessary for ambulance applications, as well as other vocational vehicles where seating layout, cabinet space and aisle width can be affected by wheel wells inside the patient compartment. Raising the passenger floor height above the chassis frame for additional tire clearance is undesirable and may not be possible within vertical CG limits for brake system and/or ESC compliance.
  - **Super Single Tires:** An OEM option is available for super single tires for higher gross vehicle weight rating (GVWR) chassis to maintain axle ratings while maximizing track width and inner tire clearance to the frame (see previous frame-tire clearance dimensions).

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide vehicle identification number (VIN)-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.
- **Overall CG Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits are defined for horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having these details available as far in advance prior to chassis order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Additional Dimensional Information

- **Track Width – Front and Rear:** Supplying separate track width values for the front and rear axles, including any differences based on wheelbase, cab, drive and powertrain combination, ensures compatibility with various body configurations.
- **Turning Radius:** Providing both wall-to-wall and curb-to-curb turning radius values assists in planning vehicle maneuverability in different environments, and some ambulance customers include specifications and maximum values for turning radius.

Electrical System (for all Propulsion Methods, Unless Otherwise Noted)

This section describes the desired support of the chassis electrical architecture for ambulance manufacture, which in many cases can apply to other passenger transport vehicle applications.

Lighting, Wiring, Connectors, Sensors

- **Upfitter Circuits:** The electrical system includes dedicated circuits and accessible connection points for upfitters to integrate additional lighting systems or accessories. The system also accommodates combined or separate rear lighting functions without the need to reflash lighting control modules. This provision simplifies the process of adding customized lighting to the vehicle.
- **Reserve Capacity on Lighting Circuits:** The chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits or exceeding programmed threshold percentages monitored by the system.
- **Industry Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits under F/CMVSS 108 (such as turn signals and brake lights) and auxiliary lighting needs (such as emergency and scene lighting).
- **LED Compatibility:** The chassis electrical system ensures compatibility with LED lighting and includes proper voltage regulation to support.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches wide.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the completed vehicle. Easy methods for sensor calibration do not require special tools and are provided in body builder information.
- **Connector Type, Quantity and Pin Position Standardization:** Collaboration with the industry drives toward standardization of connector types, quantities and pin positions. This ensures broad compatibility and simplifies the upfitting process.
- **OEM Connector for Back-Up Alarm:** An OEM connector is located near the rear of the chassis for connecting a back-up alarm. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **Approved Power Pickup:** The chassis design offers approved power pickup points for various circuit functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting the cab and running to the rear of the frame, including extended AF options. This organized routing prevents interference with other components and maintains clearance for added wiring.
- **Engine Bay/Front Compartment Pass-Thru Capability:** The chassis design includes dash panel pass-thru capabilities for upfitters, allowing them to easily route necessary wiring and components through the front panel.

Auxiliary Lighting Needs

- **Emergency/Warning/Strobe Lighting Circuits:** Providing dedicated circuits for various emergency, warning or strobe lighting.
- **Headlamps and Controls (Wig-Wags):** Enabling wig-wag functionality for headlamps and controls is necessary for emergency vehicle visibility.

Electrical System Controls

- **Upfitter Switches and Controls:** OEM Upfitter switches generally are not used by ambulance manufacturers. Ambulance multiplex systems require custom switch functions, and builders end up installing their own or repurposing OEM switches to utilize the backlight. Enabling this practice to accommodate alternative switches for backlighting is desirable.
- **Advanced Control Abilities Through CAN BUS:** The communications network incorporates an industry-standard CAN BUS interface, such as J1939, to provide a comprehensive connection for ambulance system controls. This interface allows manufacturers to perform various functions, in particular:

  1) Control PTO/battery charge protect mode
  2) Perform remote engine start
  3) Perform remote engine stop
  4) Control chassis horn
  5) Control transmission interlock
  6) Read engine RPM
  7) Vehicle speed
  8) Read engine status
  9) Read engine hours running
  10) Headlight high/low switch position
  11) Park/headlamp operation
  12) Read e-brake state
  13) Park brake switch status
  14) Turn signal light(s) on
  15) Brake pedal depressed
  16) Ignition switch position
  17) Read power takeoff (PTO) related parameters (status, engine RPM, etc.)
  18) Read AUX switch states
  19) Park/neutral
  20) Voltage level of 12V system *
  21) Battery state of charge *
  22) Amp draw on 12V system *
  23) AC compressor status (on/off)
  24) Door open/closed status
  25) Ambient air temperature
  26) Occupant and seatbelt status
  27) Tire pressures

  Data input to chassis:

  1) AC clutch request on (rear system control if tied into OEM system)
  2) High idle/PTO mode control
  3) High idle engine RPM desired
  4) Wig-wag headlight control (assuming CAN data access is provided for headlamp status, this prevents cutting into headlamp circuits)
  5) Engine start/stop for idle reduction systems
  6) Ability to silence chassis horn when horn switch used for siren control
- **Telematics Integration:** The design aims to eliminate the need for separate telematics systems by integrating telematics between the chassis and body. This streamlines data collection and communication for fleet management purposes. The ability to interface/interoperate with the OEM system to distribute data to the customer-based system is desired to eliminate the need for a separate transmitter system in the vehicle. The customer base has already invested in proprietary, established systems and would not fully use the OEM system.
- **Power Connections for BEV Chassis:** Design offers a standard power connection for upfitters to operate installed equipment, such as an electric power takeoff (ePTO) or electric compressor. Proposed connections include a 48VDC, 150-amp continuous-duty connection, as well as a 12VDC, 100-amp connection for legacy systems. Moreover, for BEV chassis, the design enables operation and control of the cab and patient compartment climate while the vehicle is not in transit.

*Monitoring of different aspects of the 12V system is particularly beneficial, as manufacturers currently have to add auxiliary devices for this purpose.

- **Transmission Interlocks:** The communication network ensures cybersecurity measures are maintained while providing access to transmission interlocks to meet safety standards for wheelchair lifts.
- **Inverter Integration:** The design includes inverter integration features that offer flexibility for OEM or customer-selected inverter options. The inverter is supported by the electrical architecture to provide an engine-off operation mode to continue providing power to selected equipment.
- **No Reinitialization After Remote Start:** The chassis design ensures the inverter does not require reinitialization after a remote start. This feature enhances ease of use and minimizes interruptions, allowing equipment powered by the inverter to remain functional without manual intervention.
- **Power Connections for BEV Chassis:** Design offers a standard power connection for upfitters to operate installed equipment, such as an ePTO or electric compressor. Proposed connections include a 48VDC, 150-amp continuous-duty connection, as well as a 12VDC, 100-amp connection for legacy systems. Moreover, for BEV chassis, the design enables operation and control of the cab climate unit while the vehicle is not in transit.
- **Physical Battery Connections for High Electrical Loads:** To accommodate high electrical loads, such as a 5KW inverter, the chassis design provides physical battery connections. These connections ensure the inverter can draw power efficiently from the battery while maintaining electrical safety and stability.
- **Cybersecurity Specifics:** Addressing cybersecurity concerns is critical, with a focus on protecting end user telematics systems and data from unauthorized access and cyber threats. OEM cybersecurity measures must prevent interference with ambulance data reception/transmission.
- **EMI/RFI Shielding and Emissions:** The design incorporates necessary electromagnetic interference (EMI) and radio frequency interference (RFI) shielding to mitigate potential interference issues and ensure optimal performance of electronic components added by upfitters, including any additional countermeasures needed for BEV applications. Moreover, the design adheres to established limits for emissions, including Canadian Interference-Causing Equipment Standards (ICES), and clear OEM guidance is provided to maintain compliance.

Regulatory/Safety

ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles

- **Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.

F/CMVSS Considerations

- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the chassis OEM provides maximum unloaded vehicle weight (max UVW) values to maximize upfit capacity for different vocational applications. These specifications help upfitters and end-users choose appropriate chassis configurations to optimize their intended body/equipment upfit.
- **Mirror-Based Clearance Lamps:** If provided on the forward side of the outside rearview mirrors, enable compliance with pass-thru certification for amber lamps to serve as front clearance lamps.
- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Backup Camera Connectivity:** The design features the ability to connect both digital and analog backup cameras, offering flexibility to operators based on camera system preferences. Additionally, a universal backup camera connector is provided, ensuring compatibility across different manufacturers' systems.
- **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an open web location for generic IVDs of each incomplete vehicle model, providing clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.

EPA/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (ICE)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications and without waiting for physical vehicles or vehicle emission control information labels.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.
- **Low Rolling Resistance (LRR) Tires:** Recommending or requiring LRR tires can contribute to improved fuel efficiency and reduced emissions, but strong consideration must be given to the critical mission of ambulance applications and their need to operate in the most broad environmental conditions and on-/off-road.

Additional Body Builder Information

- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published by the OEM, detailing all required compliance data points for each vehicle model. This includes curb weight, max UVW, as-built chassis CG dimensions, top of frame height, seat points, passenger load, and other info needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.
- **Early Access to Information:** Body builder guides and IVDs are made available at least two months before ordering opens for a new model year. This advance access ensures body builders have the necessary information to plan and design their upfit solutions well in advance, streamlining the process. Provide access to lighter CAD files and electrical diagrams at the time of vehicle release.
- **Electrical System Control Descriptions:** Comprehensive descriptions for upfitter switches, BCM access/programmability and CAN BUS/internal chassis data stream are provided. This information empowers body builders to integrate electrical components seamlessly while ensuring compliance with safety and operational requirements.
- **Drill/No-Drill Zones:** The design includes details for drill/no-drill zones, especially in critical areas such as the dashboard, near fuel or electrical systems underneath floor sections, within pillars and other likely areas needed for attachment/modification by upfitters. This information ensures upfitters are aware of permissible areas for modifications.

Fleet Operations

The chassis design includes features and considerations that address fleet operations, ensuring efficiency, information accessibility and operational regulatory compliance.

- **Range:** The chassis design provides real driving range estimates for different scenarios, taking into account both curb weight and fully loaded weight. This information offers fleet operators accurate insights into the vehicle's expected range under various operating conditions, allowing for better route planning and management. Ambulances require a driving range of at least 250 miles without refueling.
- **Info/Telematics/Communications Needs:** The design facilitates access to crucial vehicle information through telematics and communication systems. Fleet operators can gather data from the vehicle's CAN BUS, enabling remote diagnostics, performance monitoring and predictive maintenance, including integration of their own systems.
- **BEV Recharge Time:** The chassis design accounts for varying temperature conditions and charging rates during BEV recharging. By providing information on recharge times under different scenarios, fleet operators can plan charging schedules more effectively and ensure optimal vehicle utilization.
- **Drive/Duty Cycle:** The chassis design factors in the specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, rural transit, highway driving and other unique scenarios. The chassis is engineered to handle the demands of different duty cycles.

Other

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.
- **Chassis Performance Requirements from the Federal Specification for the Star-of-Life Ambulance:** The following performance metrics of ambulance chassis are excerpts, including section references, from the Federal Specification for the Star-of-Life Ambulance, rev. F. July 1, 2007. These requirements are current as of the publication of this guide and are used for ambulances purchased under the federal specification, which includes units purchased by the General Services Administration and also required by many states. They relate directly to chassis performance, as designed within established OEM capacity ratings, and final-stage ambulance manufacturers and certifying test services require representations from chassis OEMs for compliance.

3.4.5 SPEED.
The vehicles shall be capable of a sustained speed of not less than 65 mph over dry, Hard surfaced, level roads, at sea level, and passing speeds of 70 mph when tested under normal ambient conditions.

3.4.6 ACCELERATION.
Vehicle shall have a minimum average acceleration, at sea level, of 0-55 mph within 25 seconds. Test shall be performed under normal ambient conditions.

3.4.7 GRADEABILITY.
The vehicle shall be capable of meeting the following performance requirements. The determination shall be made by actual test or OEM's certified computer prediction.

3.4.7.1 GRADEABILITY AT SPEED.
Minimum gradeability at speed shall be 55 mph on a 3% (1.72°) grade.

3.4.7.2 MINIMUM LOW SPEED GRADEABILITY.
The minimum low speed gradeability shall be 5 mph on a 35% (19.3°) grade.

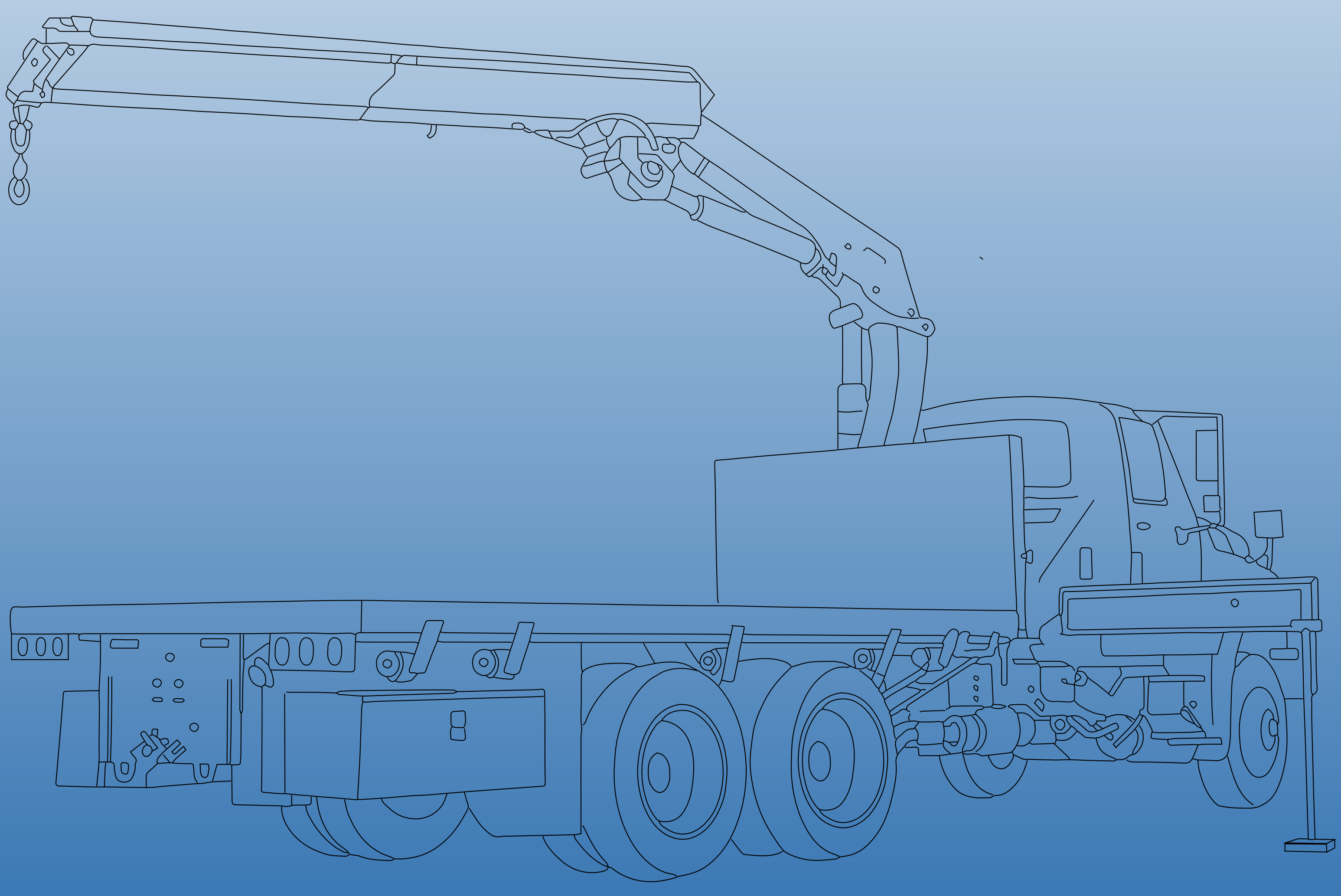
3.4.8 FUEL RANGE.
The ambulance shall be capable of being driven for at least 250 miles without refueling.

3.6.3.2 ENGINE LOW TEMPERATURE STARTING.
The engine shall start satisfactorily without the aid of engine block preheating devices (except glow plugs) or combustion air preheater at 0°F. The determination shall be made by actual test or OEM's certification.

Additional Resources

- Ambulance Manufacturers Division information: **ntea.com/amd**
- SafeAmbulances project information: **nasemso.org/projects/project-archive/safeambulances**

ARTICULATING CRANES



INTRODUCTION

Articulating Crane Council of North America (ACCNA)

ACCNA, an NTEA operating division established in 1992, serves common interests of articulating crane manufacturers. As many of these specialized truck-mounted crane manufacturers reside overseas, membership includes authorized national importers.

ACCNA tracks changes to Occupational Safety and Health Administration (OSHA) standards involving cranes, as well as applicable state requirements. OSHA's standards for cranes and derricks used in construction are contained in Code of Federal Regulations Title 29 Part 1926, Subpart CC. Since it regulates workplace safety, changes to OSHA standards become the responsibility of equipment owners/operators. ACCNA members forecast the effects of such regulatory changes to ensure customers can meet new requirements based on equipment use and function.

A key element of construction standards for cranes involves certification requirements for operators, which took effect in 2018. Working ahead of these requirements, ACCNA partnered with National Commission for the Certification of Crane Operators (NCCCO) to develop a series of written and practical exams for articulating crane operators that launched in 2009. This was a significant undertaking as nothing was previously created to formally officiate an operator for this type of equipment. The task force, which included ACCNA member company representatives, created three categories of articulating crane operator certification to cover construction industry equipment groupings subject to the new regulations. The success of this cooperative program continues as articulating cranes and operator requirements evolve.

The Articulating Crane Industry

Truck-mounted articulating cranes are specialized hydraulic lifting devices featuring multiple articulating boom sections that offer advantages of moving heavy loads into positions not possible or practical for more traditional telescopic cranes. They are also known as knuckleboom and figure-4 cranes due to their similarity to the human finger and the form they take in their stowed position. Each boom segment can bend and telescope, offering a high degree of dexterity to enable extremely controlled loading and unloading of heavy, bulky items. Articulating crane trucks are used in various industries, including construction, utilities, materials delivery and handling, and maintenance operations.

Given their weight and usage, they are not typically installed on light vehicles — small versions of this type of crane start on Class 3 chassis applications. Industry volumes over the last five years have been approximately 1,500 units per year, produced both domestically and abroad for the North American market.

The Market

Articulating cranes have adapted to numerous market applications, primarily through different boom attachments developed for special functions. These devices play a critical role in the construction and maintenance of buildings, bridges, utilities and other infrastructure projects. As such, spending in construction-related sectors influences the market for these machines. They are used to lift and position materials, tools and equipment at heights and angles that are challenging to reach with traditional methods, and are popular for building material delivery. Their design enables them to hoist loads up and over structures and within confined areas in direct support of crane end attachments, rather than having them suspended by a cable.

Cradle attachments developed for delivering drywall allow the materials to be positioned for loading through windows or other openings in building structures. Articulating crane manufacturers have created radio controls for remote operation, allowing the operator to continuously locate to the most optimal position for safety and visibility of the crane and load. These controls also offer the advantage of having a single employee transport, deliver and unload materials. In addition, cranes can be outfitted with winches for operations where traditional cable lifting methods are needed or special boom attachments are not available for a particular load.

Other variations of truck-mounted articulating cranes include claw and clamshell-styled end attachments used in applications such as railroad maintenance, logging and utility operations for lifting bundles of track ties, logs and pipes, as well as removing garbage and excess materials from culverts and drainage areas. These variations can include an elevator operator's station. Special handling attachments are also used for removing/replacing tires and wheels on large off-highway equipment. Large concrete forms can be delivered and placed in precise positions for building foundations and infrastructure construction operations.

The Challenges

While there are some domestic manufacturers, many articulating cranes are imported into the North American market by distributors. But whether a domestic manufacturer or distributor, these companies install the cranes and build the trucks, so they face the same challenges as other as final-stage manufacturers, along with the added complexity of integrating these cranes in a variety of specialized vehicle configurations. Common challenges faced by all manufacturers are amplified when upfitting truck chassis to incorporate the crane and associated equipment.

Articulating cranes add significant weight to the truck chassis. Ensuring proper weight distribution is not only critical for vehicle operation, but also for crane stability during its operations. Manufacturers must perform stability calculations and tests to optimize crane and stabilizer placement in order to prevent overloading the crane and structural loadpath. These cranes have a complex geometry that requires clearance for their range of motion. Manufacturers need to factor this into their vehicle layout to prevent contact with other components on the truck and ensure proper clearance in confined spaces. Mounting an articulating crane onto a truck chassis requires a rigid base, known as a crane box, as well as chassis frame reinforcement in heavier applications to handle increased load and torsional stress.

As with other truck-mounted cranes, articulating cranes rely on hydraulic systems to control their movements. Stabilizers deployed during crane operations also operate from hydraulic power, and power takeoff (PTO) systems and controls are required as part of the overall integration of the crane. Note, articulating cranes use stabilizers to steady the vehicle during crane operations, rather than outriggers which support the weight of the entire vehicle by lifting it.

Safe vehicle and crane operation are manufacturer design priorities. The machines themselves contain a number of automated safeguards, such as load moment limiters to prevent tipping or exceeding the crane's capacity. Given the industries these truck cranes serve, their operation can fall under different workplace safety regulations under federal and state OSHA programs, including construction, forestry and maritime operations. Dense urban areas like New York City can have separate requirements for the design, certification and inspection of cranes above certain dimensions of reach or load capacity, intended to perform lifting operations within municipal boundaries.

Additionally, federal OSHA regulations require operators of these and other types of cranes to achieve certification of their operational skills through accredited programs. As previously mentioned, ACCNA partnered with NCCCO to develop the first such program for articulating crane operators, as well as test facilitator credentialing. There are several versions of the test to cover distinct skillsets of different boom attachments used for the various aforementioned vocational applications. **Learn more** about this program.

Another aspect of their safe and efficient operation comes from the manufacturer's design for ease of inspection and maintenance. Vehicle layout and equipment features must enable ease of access for required, periodic inspections and maintenance functions.

These crane systems continuously evolve to improve their abilities to serve current industry applications, as well as progress into new markets. But they require a broad overhead of engineering and technological advancement by the manufacturers to maintain these product offerings and vocational niches.

DESIGN CONSIDERATIONS

Offering a chassis product to this market, as the foundation of an articulating crane truck, requires chassis OEM design intention. The chassis should be viewed as an extension of the crane, rather than the other way around, to provide features needed for the integration of these machines and the safe, optimal layout and function of their final configuration.

Chassis Features and Functions

Cab/Passenger Compartment

- **Cab Tilt Access and Dimensions (Cab-Over-Engine Chassis):** The chassis design incorporates provisions for cab tilt access. Guidelines are provided regarding proper techniques for tilting the cab, ensuring safe and efficient maintenance access to the engine and other components. Chassis OEM information outlines both recommended practices (dos) and precautions (don'ts).
- **Rear Seat Removal Accommodation:** On crew and extended cabs, allow for rear seat removal to accommodate storage systems for high-value electronics and tools.
- **Remote Access and Requirements:** Remote access features are included in the chassis design, with considerations for antennas and telematics control units. Additionally, a reconditioning circuit is integrated to facilitate remote power activation or vehicle system warm-up.

- **Vehicle Power On – In-Cab Emergency Shutoff Access and Labeling:** This is particularly for keyless ignition/activation systems. The chassis features accessible emergency shut-off mechanisms, which are clearly labeled for quick identification. In critical situations, these shut-off points can be readily accessed by the operator to prevent potential hazards and secure the vehicle. This includes educational materials provided to guide operators on the correct procedures for powering the vehicle on/off.

Frame

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how these modifications can be made while maintaining structural integrity and compliance with vehicle safety standards.
- **Parallel Rails with Flat Top and Bottom Surfaces:** The chassis is designed with parallel rails that have both a flat top and bottom surface. This design eliminates steps or offsets along the length of the frame behind the cab. The consistent section height of the parallel rails promotes uniformity for upfit installations. Crane base structures utilize clamp-style mounting to the chassis frame that requires flat, parallel flange surfaces for the clamp plates, along with inboard/outboard clearance for the large fasteners involved.
- **Clean CA/Top-Bottom of Frame Design:** The preferred design aims for a clean cab-to-axle (CA), where no OEM equipment protrudes above or outboard the frame for the entire length behind the cab. Additionally, crane mounting requires no OEM equipment directly underneath the frame, at a minimum of 3–5 feet behind the cab and behind the rear suspension, along with a minimum inboard clearance from the frame of 2 inches in those sections to accommodate clamp mount inboard fasteners. Except for tires, the chassis design ensures no suspension or other protrusions extend above the top surface of the frame. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, aiding compatibility with mounting designs and reducing potential interference.
- **C-Channel Frames:** Traditional C-channel frames are the preferred shape and designed with adequate material thickness, strength and clearance around the frame rails.
- **Crane Prep Option:** Consider a factory crane prep chassis option to minimize the amount of subframe and reinforcement crane manufacturers need to add in their designs.
  - This option would be primarily for Class 5–7 gross vehicle weight rating (GVWR) units, as Class 8 offerings are typically more configurable to accommodate crane-specific features.
  - This option would provide a maximum resisting bending moment (RBM) above that of the stock frame.
  - RBM values are available ahead of production, including RBM values for the frontal frame section (i.e., frame horns) utilized for front-mounted stabilizers, for which crane manufacturers must plan designs.
- **Timely Chassis Information for Upfitters:** OEMs provide comprehensive and firm chassis information to upfitter facilities before the chassis arrives. This allows upfitters to source long-lead-time body components in parallel with chassis production and delivery, streamlining the build process.
  - Ideally, 2D/3D CAD data is available for specific chassis configurations before the chassis is ordered and available to manufacturers/upfitters outside of the dealer network. This would enable upfitters to obtain 2D/3D computer-aided design (CAD) directly to determine chassis suitability and identify challenges prior to customers placing an order. Such access would benefit many vocations to help ensure dealers place orders for the optimal chassis, especially where existing prep package offerings are available.
- **Frame Length Behind Rear Axle (AF):** Priority should be given to options for additional AF dimensions. These are highly desirable as a means for the upfitter to avoid adding frame extensions. Options for a plus-2-foot and plus-4-foot extension of the rear frame rail, beyond standard dimensions, would greatly benefit rear-mounted cranes and associated bodies. This allows the upfitter to remove excess material, if any, rather than welding extensions. This option would also reduce the need for the chassis OEM to offer frame extension kits.
- **Standardized Frame Extension Features and Kits:** For as-built chassis that require frame extension, standardized pre-punched frame holes and common features are provided at the back of the frame to simplify the process of adding frame extensions. This design choice eliminates the need for welding when adding frame extensions, enhancing efficiency and reducing assembly complexity. Additionally, OEMs offer standardized frame extension kits that include potential mating components. These kits provide upfitters with necessary components and guidelines for extending the chassis frame, ensuring consistent and reliable results.

- **Universal Hole Pattern at Rear of Frame:** A universal hole pattern and locations are established at the rear of the frame, including extensions, across different manufacturers. This ensures uniformity and compatibility when attaching components.
- **Desired Wheelbase, CA and AF Dimensions:**

Vehicle Class 1–6	Wheelbase (Inches)	AF (Inches)
5 and 6	Current wheelbase offerings have been accommodated by the articulating crane industry	Create options for additional 2 feet and 4 feet of AF

- **Mounting/Equipment Attachment and Chassis Dimensions:** The chassis design includes several considerations to facilitate the attachment of mounting equipment for crane applications. These features ensure upfitters can efficiently and securely attach various components and bodies to the chassis while adhering to industry standards.
- **Outside Frame Rail Width:** The outside frame rail width is standardized, with chassis cabs featuring a width of 34 inches. While this is an unofficial, legacy dimension, preserving it will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it's critical to preserve those that the industry has used for many decades of development.
  - Further, a tolerance of +/–0.5 inches needs to be held in chassis design and production so the frame is no narrower than 33.5 inches, nor wider than 34.5 inches for crane and other vocational vehicle applications. Market reception to dimensions outside of this range will be poor.
- **Auxiliary Power:** The chassis design includes a range of auxiliary power features and considerations to support various power needs, including both internal combustion engines (ICEs) and battery electric vehicles (BEVs). These features ensure that upfitters have access to the necessary power sources for their applications and enable efficient operation and customization.
  - **Auxiliary Fuel Port (ICE):** Crane applications do not currently require generators or other fuel-powered provisions. They draw hydraulic power from PTO provisions, so auxiliary fuel port access is not a necessary feature.
  - **Engine Off, Memory Power:** Cranes require keep-alive memory from the chassis batteries while parked and can draw them down quickly. Currently, keep-alive memory on modern chassis does not necessarily shut down automatically before chassis batteries are depleted. Chassis electrical system monitoring is needed to prevent keep-alive battery power draw below levels needed for engine start.
  - **Transmission PTO:** Hydraulic power for crane applications comes primarily through transmission-driven PTO. Up to 140hp is required for large cranes in Class 8 applications.
  - **PTO Clearance:** Piston pumps are used, rather than gear-driven pumps, due to the need for higher system pressures. These pumps are larger and need more clearance than geared pumps from exhaust and other chassis components in the same vicinity. For Class 5 chassis that are based on lighter chassis platforms, their weight capacities allow for cranes requiring additional pump clearance, but their chassis architecture does not provide the necessary clearance currently available for pumps used in crane applications in Class 6 and higher models. Customers would prefer to optimize the vehicle using the lower weight class.
  - **Electrical Access – 12V, 24V, etc.:** While 12V is currently preferred for compatibility with a wide range of auxiliary equipment, 24V is also supported to accommodate specific applications requiring higher voltage levels. These provisions cater to applications requiring 30A and less, as well as those exceeding 30A. Products currently used in the European market utilize 24V chassis power, and manufacturers would support standard use of this voltage in the North American market.

Fuel

- **Fuel and DEF Tanks for ICE Chassis:** For ICE chassis, a crane-prep option includes both fuel and diesel exhaust fluid (DEF) tanks with an undercab location.
- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 7 vehicles, aim for a standardized DEF fill location. Ideally located under the hood, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.

Exhaust for ICE Vehicles

- **Exhaust Considerations for ICE Vehicles:** The chassis design addresses exhaust packaging needs by keeping system components under the cab, while away from PTO openings and clear space. Vertical stack exhaust components are kept flush with the back of the cab, where the rearmost surface of the exhaust is no further rearward than the cab surface, maximizing the clean CA dimension. Vertical exhaust includes heat shielding or accommodation to protect from/deflect falling debris, particularly between body and cab.
  - Where needed, detailed guidance is provided for exhaust modification, within limits of emissions compliance, and discharge location to avoid interference with other components. Additionally, a defined clearance zone around the exhaust is communicated in body builder information, with considerations for heat shielding.
- **Extended Life DPF on Diesel:** A crane-prep option includes a longer life diesel particulate filter. This is needed due to the extended idle duty of crane trucks, and other applications that idle for extended periods would also benefit.

Axles/Suspensions

- **Dimensions and Travel Limits:** Chassis dimensions are designed to accommodate dual tires, with overall width to the exterior sidewalls not exceeding 96 inches. The chassis also includes specified travel, jounce and rebound limits to assure safe and controlled suspension movement.
- **Compensating for Body Lean:** The chassis design incorporates a method for compensating for body lean without affecting electronic stability control (ESC), braking systems, wheel alignment or other critical vehicle functions. This helps ensure a stable and controlled driving experience, even with varying load conditions.
- **Dual Leveling Valves and Stability Controls:** Dual leveling valves are integrated into the suspension system without interfering with stability controls, such as ESC. This preserves vehicle stability and safety during operation.
- **Ability to Add Auxiliary Springs:** The chassis design allows for the addition of higher capacity springs or extra leaves to the suspension system. These modifications can be made without compromising stability controls, ensuring desired load-bearing capabilities can be achieved.
- **Gross Axle Weight Ratings (GAWRs):** A crane-prep option provides an additional 1,000 pounds or front GAWR above the standard offering for typical Class 5 specifications today, and an additional 2,000 pounds above standard Class 6 front GAWR capacities. These classes need extra front axle capacity for the permanently installed crane weight, so concerns associated with braking, handling and adverse tire wear from an overly stiff front suspension should be minimized.
- **Air Suspension with Dump:** An air suspension with a dump valve is included as part of a crane-prep option. This is highly desired for Classes 5–8.
- **Rear Suspension Hanger Shims:** The rear suspension incorporates shims between the frame and outboard rear suspension attachments. This allows crane manufacturers/upfitters to unbolt suspension attachments and install long shear plates that span forward/rearward of the rear suspension. The shear plates, which are the same width as the shims previously removed, reattach to the suspension in the same design position with the same fastener specifications, preserving suspension points/geometry/integrity while incorporating rigid plates for body/crane attachment. This could also be very beneficial to other vocations. OEMs already design for this where the same suspension mounting is used on double/triple frame chassis, and the suspension is shimmed on lesser frames to match the same design position on layered frames. This is highly desired for Classes 5–8.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide vehicle identification number (VIN)-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.
- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits — defined for horizontal, vertical and lateral dimensions — are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having these details available as far in advance prior to chassis order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Additional Dimensional Information

- **Track Width – Front and Rear:** Supplying separate track width values for the front and rear axles, including any differences based on wheelbase, cab, drive and powertrain combination, ensures compatibility with various body configurations.
- **Turning Radius:** Providing both wall-to-wall and curb-to-curb turning radius values assists in planning vehicle maneuverability in different environments, especially as these cranes are designed to operate in areas of confined space.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

This section describes the desired support of the chassis electrical architecture for crane body upfits, which in many cases can apply to other vocational vehicle needs.

Lighting, Wiring, Connectors and Sensors

- **Upfitter Circuits:** The chassis design includes dedicated circuits and accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Reserve Capacity on Lighting Circuits:** The chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits or exceeding programmed threshold percentages monitored by the system.
- **Industry Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits (such as turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes).
- **Emergency/Warning/Strobe Lighting:** The chassis design includes provisions for emergency, warning or strobe lighting systems on the front and rear of the chassis. These systems enhance vehicle visibility and safety when operating in hazardous conditions.
- **LED Compatibility:** The chassis design ensures compatibility with LED lighting for both the vehicle's lighting system and trailer tow lighting circuits. This includes proper voltage regulation to support LED lighting.
- **Standard Trailer Tow Provisions:** Continue providing standard options for trailer towing, including trailer lighting connectors and wiring.
- **Relocating OEM Lights, Antennas and Sensors:** Guidelines are provided to relocate OEM lights, antennas and sensors, especially in applications with aerodynamic devices. This ensures proper placement and functionality when moving components for different body configurations.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the upfitted body. Easy methods for sensor calibration, which do not require special tools, are provided in body builder information.
- **Connector Type, Quantity and Pin Position Standardization:** Collaboration with the industry drives toward standardization of connector types, quantities and pin positions. This helps ensure broad compatibility and simplifies the upfitting process.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches wide.
- **OEM Connector for Back-Up Alarm:** An OEM connector for a back-up alarm is located near the rear of the chassis. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **Approved Power Pickup:** The chassis design offers approved power pickup points for various circuit functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting from the cab and running to the rear of the frame, including extended AF options. This organized routing prevents interference with other components and maintains clearance for added wiring.
- **Engine Bay/Front Compartment Pass-Thru Capability:** The chassis design includes dash panel pass-thru capabilities for upfitters, allowing them to easily route necessary wiring and components through the front panel.

Electrical System Controls

- **Upfitter Switches and Controls:** A minimum of six in-dash upfitter switches are provided, offering various modes of operation, such as ignition hot, battery hot, momentary and maintained functions. Upfitter switch wiring terminates in a non-proprietary, commonly available connector(s). The design enables access to the body control module (BCM) for programming and customization, enhancing chassis adaptability to specific upfit requirements.
- **Advanced Control Abilities Through CAN BUS:** The communications network incorporates an industry-standard CAN BUS interface, such as J1939, to provide a comprehensive connection for system controls. This interface allows manufacturers to perform various functions, in particular:
    1) Control the PTO (engagement and engine RPM): PTO engagement must be maintained with engine start-stop, especially for manual and automated manual drivetrains, so the PTO stays engaged for restart.
    2) Perform remote engine start*
    3) Perform remote engine stop*
    4) Control chassis horn*
    5) Control transmission interlock
    6) Read e-brake state
    7) Vehicle speed
    8) Park/neutral
    9) Read PTO-related parameters (status, engine RPM, etc.)
    10) Read AUX switch states
- **Telematics Integration:** The design aims to eliminate the need for separate telematics systems by integrating telematics between the chassis and body. This streamlines data collection and communication for fleet management purposes. The ability to interface/interoperate with the OEM system to distribute data to the customer-based system is desired to eliminate the need for a separate transmitter system in the vehicle. Customer base has already invested in proprietary, established systems and would not fully use the OEM system.
- **Power Connections for BEV Chassis:** The design offers a standard power connection for upfitters to operate installed equipment, such as an electric power takeoff (ePTO) or electric compressor. Proposed connections include a 48VDC, 150-amp continuous-duty connection, as well as a 12VDC, 100-amp connection for legacy systems. Moreover, for BEV chassis, the design enables operation and control of cab climate while the vehicle is not in transit.
- **Transmission Interlocks:** The communication network ensures cybersecurity measures are maintained while providing access to transmission interlocks to meet safety requirements during crane operations, which prevent vehicle motion while stabilizers/cranes are deployed and deployment unless all enabling conditions are met, and interlocks are enabled through PTO functions.
- **Inverter Integration:** The design includes inverter integration features that offer flexibility for OEM- or customer-selected inverter options. The inverter is supported by the electrical architecture to provide an engine-off operation mode to continue giving power to selected equipment.
- **No Reinitialization After Remote Start:** The chassis design ensures the inverter does not require reinitialization after a remote start. This feature enhances ease of use and minimizes interruptions, allowing equipment powered by the inverter to remain functional without manual intervention.
- **Physical Battery Connections for High Electrical Loads:** To accommodate high electrical loads, such as a 5KW inverter, the chassis design provides physical battery connections. These connections ensure the inverter can draw power efficiently from the battery while maintaining electrical safety and stability.
- **EMI/RFI Shielding and Emissions:** The chassis electrical architecture incorporates necessary electromagnetic interference (EMI) and radio frequency interference (RFI) shielding to mitigate potential interference issues and ensure optimal performance of the crane and stabilizer systems, including any additional countermeasures needed for BEV applications. Moreover, the design adheres to established limits for emissions, including Canadian Interference-Causing Equipment Standards (ICES), and clear OEM guidance is provided to maintain compliance.

*A hard-wired chassis interface is provided as part of a crane-prep option for control of these items from crane remote control systems. This is highly desired for Class 5–8 chassis offerings, and would likely benefit other vocational upfits.

Regulatory/Safety

- **ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.
  - In particular, relocation of sensory devices should be explored by chassis OEMs to determine if the same performance from automatic emergency braking (AEB), active cruise control, blind spot monitoring, etc., is possible, where affected by crane and stabilizer systems, as well as bodies and other equipment. For example, crane booms and front-mount stabilizer systems can require positioning within the original frontal vision camera and radar field-of-view. Abilities to relocate this sensory equipment and easily recalibrate these systems are absolutely necessary if they are to coexist with the multitude of work truck configurations with which their functions conflict.

F/CMVSS (Federal/Canada Motor Vehicle Safety Standards) Considerations

- **Mirror-Based Clearance Lamps:** If provided on the forward side of the outside rearview mirrors, enable compliance with pass-thru certification for amber lamps to serve as front clearance lamps.
- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Backup Camera Connectivity:** The design features the ability to connect both digital and analog backup cameras, offering flexibility to operators based on camera system preferences. Additionally, a universal backup camera connector is provided, ensuring compatibility across different manufacturers' systems.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an open web location for generic IVDs of each incomplete vehicle model, providing clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.
  - **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the body and added equipment.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (ICE)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications and without waiting for physical vehicles or vehicle emission control information labels.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum unloaded vehicle weight (max UVW) limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.
- **Low Rolling Resistance (LRR) Tires:** Recommending or requiring LRR tires can contribute to improved fuel efficiency and reduced emissions, but strong consideration must be given to the critical mission of crane applications and their need to operate in the most broad environmental conditions and on-/off-road.

Additional Body Builder Information

- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published by the OEM, detailing all required compliance data points for each vehicle model. This includes curb weight, max UVW, as-built chassis CG dimensions, top of frame height, seat points, passenger load, and other information needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.
- **Early Access to Information:** Body builder guides and IVDs are made available at least two months before ordering opens for a new model year. This early access ensures body builders have the necessary information to plan and design their upfit solutions well in advance, streamlining the process. Provide access to lighter CAD files and electrical diagrams at the time of vehicle release.
- **Electrical System Control Descriptions:** Comprehensive descriptions for upfitter switches, BCM access/programmability and CAN BUS/internal chassis data stream are provided. This information empowers body builders to integrate electrical components seamlessly while ensuring compliance with safety and operational requirements.
- **Drill/No-Drill Zones:** The design includes details for drill/no-drill zones, especially in critical areas such as the dashboard, near fuel or electrical systems underneath floor sections, within pillars and other likely areas needed for attachment/modification by upfitters. This information ensures upfitters are aware of permissible areas for modifications.

Fleet Operations

The chassis design includes features and considerations that address fleet operations, ensuring efficiency, information accessibility and operational regulatory compliance.

- **Range:** The chassis design provides real driving range estimates for different scenarios, taking into account both curb weight and fully loaded weight. This information offers accurate insights for fleet operators into the vehicle's expected range under various operating conditions, allowing for better route planning and management.
- **Info/Telematics/Communications Needs:** The design facilitates access to vehicle information through telematics and communication systems. Fleet operators can gather data from the vehicle's CAN BUS, as well as the crane system, enabling remote diagnostics, performance monitoring and predictive maintenance, including integration of their own systems.
- **BEV Recharge Time:** The chassis design accounts for varying temperature conditions and charging rates during BEV recharging. By providing information on recharge times under different scenarios, fleet operators can plan charging schedules more effectively and ensure optimal vehicle utilization.
- **Drive/Duty Cycle:** The chassis design factors in specific drive and duty cycle requirements of fleet operations. This includes considerations for urban building materials delivery routes, highway driving and other unique scenarios.

Other

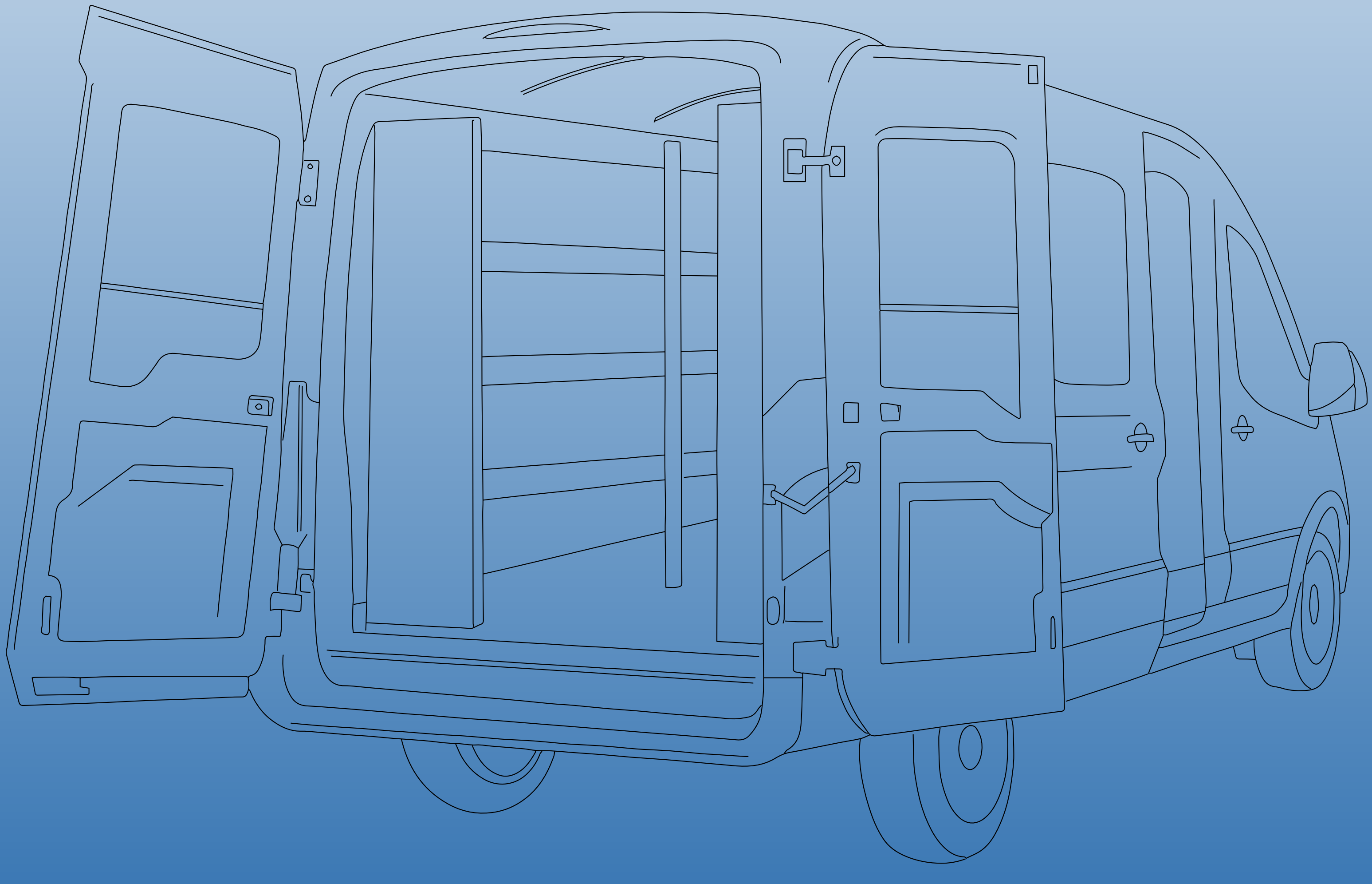
BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

Additional Resources

- Articulating Crane Council of North America Information: **ntea.com/accna**
- National Commission for the Certification of Crane Operators Articulating Crane Operator Certification information: **nccco.org/nccco/certifications/articulating-crane-operator/certification-overview**

CARGO VAN INTERIORS



INTRODUCTION
Industry Market for Cargo Van Interiors

The cargo van interiors market is a significant segment within the commercial vehicle industry, primarily catering to businesses and industries that deliver goods and provide services, but do not require large vehicles for their operations. Vehicles with an enclosed cargo space have been produced since the early era of the automotive industry, making them essential for last-mile delivery services, contractors and trades, and many businesses (large and small).

Cargo vans, and their interior equipment, are widely used in the delivery and logistics sector, serving e-commerce companies, the U.S. Postal Service and many forms of local businesses. Tradespeople and service providers rely on cargo vans to transport tools, equipment and supplies to job sites, including construction, plumbing, electrical work and HVAC (heating, ventilation and air conditioning). High roof versions of the OEM vans have supplanted the need for the truck equipment industry to perform raised roof modifications for multipurpose vehicle and bus applications, as well as mobile workshops and services such as windshield replacement, roadside assistance and pet grooming.

Common interior equipment configurations involve partitions and shelving, often referred to as bins and racks, for which there are numerous manufacturers and variations to suit different end-user applications. Interior shelving, racks and storage solutions have been adapted to many specialized niche uses, while optimizing cargo space and organization. Other variations include crew vans with a partition behind, or integrated into, a second-row seating system to accommodate more passengers while still utilizing the rear of the vehicle for carrying cargo.

Newer cargo van products in the North American market are often based on European-style products, as the natural utility of these vehicles is globally recognized. This broad consistency of the vehicle platform offers customers that occupy multiple markets the ability to standardize interior configurations on a larger scale. But, while a given van model can be essentially identical across world markets, the interior configurations and equipment come in many forms as a function of the vocational uses in those markets, allowing cargo vans to be both standardized and specialized.

Given trends in urbanization and continued growth in e-commerce, van interior systems will remain a staple in the world economy of truck equipment, leading to new applications for cargo vans as end users continue to downsize and upsize vehicle needs from their current uses. Primarily occupying the Class 2 gross vehicle weight rating (GVWR) range, smaller variants fall under Class 1. There are many advantages to vehicles in this weight range, as they generally do not fall under federal or state motor carrier regulations, which greatly simplifies requirements for fleets and their drivers. However, there is a newer movement into Class 3 with heavier models, primarily battery electric vehicles (BEVs) that will rely upon higher GVWRs in order to provide payload capacity comparable to their internal combustion engine (ICE) counterparts. As a market indicator of this industry, volumes for upfitted cargo vans over the last five years have been approximately 275,000 per year.

The Challenges

Manufacturers and installers of cargo van equipment, which are the same companies in some cases, face a variety of challenges when designing/developing products and upfitting commercial vans for specific purposes and industries. The installation of partitions, shelving, storage systems, workshop arrangements, etc., touch on multiple sets of requirements for the equipment itself, the vehicle and end-users.

Different industries have unique equipment applications for their cargo van equipment, requiring the balance of customization to meet specific needs with the benefits of standardization. Repetitive activities for delivery operations seek to minimize driver steps and motion, improving ergonomics of driving and delivering goods. Providing efficient layout and ease of access to the cargo area, while offering features to protect occupants from shifting cargo and incorporating durability for daily use, are examples of this design balance.

Vehicle technology advancements, including those in response to newer motor vehicle safety standards, continue to challenge van interior system manufacturers. Partitions provide an obvious safety benefit for front occupants, but must be located in a critical vicinity where the vehicle structure and occupant safety restraints also have vital functions. The vehicle area next to and behind the front seats accommodates many safety functions that require clearance, such as deployment zones for side and side curtain airbags along the pillar and roof rail regions, as well as these same areas and the headliner, which are subject to head impact requirements. Attachment to pillar and roof structures also play roles in side impact and roof crush resistance. Manufacturers are challenged to design and develop their products to provide occupant safety and cargo security, while allowing the vehicle safety systems to perform their role.

Installation, attachment and integration of equipment into modern vehicles continues to trend into more complexity, and cargo vans are no exception. OEM use of more structural steels for added structure and durability, and weight reduction of cargo vans are also increasing challenges for drilling mounting holes and fastening equipment. BEV models are bringing more of these same constraints for available floor space for mounting locations by installers due to large areas occupied by batteries, directly under the floor. Additionally, manufacturers of cargo van interiors will need to continue to pursue lightweighting products to help compensate for weight increases on BEV model variants in order to provide similar cargo capacity of their ICE counterparts.

Many industries that utilize cargo vans in their operations require advanced technology and communication systems in their custom work vans. Integrating GPS, telematics, communication devices and power sources while ensuring user-friendly interfaces add to the challenges faced by manufacturers of interior systems.

FULL-BODY CARGO VAN INTERIORS DESIGN CONSIDERATIONS

Chassis Features and Functions

Body and structure

- **Passenger Compartment Area:** The area between the front seats provides valuable real estate for the utility of center console storage, laptop mounting and other equipment options, as well as the mutually exclusive function to provide ergonomic access to the rear of the vehicle. The following expresses the needs for both, as well as other features of the front compartment, along with possibilities of the OEM providing these options and/or creating the ability for installers to add them.
- **Center Console Attachment:** For units that do not come standard with an OEM console, the front seat configuration should allow for secure installation of a center console to the floor between the driver and passenger seats, providing storage and organization options. For units with an OEM center console, the console design includes provisions for easy removal and avoids locating modules or any other electronic components in the console that must remain in the vehicle with the console removed.
- **Laptop Holder Attachment:** Include OEM provisions for attaching a laptop holder or work surface without interfering with the seat bolts.
  - An OEM option or provisions for an aftermarket device are included in the dash area, below the traditional location of cup holders, for a slide-out workstation for laptop operation. There is a high desire for taking advantage of space available in the dash or as part of a removable center console between the seats for such a feature.
- **Clear Space Between Seats:** Ensure there are no permanently attached obstructions, such as a parking brake, between the driver and passenger seats that could restrict access to the rear of the vehicle.
- **Removable Dash Components:** Any dash-mounted items, like cupholders, that extend toward the area between the front seats, should be designed for easy removal, allowing the driver/front passenger additional clear space to access the rear of the vehicle.
- **Passenger Seat Removal:** Provide clear guidance on how to remove the factory-installed passenger seat when needed for specific cargo configurations. This includes creating any methods/provisions/programming needed for proper deactivation of applicable restraint systems.
- **Upper Interior Headliner/Trim:** The OEM upper interior headliner and trim materials needed for compliance with Federal/Canada Motor Vehicle Safety Standard (F/CMVSS) 201 sufficiently extend rearward to prevent the need for additional countermeasures to be installed by upfitters.
- **Mounting Points:** Include standardized mounting points within the cab that can accommodate various accessories, such as cab boxes, inverters or additional storage devices.
- **Step Well Lighting Enhancement:** If not included by the OEM, each step well area design incorporates recessed features to install lighting to aid visibility, especially in low-light conditions, and helps minimize slip and fall incidents, while protecting the lamp and promoting safety for drivers and cargo handlers.

Operator Comfort and Safety

- **HVAC Options:** Provide options and controls for operators to prioritize HVAC settings between the cargo and passenger areas.
- **Level Transition:** The van floor design ensures a smooth and level transition between the front occupant compartment at the B-pillar into the cargo area, providing a level floor from the front occupant compartment to the rear doors. This minimizes trip hazards and facilitates movement of operators between these spaces. This same feature is desired for any other platform variant that allows ingress/egress to the rear of the vehicle, especially on high roof models.

- **Grab Handle Attachment:** Grab handles are needed at all door openings. When they are not standard equipment from the OEM, holes are needed to mount them, especially for high-strength steel to prevent the need for installers to drill/install mounting provisions. To accommodate weld nuts in the B-pillar and rear door frame, consistent spacing is needed. A desired spacing and fastener accommodation would be 8 inches center-to-center, with M10 hardware to provide secure attachment points for grab handles.
  - Position grab handles at approximately chest height for ease of use. Additionally, offer a low mount option for industries or users requiring full-height grab handles. This accommodates a variety of operator safety needs.

Attachment Provisions

- **Features for Partition Installations:**
  - **Weld Nuts:** The interior sheet metal includes a full array of weld nuts around the B-pillar, the rear face of the roof bow at the B-pillar and a row in the floor (approximately in the plane of the rear of the B-pillar) to allow for flexible partition attachment options, eliminate the need for a continuous track which can become a trip hazard and debris-catcher, and to provide support for partition loads.
  - **Roof Bow Alignment:** The structure aligns the roof bow in the same plane as the rear face of the B-pillar to create a smooth and continuous attachment surface.
  - **B-Pillar and Pillar Trim:** The B-pillar rear is exposed so the partition can be mounted to structure without cutting away trim. Alternatives include creating a vertical, two-piece form of B-pillar trim (front and back) to allow the rear portion of the trim to be removed for partition/wing panel attachment. Maintain consistent B-pillar structure and trim across all model variants of the same vehicle platform, including consistency of the upper sections for different roof heights. This allows for standardization of partition attachment and consistency in partition design/shape.
  - **Airbag Curtain Inflation:** Locate all airbag curtain inflation components forward of the 300 mm boundary that lies rearward of the SgRP (seating reference point) defined in 49 CFR 571.201 S6. Locating these components ahead of this boundary avoids the need to provide cutouts in the partition or foam countermeasures in the upper interior area where the partition is positioned.
- **Roof Attachment Features:**
  - **OEM Mounting Features:** The roof design considers OEM mounting features to prevent installers from needing to drill into the roof. Eliminating the need to drill into the roof for exterior attachment of ladder racks and other accessories prevents potential water leaks and risks of drilling into wiring/curtain airbags/etc.
    - **Track Systems:** The highest desire is for streetside and curbside, sealed and recessed track systems or cleats that provide a consistent attachment methodology manufacturers can use to standardize adaptability of different types of ladder racks and other ancillary equipment, such as scene lighting and video camera equipment. The tracks or cleats are arranged longitudinally with a consistent mounting pattern used between different versions of the same models. Ship-thru ability is enhanced to offer a variety of mounting methods and partial assembly/installation of racks/other equipment for transport without affecting the vehicle shipping envelope.
  - **OEM Weld Nuts:** A second-best attachment feature would be OEM weld nuts in the roof exterior.
- **Design Loads to Consider for No-Drill Roof Attachment Systems:**
  - **Ladder Racks:** Approximately 500 pounds total — 200 pounds for the rack and 300 pounds for a full complement of double-stacked ladders (150 pounds per side).
  - **Antennas:** The preferred technology would not require a “shark fin” or other feature on the roof that can interfere with roof-mounted equipment or secured cargo. Where used, the antennae is forward-mounted on the vehicle (forward of the B pillar so all roof attachments can be made without antenna interference) and no greater than 2 inches above the roof line. The forward positioning may also enhance reception.
- **Roof Bows:**
  - **Accommodation for Interior Ladder Rack and Other Structures Mounted to the Upper Interior:** The roof bow structure includes weld nuts along the roof bow centerline, capable of supporting the rack and a single 8-foot, non-extension ladder.
  - **Design Loads to Consider for No-Drill Roof Bow Attachment Systems:** Interior ladder racks – approximately 60 pounds total with 30 pounds each for the rack and ladder.
  - **Spacing:** Maintain 14-inch roof bow spacing between weld flanges. This is the current norm for roof-mounted vents and air conditioning (AC) systems.
  - **Dome Lighting:** The design provides for dome lamps to be mounted in front of roof bows to eliminate snagging and damage when loading cargo. Typical OEM installation places lamps underneath roof bows where they are exposed to cargo loading/unloading damage. Lamp attachment needs to allow repositioning; current methods include a bridge that spans roof bows as a mounting method.
  - **Additional Attachments:** Weld nuts are included near the roof bow-sidewall joints to enable various attachments.

- **Flooring Provisions/Floor Attachment Features:**
  - **Recessed Floor Track System:** The floor design considers mounting features from the OEM to prevent installers from needing to drill through the floor for the attachment of partitions, shelving and numerous other interior components. The desired design is a recessed floor track system, running laterally across the cargo floor at each pillar. Eliminating the need to drill into the floor for interior attachment of shelving, cabinetry and other accessories/equipment prevents the potential for many hazards of contact with brake lines, fuel tanks/lines, electric vehicle (EV) batteries/cables, other chassis components and water leaks. This is extremely important for EV applications, as emerging products create the potential necessity of battery removal by upfitters to safely drill through and access the underside cargo floor.
    - Alternatively, consider OEM-provided weld nuts with the preference to have two rows of weld nuts along each wall at a fixed spacing (i.e., 6 inches and 12 inches) inboard of the body sidewall vertical members. This would be an area for establishing some tolerances around location of OEM-provided weld nuts for applications other than cargo tiedowns (i.e., flooring). Under this option, adequate clear space for fastener installation is need to ensure minimum distances from fuel tanks, battery packs, exhaust components, etc.
  - **OEM Flooring Option:** Thick flooring structure that sits between and on top of the base floor corrugations is provided. The flooring option provides a flat, durable surface to support heavy loads rolled into the cargo area without damaging the base floor. The optional floor overlay includes attachment points that do not require drilling or removal of the flooring option to utilize them.
  - **Load Rating of Floor Attachments:** Load ratings are provided for each OEM fastening location with defined loading in shear and axial directions.
  - **Floor Reinforcement Ribs:** Attention is given in the design of the OEM floor reinforcement ribs, such that they are uniform in arrangement/spacing and of the same height.
- **Sidewalls/Attachment Provisions:**
  - The sidewall design considers mounting features from the OEM to prevent installers from needing to drill into the wall structure. The preferred design features two track systems in each section of sidewall, one upper and one lower. The lower track is desired to be approximately 12–16 inches above the floor to clear the rear wheel wells. Continuing a no-drill concept for interior installations, the wall tracks would prevent drill-through situations where the outer wall is pierced, as well as contact with wires and any other components housed within the sidewalls. A track system also spreads the load, which will help eliminate a common issue with wall pull-out of fasteners and simplify the installation process for upfitters.
  - Alternatively, consider OEM weld nuts or holes — longitudinally arranged along the top header and along the lower sidewall — sized for installation of ¼-inch plus nuts. Ideally, a third row of the same size holes would be located at a middle height, such as at 16 inches, to the cargo floor. A minimum of six fastening points are provided in each row.
  - Load ratings are provided for each OEM fastening location with defined loading in shear and axial directions, including D-rings.
  - Side walls include provisions for installation of cargo tracks to facilitate secure equipment storage. Heavier gauge material or other forms of reinforcement are included at mounting points.
  - Side wall, pillar and roof rail design seek to minimize curvature, providing a more flush inner surface for mounting points.
- **Rear Cargo Doors:**
  - A reserve capacity value is provided for rear cargo van doors. The inside surfaces provide a convenient location for attachment of small racks/holsters for cargo items. In recognition of the weight borne by door hinges, a reserve weight capacity is needed as a guide for upfitters fulfilling customer requests utilizing door positions for additional storage in order to prevent premature wear and functional issues, as well as maintain OEM warranty.
  - Attention is given to the inner face of the rear doors, such that they offer a consistently vertical/flat mounting surface for small racks/cargo containment systems.
  - Additional functionality is available to adjust swing limits for rear doors at 90 degrees, 180 degrees and 230 degrees.
- **Steps/Exterior Attachments:**
  - Include attachment provisions for rear steps with horizontal through-bolt passages through the rear frame ends or unibody rail structure. Additionally, weld nuts are provided approximately 12 inches forward of the through-bolt location (along the frame or unibody structure) for attachment of bracing and additional support structure for the steps.
  - Side door openings include provisions for attachment of entry steps to the chassis frame/unibody structure. Chassis mounting of side entry steps is needed for the high duty cycle of loading/unloading through doorways to provide firm entry steps, avoiding flexure and durability issues that can occur from body-mounted steps.
  - Rear bumpers offer an optional plate reinforcement to be used as a mounting base for mechanical vises used by plumbing, HVAC and other industry trades.
  - The roof line offers mounting accommodations for the ability to add bows for extra load support when additional strength is needed for roof loading.

- **Auxiliary Power:** The cargo van design features a range of auxiliary power features and considerations to support various power needs, including both internal combustion engines (ICEs) and battery electric vehicles (BEVs). These features ensure upfitters have access to the necessary power sources for their applications and enable efficient operation and customization.
  - **For ICE:** An auxiliary fuel port is integrated into the fuel sender assembly. This feature allows for convenient access to auxiliary fuel sources, catering to applications that require fuel supply from the main tank for generators, compressors, heaters, etc. The standardized fuel tap includes an easily accessible length of hose provided by the OEM to eliminate any need for upfitters to drop the fuel tank to access the fuel port. The option for a second auxiliary fuel port is also desired for applications that require more than one fuel-powered device, such as both a compressor and heater for mobile workshop applications.
  - **Electrical Access – 12V, 24V, etc.:** While 12V is currently preferred for compatibility with a wide range of auxiliary equipment, it's envisioned that the industry would likely migrate to 48V. The current provisions should continue to cater to applications requiring 30A and less, as well as those exceeding 30A.
- **Fuel:**
  - **DEF Fill Location:** Cargo van OEMs aim for a standardized diesel exhaust fluid (DEF) fill location under the hood for easy access.
  - **BEV Charge Point Cover:** Ensure the cover for the vehicle's charging point is manually released, allowing it to be operated manually if the vehicle's charge is depleted.
  - **Electrical Charge and Adapters for Hybrid/EV:** The platform is equipped with the necessary infrastructure to support electrical charging, accommodating various power levels and connector types. This feature ensures compatibility with different charging stations and contributes to vehicle versatility, especially in hybrid or electric configurations.
  - **Off-Gas Protection/Provisions During BEV Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common van upfits, such as floor mounting fasteners. Details on preventing interference with the off-gas provision must be provided in body builder information.
- **Exhaust Discharge for ICE:** The exhaust discharge should terminate beyond the edge of the body, ideally 1–2 inches outboard. This design should discourage exhaust modifications to meet applicable requirements.

Heating, Ventilation and Air Conditioning (HVAC)

- **Auxiliary Heat/AC Provisions and Additional Capacities:** The vehicle platform includes provisions for auxiliary heat and air conditioning systems. These provisions include taps that allow upfitters to integrate supplementary heating and cooling capabilities as required by different vocational applications, such as mobile workshops. Further, the OEM system design enables separate control of temperature between the front occupant and rear passenger/cargo areas. The ability to continue to utilize the chassis AC and heating systems will remain a critical need for cargo van upfits on ICE vehicles in the future. The auxiliary taps are routed and capped at a position underneath the vehicle for access in the vicinity of the B-pillar, underneath the driver's seat. This is a familiar location where these features are offered on current chassis cab and cutaway models.
- **Auxiliary Compressor and Condenser Capability/Packaging:** The chassis design acknowledges the need for an auxiliary AC compressor on the high-voltage (HV) system. This feature, available as a standalone OEM option or as part of a van prep package, enhances the overall cooling capacity and ensures additional HVAC system capability. Otherwise, ICE vehicles need to simplify the installation of a second AC compressor, or have a larger capacity OEM compressor for AC system tie-in.

Axles/Suspensions

- **Minimize Wheel Wells in Cargo Area:** Reduce or eliminate the intrusion of wheel wells into the cargo area to maximize equipment and cargo space.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is critical for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** OEMs provide vehicle identification number (VIN)-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, body/roof variations and powertrain combination, enabling accurate weight calculations for different configurations.
- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits — defined for horizontal, vertical and lateral dimensions — are based on the vehicle's unloaded state and when fully loaded to the GVWR. This information also includes any applicable minimum front curb weight value needed for proper handling/braking.
- **Curb Weight/CG Dimensions:** The OEM provides the VIN-specific curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having these details available as far in advance prior to vehicle order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

This section describes the desired support of the chassis electrical architecture for cargo van upfits, which in many cases can apply to other vocational vehicle needs.

- **Electrical Routing:** A designated and protected path for electrical wiring is provided for efficient conduit routing from the dash console to the rear of the vehicle. This facilitates efficient and organized installation of electrical components throughout the cargo area.
- **Enhancing Interior Lighting:** Include a connection point that allows for enhancement of interior lighting with secondary LED light panels.
- **12V Auxiliary Power Rear of B-Pillar:** Include a connection point behind the B-pillar for 12V auxiliary power. This power source can be used for auxiliary batteries, inverters and other installed equipment.
- **Ignition Hot/Constant Hot Points:** Provide ignition hot and constant hot electrical points at the forward end of the headliner, in the vicinity of the inside rearview mirror. This wiring location is ideal for customer telematic installations and eliminates the need for the upfitter to route wires through A-pillars, around airbag systems and disturbing headliners.

Lighting, Wiring, Connectors and Sensors

- **Upfitter Circuits:** The electrical system design includes dedicated circuits and accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Reserve Capacity on Lighting Circuits:** The electrical system accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits or exceeding programmed threshold percentages monitored by the system.
- **Industry-Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals.
- **Required and Auxiliary Lighting Circuit Needs:** The electrical system design accommodates both required lighting circuits (such as auxiliary turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes).
- **Emergency/Warning/Strobe Lighting:** The electrical system design includes provisions for emergency, warning or strobe lighting systems for the front, roof or rear of the van where customer operations require additional visibility.
- **LED Compatibility:** The auxiliary lighting provisions for upfitters are compatible with LED lighting. Trailer tow lighting circuits also accommodate LEDs. This includes proper voltage regulation to support LED lighting.
- **Standard Trailer Tow Provisions:** Continue providing standard options for trailer towing, including trailer lighting connectors and wiring. A delete option should also be available for units requiring equipment incompatible with towing, such as some liftgate configurations or where customers need to prevent towing operations.
- **Relocation/Reinstallation of OEM Sensors for Equipment Installations:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other vehicle locations, and reinstall them in compatible locations, such as where liftgates/rear ramps may interfere with reverse sensory devices and cameras. Easy methods for sensor calibration, which do not require special tools, are provided in body builder information.
- **Configurable Dome Lamps:** Dome lamps feature on/off switch programmability. This configuration would allow dome lamps to come on when any door is opened (front/side/rear) with master shut-off by the driver and a second master switch at the rear door. This is a high desire expressed by last-mile delivery and trades customers.
- **Connector Type and Pin Position Standardization:** Collaboration with the industry drives toward standardization of connector types and pin positions. This ensures broad compatibility and simplifies the upfitting process.
- **OEM Connector for Back-Up Alarm:** An OEM connector is located near the rear of the chassis for connecting a back-up alarm. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **Consistent Auxiliary Fuse Box Location:** Establish a consistent location for the auxiliary fuse box, making it easy for upfitters to access and connect additional electrical components.
- **125V Receptacle Accommodation:** Flat surfaces are needed in areas of the exterior trim and/or sheet metal to incorporate exterior 125V outlets, shore power plugs and other features requiring a flush exterior mounting surface. Flat surfaces are located outside of the fully open positions of sliding and/or barn doors.

Camera Systems

- **Approved Monitor Installation Location:** Clearly specify an approved location for the installation of additional monitors (for auxiliary, non-FMVSS 111 functions) in the vehicle. This guidance ensures upfitters can add screens without compromising safety or visibility of required systems.
- **Relocation Provisions for OEM Rear Camera:** Provide compliant relocation provisions for the OEM rear camera while maintaining functionality of the 360-degree camera system. This is especially important when, for example, installing a liftgate that may obstruct the camera's view.
- **Approved Cable Routing Location:** Specify approved wire/cable routing path for auxiliary cameras through the length of the vehicle, combining the provisions needed for conduit pathways of other wire routing where possible.

Electrical System Controls

Upfitter Switches

- **OEM Switches:** The OEM cabin switches are designed to accommodate common upfit requirements for cargo vans. This includes functions like courtesy lighting, liftgates and more.
- **In-Dash AUX Upfitter Switches:** A minimum of six in-dash upfitter switches are provided. They can be configured or programmed to operate either on battery power or ignition power, offering flexibility in controlling upfit components.
- **Upfitter Switch Wiring and Connectors:** Upfitter switch wiring terminates in a conveniently accessible location, such as in the lower portion of the dash console, with industry-standard connectors. This design facilitates quick and secure connections during upfitting.
- **Programmable Switch Timed Shut-Off:** Switches are designed to be programmable for timed shut-off intervals. This feature allows upfitters to set time durations for specific functions to automatically turn off, enhancing energy efficiency.
- **Physical Battery Connections:** Physical battery connections capable of handling high electrical loads are included in the chassis design. They enable the connection of powered components, such as a 5KW inverter, supporting various upfit applications.
- **Advanced Control Abilities Through CAN BUS:** The communications network incorporates an industry-standard CAN BUS interface, such as J1939, to provide a comprehensive connection for system controls. This interface allows upfitters to perform various monitoring/control functions, in particular:
  1) Read door status
  2) Read ignition status
  3) Read PRNDL status
  4) Temperature monitoring and control of occupant and cargo areas
  5) Lighting controls – dome lamp circuits, strobe lamps (OEM or other)
  6) Transmission interlocks and controls for lifts/ramps, door locks, etc.
  7) Read power takeoff (PTO)-related parameters (status, engine RPM, etc.)
  8) Control the PTO (engagement and engine RPM for clutch pumps and battery charge protect mode)
  9) Perform remote engine start
  10) Perform remote engine stop
  11) Control chassis horn
  12) Read e-brake state
  13) Read AUX switch states
- **Telematics Integration:** The design aims to eliminate the need for separate telematics by enabling integration of third-party systems. This streamlines data collection and communication for fleet management purposes. The ability to interface/interoperate with the OEM system to distribute data to the customer-based system is desired to eliminate the need for a separate transmitter system in the vehicle. The customer base has already invested in proprietary, established systems due to limits of access and use of data/privacy issues with OEM-supplied systems.
- **Power Connections for BEV Chassis:** Design offers a standard power connection for upfitters to operate installed equipment, such as an electric power takeoff (ePTO) or electric compressor. Proposed connections include a 48VDC, 150-amp continuous-duty connection, as well as a 12VDC, 100-amp connection for legacy systems. Moreover, for BEV platforms, the design enables operation and control of the occupant and cargo climate while the vehicle is not in transit.
- **Cybersecurity Specifics:** Addressing cybersecurity concerns is critical, with a focus on protecting end-user telematics systems and data from unauthorized access and cyber threats.

- **EMI/RFI Shielding and Emissions:** The design incorporates necessary electromagnetic interference (EMI) and radio frequency interference (RFI) shielding to mitigate potential interference issues and ensure optimal performance of electronic components added by upfitters, including any additional countermeasures needed for BEV applications. Moreover, the design adheres to established limits for emissions, including Canadian Interference-Causing Equipment Standards (ICES), and clear OEM guidance is provided to maintain compliance.

Regulatory/Safety

ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles

- **Upfit Compatibility:** Vehicle safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, vehicle systems allow for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.

F/CMVSS Considerations

- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the OEM provides maximum unloaded vehicle weight (max UVW) values to maximize upfit capacity for different vocational applications. These specifications help upfitters and end-users choose appropriate vehicle configurations to optimize their intended upfit.
- **Cameras vs. Mirrors:** The vehicle design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Backup Camera Connectivity:** The design features the ability to connect both digital and analog backup cameras, offering flexibility to operators based on camera system preferences. Additionally, a universal backup camera connector is provided, ensuring compatibility across different manufacturers' systems.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an open web location for generic IVDs of each incomplete vehicle model, providing clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper vehicle selection for a given upfit.
  - **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (ICE)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable roof-mounted equipment. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications and without waiting for physical vehicles or vehicle emission control information labels.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.

Additional Body Builder Information

- **Suspension Travel:** The OEM provides detailed suspension profiles in CAD, including maximum effective and metal-to-metal/ full jounce limits. Detailed tire clearance envelopes for each model are also needed. This envelope represents the arc of suspension travel more comprehensively, ensuring tire movement is accounted for in various scenarios. These profiles are supplied before start of production, at the point of design freeze, to facilitate design and engineering integration for equipment, such as automatic tire chain systems.
  - Provide load ratings and pull force information for all mounting points to assist body builders.
  - Share comprehensive information about seat positions, including recline and position adjustments.
  - Standardize step file conversion and limit step file sizes for transfer and conversion.
  - Publish a clear VIN guide and decoding tools.
  - Standardize step file conversion and limit step file sizes for transfer and conversion.
  - Provide order option lookup tool that allows users to easily identify OEM vehicle specifications, such as partition, floor, wall liners, doors, trim level, etc.
- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published by the OEM, detailing all required compliance data points for each vehicle model. This includes curb weight, max UVW, as-built chassis CG dimensions, top of frame height, seat points, passenger load, and other info needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.
- **Early Access to Information:** Body builder guides and IVDs are made available at least two months before ordering opens for a new model year. This early access ensures body builders have the necessary information to plan and design their upfit solutions well in advance, streamlining the process. Provide access to lighter computer-aided design (CAD) files and electrical diagrams at the time of vehicle release.
- **Electrical System Control Descriptions:** Comprehensive descriptions for upfitter switches, BCM access/programmability and CAN BUS/internal chassis data stream are provided. This information empowers body builders to integrate electrical components seamlessly while ensuring compliance with safety and operational requirements.
- **Drill/No-Drill Zones:** The design includes details for drill/no-drill zones, especially in critical areas such as the dashboard, near fuel or electrical systems underneath floor sections, within pillars and other likely areas needed for attachment/ modification by upfitters. This information ensures upfitters are aware of permissible areas for modifications.

Fleet Operations

The vehicle design includes features and considerations that address fleet operations, ensuring efficiency, information accessibility and operational regulatory compliance.

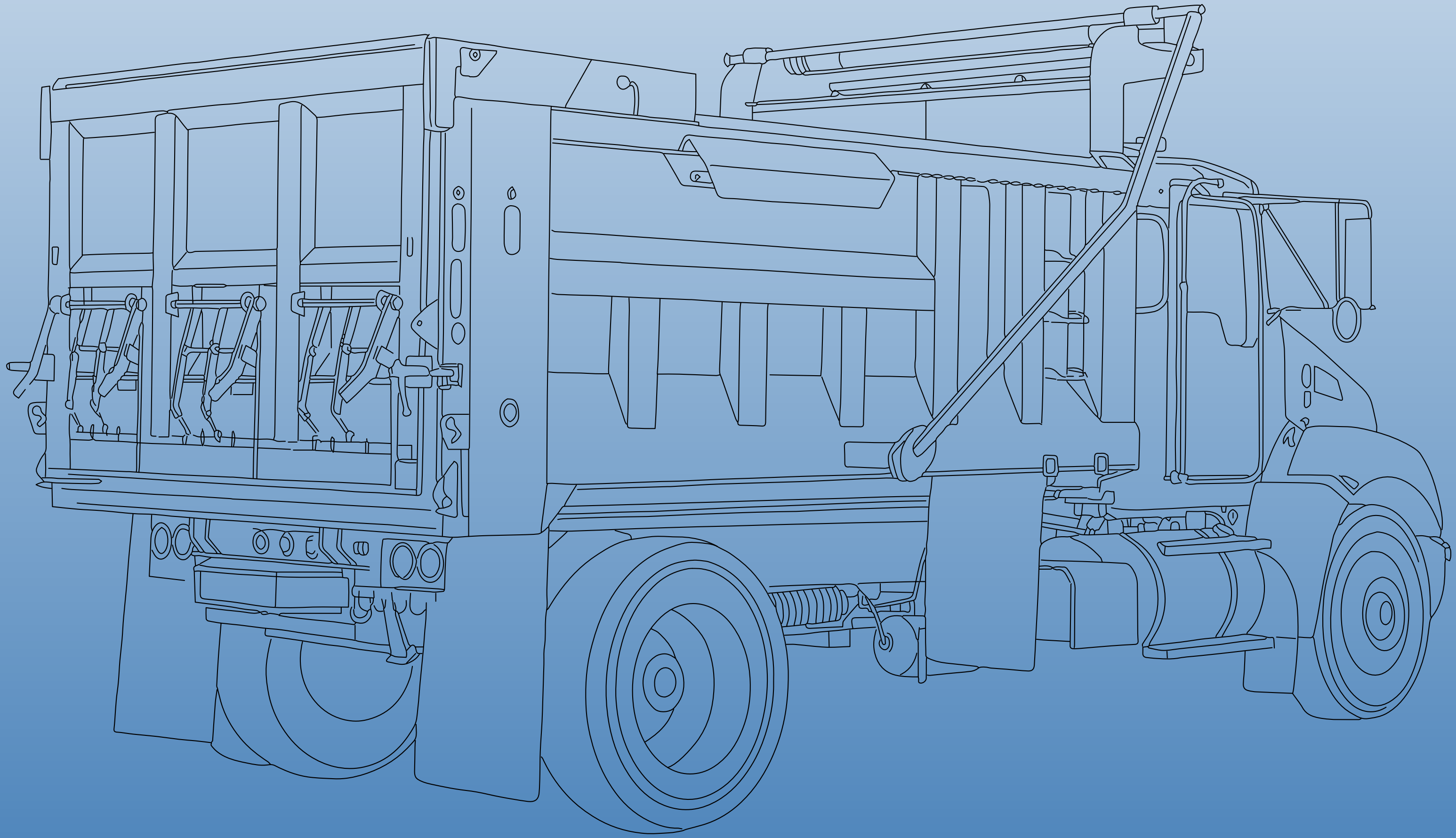
- **Range:** The chassis design provides real driving range estimates for different scenarios, taking into account both curb weight and fully loaded weight. This information offers accurate insights for fleet operators into the vehicle's expected range under various operating conditions, allowing for better route planning and management.
- **Info/Telematics/Communications Needs:** The chassis design facilitates access to vehicle information through telematics and communications systems. Fleet operators can gather data from the vehicle's CAN BUS, as well as that of connected equipment, enabling remote diagnostics, performance monitoring and predictive maintenance, including integration of their own systems.
- **BEV Recharge Time:** The chassis design accounts for varying temperature conditions and charging rates during BEV recharging. By providing information on recharge times under different scenarios, fleet operators can plan charging schedules more effectively and ensure optimal vehicle utilization.
- **Drive/Duty Cycle:** The chassis design factors in specific drive and duty cycle requirements of fleet operations. This includes considerations for urban delivery routes, highway driving and other unique scenarios.
- **Speed Limiting:** Vehicle functionality provides options to limit speed for safety, fuel economy/range management and insurance benefits.

Other

BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

DUMP BODIES



INTRODUCTION
The Dump Body Industry

Dump bodies (e.g., dump trucks, plow trucks, asphalt trucks) are a longstanding, traditional style of work truck body used heavily in the delivery of dirt, rocks, sand, gravel and other commodities. Refined over many years to optimize weight, durability and functionality, they are installed on a wide variety of chassis ranging from Class 3–8 vehicles. Industry volumes over the last five years have been approximately 80,000 bodies per year, produced by a number of manufacturers.

The Market

The market for dump trucks encompasses a wide range of commercial vehicles that feature an open cargo area mounted on a truck chassis. These vehicles are widely used across various industries for transporting equipment and materials. As with many other vocational markets, the delayed replacement of older vehicles in existing fleets (due to the pandemic-driven shutdown of commercial chassis production) as well as the Infrastructure Investment and Jobs Act, should lead to steady demand for dump trucks needed for the multiple infrastructure building projects for years to come.

Dump body trucks are utilized by multiple industries, including delivery and logistics, retail, construction (road and building), landscape, snow removal and more. Dump trucks use hydraulic cylinders to articulate the body to dump or spread the material transported to the job site. These hydraulic cylinders use hydraulic fluid and are operated by a hydraulic pump that is either power takeoff (PTO)-driven, transmission direct-mounted or electric over hydraulic pumps.

Dump truck duty cycles help dictate the chassis selection. Dump body manufacturers have been taking advantage of higher strength material to improve weight; however, some materials transported, such as rocks and boulders, have to be balanced in their durability for these severe loads.

The Challenges

Manufacturers and, in-turn, end users of dump trucks are affected by the integration of bodies to newer chassis products, as well as additional equipment and/or customization needed by the ultimate customer for their vocational mission. In addition to changes in powertrain with electric and advanced fuels coming to market, the increased electrical content of all vehicles is making upfitting more complex. Further, advanced safety systems required in lighter vehicles are also being incorporated into larger vehicles with regulatory requirements following their introduction to the industry. Some technologies, such as automatic emergency braking (AEB), may directly conflict with the vehicle's vocational upfit, which will be an area of continued work with government and industry to safely and responsibly bring these technologies to commercial trucks.

Dump truck body manufacturers are constantly challenged to navigate these trends while preserving customization of products and innovation of features to improve overall and niche applications, incorporating technology for specific customer applications. Manufacturers use various steel and aluminum materials. Material selection depends on factors like durability, weight, cost and specific application requirements.

Dump body chassis installations may tend to seem straightforward with considerations for weight distribution and other basic chassis integration taken into account for motor vehicle safety and emissions compliance. But the array of diverse payload materials compounds these challenges in engineering variations across many industries and businesses in the wide variety of construction, landscape and municipal arenas.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insight from the dump body manufacturer's perspective in depiction of ideal chassis products for these work truck bodies. Some desires may overlap in an effort to emphasize the importance of features in different but related sections/chassis systems. In general, these considerations are chassis and propulsion neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

Chassis Features and Functions

Cab/Passenger Compartment

- **Air Horns:** Ideally, air horns are positioned under the cab to avoid cab roof mounting. In cases where cab roof air horns are inevitable, they are positioned at a consistent height and location across a specific chassis model. This approach, which ensures uniformity and avoids potential interference with body installation, typically includes cab shields that mount to the front of the dump body over the cab to protect the driver during the overhead loading process.
- **Interior Cab Controls:** Provisions and reinforcement are integrated into the chassis design to accommodate control mounting towers next to the driver's position for dump body controls, PTO controls and many dump trucks that are integrated with snowplow and spreader controls. Pass-thru or dedicated wiring channels from the cab interior to the engine bay or vehicle exterior is a key option for integration of various control systems to which the driver must have direct access.
- **Chassis Frame Dimensional Tolerances:** Precise dimensional tolerances are maintained throughout the chassis frame. This includes addressing factors such as maintaining side-side height (i.e., no lean) and cab-frame alignment (trueness).
- **Cab Tilt Access and Dimensions – Cab-Over-Engine (COE) Chassis:** The chassis design incorporates provisions for cab tilt access. Guidelines are provided regarding proper techniques for tilting the cab, ensuring safe and efficient maintenance access to the engine and other components. Chassis OEM information outlines both recommended practices (dos) and precautions (don'ts). Dump body hoists may need to be set back to allow for cab tilt. Keep COE engine and transmission from being above the top of the truck frame outside the cab tilt sweeping area.
- **Vehicle Power On – In-Cab Emergency Shutoff Access and Labeling:** This is particularly for keyless ignition/activation systems. The chassis features accessible emergency shut-off mechanisms, which are clearly labeled for quick identification. In critical situations, these shut-off points can be readily accessed by the operator to prevent potential hazards. The ability to add an emergency stop (both in the cab and on the vehicle hood) is typically requested for municipal dump trucks used in road maintenance and pothole patching. This includes educational materials provided to guide operators on the correct procedures for powering the vehicle on/off.

Frame

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how these modifications can be made while maintaining structural integrity and vehicle safety standard compliance.
- **General Dimensions:** The chassis dimensions are detailed, including encumbered width, cab-to-axle (CA) measurements, clean top of frame specifications and other critical measurements. These dimensions ensure compatibility with various body types and allow for accurate upfitting.
- **Pre-Production Chassis Information:** OEMs provide comprehensive and finalized vehicle identification number (VIN)-specific chassis information to upfitters before the chassis arrives at their facilities. This allows upfitters to source long-lead-time body components in parallel with chassis production, streamlining the upfitting process.
- **Industry Standard CA:** Existing wheelbase and CA dimensions have been accommodated by the dump body industry for chassis cab, cutaway and stripped chassis products. Preserving these dimensions is important to many vocational vehicle upfits.
- **Parallel Rails with Flat Top Surface:** The chassis design features parallel rails with a flat top surface, devoid of steps or offsets. This consistent section height and clean design behind the cab facilitate straightforward body attachment and provide a uniform mounting surface.
- **Clean CA/Top-Bottom of Frame Design:** The preferred design aims for a clean cab-to-axle (CA), where no OEM equipment protrudes above or outboard the frame for the entire length behind the cab. Additionally, equipment such as toolboxes and hydraulic tanks require no OEM equipment between the cab and rear suspension, or directly underneath the frame channels for hydraulic line routing. Except for tires, the chassis design ensures no suspension or other protrusions extend above the top surface of the frame. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Published Top of Frame to Top of Cab:** Clear information is published regarding the distance from the top of the frame behind the cab to the top of the cab. This information is critical for developing cab shield dimensions. Constant measuring locations should also include accessories mounted to the top of the cab.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, minimizing or eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, ensuring structural stability and compatibility with mounting designs.
- **Frame Rail Channel Shape:** Traditional C-channel frame rails are designed with adequate material thickness, strength and clearance around the frame rails. This accommodates rear dump body hinge attachments through welding at the rear of the frame by the rear spring hanger.

- **Outside Frame Rail Width:** The outside width of frame rails is standardized, with chassis cabs featuring a width of 34 inches and with these outside dimensions maintained with additional frame reinforcements (double C-channel, inverted L reinforcement, etc.). While these are unofficial legacy dimensions, preserving them will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it's critical to preserve those that the industry has used for many decades of development.
- **Frame Length Behind Rear Axle (AF):** Dump trucks typically cut off the frame within 6 inches of the rear spring hanger as the rear dump body hinge is mounted as close to the rear spring hanger as possible. Additionally, welding on the rear frame needs to be accommodated for body dump body hinge installation and rear towing systems mounted to the end of the frame.
- **Section Modulus vs. RBM:** Dump trucks will typically have a lower yield strength and higher section modulus to allow for frame flex in the dumping application. A dump body hoist typically will impart the largest section within 12–24 inches behind the cab in the dumping process. For Class 5 and lower vehicles, include sufficient RBM to support the dump body and hoist without use of a subframe. This keeps bed heights 3–4 inches lower and is desired by the user.
- **Industry-Standard Track Width Dimension:** The chassis adheres to an industry-standard track width dimension to ensure compatibility with various bodies and axles with federal width limits.
- **Minimum Clearance Along Frame Rails:** The chassis provides a minimum clearance of 2 inches along the frame rails, preventing interference with items like fuel cells or batteries and allowing for proper body attachment.
- **Ground Clearance and Battery Guarding/Access Points:** Clear definitions for ground clearance and battery guarding/access points are established, promoting safety and efficient upfitting.
- **Charging Port Access and Guarding (Hybrid/Electric Vehicle Powertrain):** If the charging port is located in the frame area, provisions are made for its access, location and guarding. Additionally, the charge point access is preferred on the driver's side of the vehicle to enable the driver to determine they are disconnected before operation.
- **Battery Electric Vehicle (BEV) Battery Mounting:** Dump trucks rarely dump on flat level ground. The battery packs need to be mounted and isolated to allow for frame twist when dumping, therefore protecting battery pack integrity.

Chassis Class 3–8 Body Length, CA and AF

For dump body applications, the traditional body length, CA and AF dimensions are adequate, but options for 6-inch increments of CA/CT on larger chassis are desired.

Body Length (Feet)	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CT/CA Dimension	CA 60 inches	CA 60 inches	CA 84 inches	CA 96 inches	CA102 inches CT 84 inches	CT 96 inches	CT 108 inches	CT 120 inches	CT 132 inches	CT 144 inches	CT 156 inches	CT 168 inches	CT 180 inches	CT 192 inches	CT 204 inches	CT 216 inches	CT 228 inches

Mounting/Equipment Attachment

- **Equipment Attachment:** If there is limited clearance along the frame in certain sections due to the chassis configuration, provisions are made for additional attachment points. This ensures bodies and equipment can be securely attached, even in cases where traditional attachment methods might be challenging due to space constraints, such as the inside of a C-channel next to a fuel tank or electric vehicle (EV) battery.
- **Standardized Pre-Punched Frame Holes:** The chassis design includes standardized pre-punched holes at the back of the frame. These are strategically placed to facilitate the addition of body mounting hardware. Ideally, body attachment points are designed with standardized spacing relative to a reference datum, such as the axle center line or the back of the cab. This approach allows body manufacturers to produce bodies with pre-installed mating mounting surfaces, reducing variability and promoting ease of assembly.
- **Clean Top of Frame and Between Frame Rails:** Dump body hoists need a clean top of frame for mounting, plus no other chassis items (shock towers, fuel lines, etc.) protruding above the top of the frame. Additionally, if crossmembers are below the top of the frame, this assists with clearances required for scissor-style dump body hoists.

Auxiliary Power (see also Electrical Section)

- **Auxiliary Fuel Tap (Internal Combustion Engine Powertrains):** An auxiliary fuel port on the fuel tank sending unit or other means of accessing onboard fuel from the tank continues to be needed, now and into the future, for equipment requiring fuel, such as generators and auxiliary heaters. This helps ensure a convenient and standardized method for accessing fuel with a means to prevent drawing the tank to empty.

- **Electrical Access and High Amp Provisions:**
  - **12V, 24V, etc.:** The chassis offers various electrical access points to accommodate different voltage requirements, such as 12V and 24V systems. These access points are strategically placed for convenience and efficiency during upfitting. 12V power will continue to be needed, as products from the industry's component/system manufacturers are heavily 12V based. Wide coordination is needed to transition to higher voltages.
  - **High Amp Provisions (30A and Less/Over 30A):** The chassis design accounts for high amperage demands. Differentiated provisions are made for power requirements under 30A and those exceeding 30A, ensuring reliable power distribution to auxiliary equipment and devices, including electric-driven hydraulic pumps used typically on Class 2–4 dump trucks.
- **Location of AUX Power Pickup – End of Frame Preferred:** Ideally, the pickup point for auxiliary power is located behind the cab with a second one at the end of the frame. This placement simplifies routing and connection of auxiliary electrical components, such as an electrically driven hydraulic pump used for hoists behind the cab or spreaders at the rear of the vehicle, minimizing interference with other chassis features.
- **Availability of Reconditioning Circuit:** A reconditioning circuit is included in the chassis design. This allows the vehicle's auxiliary power system to automatically recharge or maintain charge in situations where power is drawn from the auxiliary power source extensively.

Fuel

- **Fuel Fill for Internal Combustion Engine (ICE) Vehicles:** If the fuel system uses a capless fuel fill, the OEM provides a standardized fuel fill cup (i.e., "sugar scoop") with an integrated cover/fuel door to prevent dirt/debris from entering the fuel fill cavity.
- **Electrical Charge and Adapters for Hybrid/EV:** The chassis is equipped with the necessary infrastructure to support electrical charging, accommodating various power levels and connector types. This feature ensures compatibility with different charging stations and contributes to vehicle versatility, especially in hybrid or electric configurations.
- **Off-Gas Protection/Provisions During BEV Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common upfits. The design should be such that large distances of clearance underneath bodies/equipment are not necessary to preserve proper ventilation function. This safeguards against potential hazards with gases becoming trapped or concentrated under/within the vehicle and ensures safe charging operations, contributing to the overall safety of the vehicle and its surroundings. Details on preventing interference with the off-gas provision must be provided in body builder information.
- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 8 vehicles, aim for a standardized diesel exhaust fluid (DEF) fill location. Ideally located under the hood or at the back of the cab, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.

Exhaust for ICE Vehicles

- **Horizontal Exhaust:** For horizontal exhaust configurations, the exhaust system is contained entirely within or underneath the frame for the entire length behind the cab. This design approach optimizes space utilization and reduces the risk of interference with upfitted bodies.
- **Vertical Exhaust:** In cases of vertical exhaust setups, the exhaust pipe is mounted to the side of the cab, ensuring it doesn't extend beyond the back of the cab. This design prevents protrusions that could affect body installation or interfere with other components, such as cab shields, maximizing the clean CA dimension.
- **Exhaust Discharge Placement:** The exhaust system discharge is directed outboard, beyond the edge of the body by 1–2 inches. This placement prevents the need for exhaust modifications to meet regulatory requirements, ensuring compliance while maintaining compatibility with various upfitted bodies.
- **Exhaust Clearance for Power Takeoff:** Maintain adequate clearance around transmission/engine opening for PTO and pump, including required heat shielding, without the necessity to disconnect or modify the exhaust system to mount the PTO and pump.

Axles/Suspensions

- **Dimensions and Travel Limits:** Chassis dimensions are designed to accommodate dual tires, with overall width to the exterior sidewalls not exceeding 96 inches. The chassis also includes specified travel, jounce and rebound limits to ensure safe and controlled suspension movement.
- **Air/Hydraulic Suspension Compatibility:** The chassis is adaptable to air and hydraulic suspension systems, allowing for customization based on specific application requirements. As part of this accommodation, the suspension layout ensures components like brake hardware and suspension parts are thoughtfully positioned within the jounce area. Class 7 or 8 dump trucks using an air/hydraulic suspension need to have provisions to dump the air from the airbags, allowing a more stable rear axle while dumping the payload.

- **Ability to Add Auxiliary Springs:** The chassis design allows for the addition of higher capacity springs or extra leaves to the suspension system. These modifications can be made without compromising stability controls, ensuring desired load-bearing capabilities can be achieved.
- **Rear Suspension Hanger Shims:** The rear suspension incorporates shims between the frame and outboard rear suspension attachments. This allows crane manufacturers/upfitters to unbolt suspension attachments and install long shear plates that span forward/rearward of the rear suspension. The shear plates, which are the same width as the shims previously removed, reattach to the suspension in the same design position with the same fastener specifications, preserving suspension points/geometry/integrity while incorporating rigid plates for body/crane attachment. This could also be very beneficial to other vocations. OEMs already design for this where the same suspension mounting is used on double/triple frame chassis, and the suspension is shimmed on lesser frames to match the same design position on layered frames. This is highly desired for Classes 5–8.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide VIN-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.

Gross Vehicle Weight Rating/Gross Axle Weight Rating (GVWR/GAWRs)

- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits are defined for horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having this information available as far in advance as possible prior to chassis order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

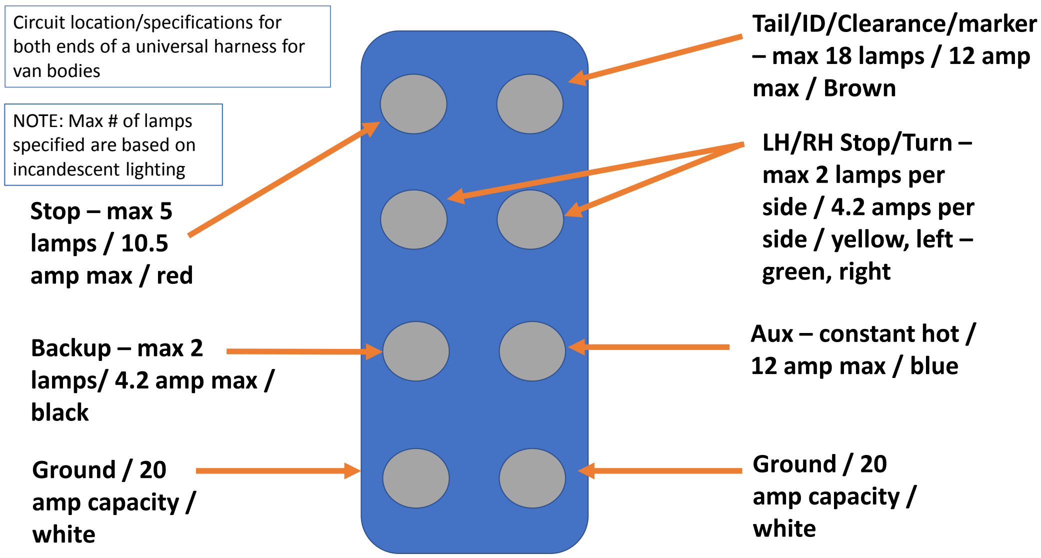
This section describes the desired support of the chassis electrical architecture for dump body upfits, which in many cases can apply to other vocational vehicle needs.

Lighting

- **Dedicated or Accessible Upfitter Circuits:** The chassis design includes dedicated circuits or accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Reserve Capacity on Lighting Circuits:** The chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits, maintaining safety and functionality.
- **Industry-Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits (such as turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes). See additional lighting circuit connector image below.
- **Emergency/Warning/Strobe Lighting:** The chassis includes provisions for emergency, warning, or strobe lighting systems on the front and rear of the chassis. These systems enhance vehicle visibility and safety when operating in hazardous conditions. Provide ample electrical reserve capacity for additional emergency/strobe lighting.
- **LED Compatibility:** The chassis design ensures compatibility with LED lighting for both the vehicle's lighting system and trailer tow lighting circuits. This includes proper voltage regulation to support LED lighting.
- **Standard Trailer Tow Provisions:** Continue providing standard options for trailer towing, including trailer lighting connectors and wiring.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the upfitted body. Easy methods for sensor calibration, which do not require special tools, are provided in body builder information.

- **Connector Type, Quantity and Pin Position Standardization:** Collaboration with the Van Body Manufacturers Division (VBMD) design drives toward standardization of connector types, quantities and pin positions. This ensures compatibility and simplifies the upfitting process. The dump body manufacturers agree with the VBMD connector.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches in width.
- **OEM Connector for Back-Up Alarm:** An OEM connector is located near the rear of the chassis for connecting a back-up alarm. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **Dump Body Manufacturers Support VBMD Generic Lighting Connector:** OEM circuits are provided according to the specifications below, from which body manufacturers can develop their own universal body harnesses.

VBMD Generic Lighting Connector



Camera Systems

- **Approved Monitor Installation Location:** Where auxiliary monitors are needed (non-Federal Motor Vehicle Safety Standard 111 compliant cameras/monitors), clear OEM guidance is provided on the approved locations for installing monitoring displays. This ensures optimal visibility for drivers while preventing installation in airbag deployment, head impact or other stay-out zones.
- **Approved Power Pickup:** The chassis design offers approved power pickup points for various functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting from the cab and running to the rear of the frame. This organized routing prevents interference with other components and maintains clearance for added wiring.

Electrical System Controls

Upfitter Switches

- **OEM Cab Switches:** The OEM cab switches are designed to accommodate common upfit requirements for dump bodies. This includes functions like strobe lights, tailgate switches and more.
- **Pneumatic Switches:** Air-controlled switches in OEM cab provisions to operate air tailgates, air shift PTOs and other dump body accessory functions that are pneumatically controlled.
- **Cab Switch Wiring and Connectors:** Cab switch wiring terminates behind the cab, conveniently accessible with industry-standard connectors. This design facilitates quick and secure connections during upfitting.
- **In-Dash AUX Switches:** A minimum of six AUX in-dash switches are provided. These switches can be configured or programmed to operate either on battery power or ignition power, offering flexibility in controlling upfit components.
- **Programmable Switch Timed Shut-Off:** Switches are designed to be programmable for timed shut-off intervals. This feature allows upfitters to set time durations for specific functions to automatically turn off, enhancing energy efficiency.

- **Physical Battery Connections:** Physical battery connections capable of handling high electrical loads are included in the chassis design. These connections enable the connection of powered components, such as up to 90 amps for components like dump body vibrators and other various upfit applications.
- **CAN BUS (J1939) Connection:**
  - **BCM Access/Programmability:** The chassis design provides access and programmability to the body control module (BCM) via the CAN BUS (J1939) connection.
  - **CAN BUS/Internal Chassis Data Stream Access:** While maintaining cybersecurity measures, upfitters can access internal chassis data streams via the CAN BUS.
  - **Transmission Interlocks and Control:** The CAN BUS connection enables upfitters to control transmission interlocks for multiple functions. It also provides control over PTO engagement and engine RPM.
  - **Remote Engine Start and Stop:** Upfitters can perform remote engine start and stop functions through the CAN BUS connection, enhancing convenience and operational efficiency.
  - **Chassis Horn and E-Brake State:** Chassis horn control and the ability to read the electronic brake (e-brake) state are accessible via the CAN BUS connection.
  - **PTO-Related Parameters:** The CAN BUS connection allows reading PTO-related parameters, such as status and engine RPM.
  - **AUX Switch States:** The states of auxiliary switches can be read through the CAN BUS connection, enabling monitoring and control of additional upfit components.
- **Telematics Integration:** The chassis design includes integration of telematics between the chassis and body. This eliminates the need for separate telematics systems.
- **Battery Electric Chassis Power Connections:** For battery electric chassis, standard power connections are provided for upfit equipment operation. A 48VDC, 150-amp continuous duty connection supports high-power components like electric power takeoff (ePTO) or electric compressors. Additionally, a 12VDC, 100-amp connection is available for legacy systems (lighting, dump body vibrators, etc.).
- **Climate Unit Control (EV):** For battery electric chassis, the design allows the operation and control of the cab climate unit even when the chassis is stationary on a work site. This feature enhances comfort and efficiency during downtime.

Electromagnetic Interference/Radio Frequency Interference (EMI/RFI)

- **Necessary Shielding:** The chassis design includes necessary EMI and radio frequency RFI shielding to mitigate potential electromagnetic compatibility issues and ensure proper operation of electronic components.
- **Emissions Limits:** The design adheres to emissions limits set by relevant regulatory bodies. Emissions are controlled to meet any relevant standards while maintaining proper vehicle operation.

Regulatory/Safety

ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles

- **Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.

F/CMVSS (Federal/Canada Motor Vehicle Safety Standards) Considerations

- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the chassis OEM provides maximum unloaded vehicle weight (max UVW) values to maximize upfit capacity for different vocational applications. These specifications help fleet managers and upfitters choose the appropriate chassis configurations to accommodate their intended body/equipment upfit. Though this is a small portion for the dump body market, it still needs to be taken into account.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an IVD website that provides clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.

- **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the body.
- **F/CMVSS 111 and Maximum Body Widths:** Clear compliance statements are provided with respect to F/CMVSS 111 and maximum body widths to maintain compliance with standard OEM mirrors. If optional OEM mirrors are available, such as trailer tow, the OEM specifies the maximum body widths for each mirror option. Methods to identify how each chassis is equipped are also provided, allowing upfitters to make informed decisions.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emissions Compliance (Internal Combustion Engine)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.

BEV Emission and RFI/EMI Compliance

- **RFI/EMI Transmittance Limits:** For BEVs, upfitters are guided on maintaining RFI and EMI transmittance limits. These guidelines ensure additional upfit equipment does not compromise the BEV's overall RFI/EMI compliance.

Additional Chassis Information

- **Tire Clearance Envelope:** Detailed information is provided regarding tire clearance envelopes for each chassis model. This information accounts for suspension travel arcs and enables upfitters to design body placement and wheel well dimensions accordingly to prevent tire contact.
- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published, detailing all required compliance data points for each vehicle model. This includes curb weight, as-built chassis CG dimensions, top of frame height, seat points, passenger load and other information needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.
- **Published Top of Frame to Top of Cab:** Clear information is published regarding the distance from the top of the frame behind the cab to the top of the cab. This information is critical for developing cab shield dimensions.

Fleet Operations

The integration of these features and considerations into the chassis design enhances the suitability of the vehicle for fleet operations. It aims to provide efficient, reliable and adaptable solutions that align with the operational needs of fleet managers and contribute to overall operational success.

- **Range:** The chassis design takes into account the range requirements of fleet operations, especially for BEVs. The vehicle's range capabilities are designed to align with intended use, ensuring it can cover the necessary distances between charging or refueling points. Consideration is given to factors such as vehicle weight, powertrain efficiency, battery capacity and energy consumption to optimize range without compromising performance. This includes amperage draw for dump body hoists relating to reduction of range specified. Unlike pickup and delivery vehicles, dump trucks will use significant electrical energy to power the hoists for the dumping operation.
- **Info/Telematics/Communications Needs:** The chassis architecture accommodates existing customer telematics systems to be integrated. Alternatively, an OEM-offered system integrates advanced information, telematics and communications systems to meet the evolving demands of fleet operations. This includes real-time vehicle data tracking, remote diagnostics, predictive maintenance alerts and GPS navigation. Telematics systems provide vehicle performance, diagnostics, maintenance alerts, driver behavior and operational efficiency, enabling fleet managers to make informed decisions for optimal fleet management.

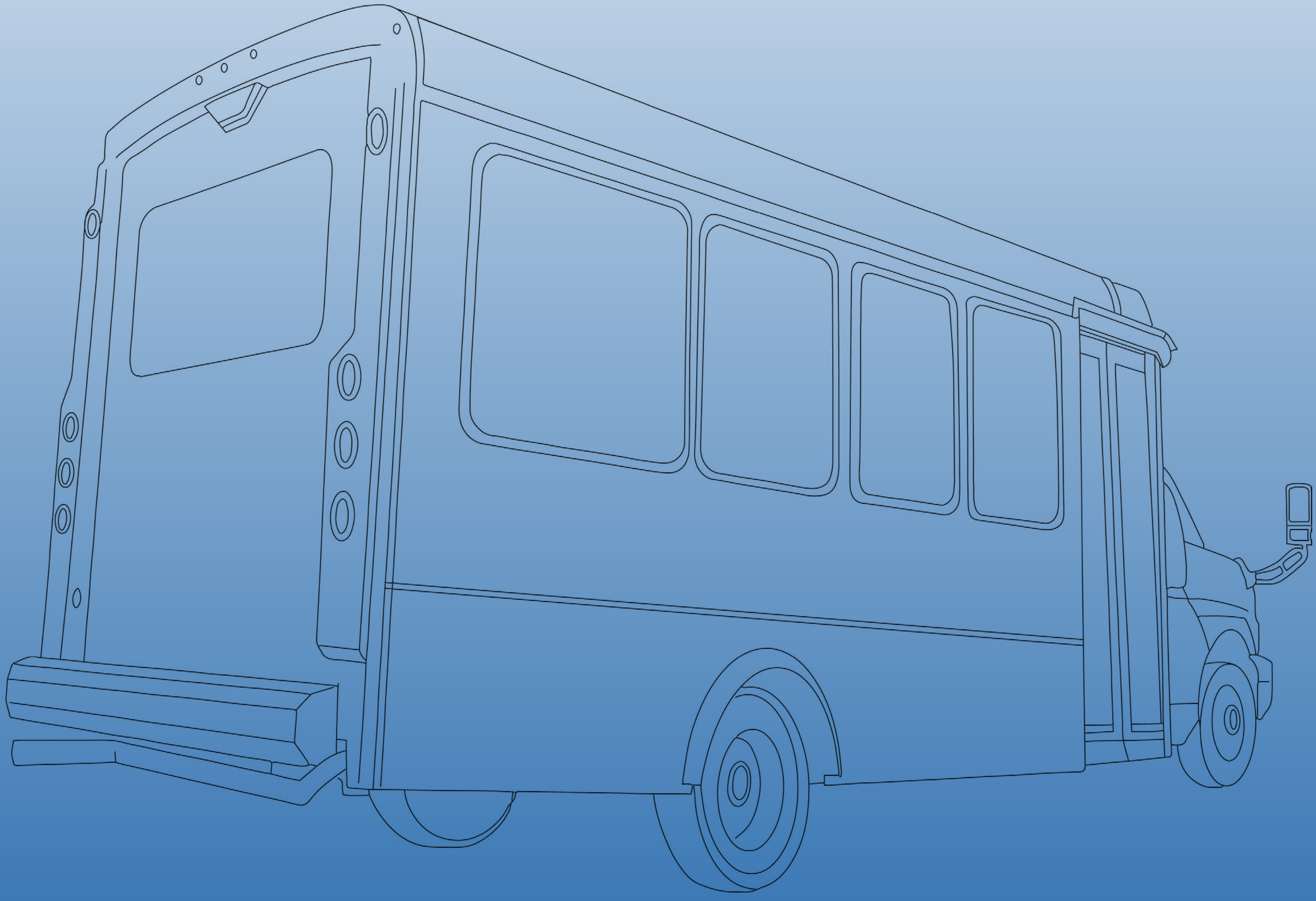
- **BEV Recharge Time:** For BEVs, the chassis architecture addresses recharge time considerations. The design ensures compatibility with various charging standards and infrastructure, allowing fleet operators to recharge vehicles efficiently. Factors such as battery capacity, charging voltage and available charging stations are taken into account to estimate and manage recharge times effectively.
- **Drive/Duty Cycle:** The chassis design factors in specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, highway driving, off-road use and other unique scenarios. The chassis is engineered to handle the demands of different duty cycles, ensuring the vehicle performs optimally and reliably under various operating conditions.

Other

BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

MID-SIZE BUSES



INTRODUCTION

Mid-Size Bus Manufacturers Association (MSBMA)

NTEA's MSBMA was founded in 1993 to enhance professionalism, safety and product quality in the mid-size bus industry. Members include bus manufacturers and other supporting companies such as component, system and service suppliers.

Many mid-size buses are purchased with Federal Transit Administration (FTA) grant money. To qualify for funding, grantees must ensure their bus models have undergone the New Model Bus Testing Program — known as Altoona testing, as the evaluation site is in Altoona, Pennsylvania.

As customers receiving FTA funds must prove purchased buses have undergone testing, they rely on manufacturers to provide proper verification. Under MAP-21 Act, Altoona tests include pass/fail criteria, designed to ensure a minimum performance level. As needed, MSBMA works with FTA to extend equivalence to applicable chassis in an effort to reduce testing for its bus manufacturing members.

MSBMA monitors other recommended changes to federal requirements that may affect its members, and is actively developing relationships with liaisons from various chassis manufacturers linked to the mid-size bus industry. During meetings, routine discussion points include all aspects of upfitting, promoting and distributing buses built on various chassis. OEM participation plays a key role in these conversations.

The Mid-Size Bus Industry

MSBMA defines mid-size buses as passenger-carrying motor coaches, built on a cutaway or rail chassis or on monocoque construction, under 40 feet in length and with a gross vehicle weight rating (GVWR) of Class 7 or less. Cutaway chassis are the predominate platform used for these buses. While members of the group build other bus products, the mid-size bus segment is differentiated by these specifications.

The Market

The market encompasses a diverse range of vehicles designed to transport a moderate number of passengers, typically between 12–40 individuals. Mid-size buses are often used in public transit systems, providing an efficient mode of transportation for urban and suburban areas where larger buses may be impractical. They are commonly used for airport shuttles, hotel transportation, corporate shuttles and other short-distance transportation needs. In the tourism industry, mid-size buses are utilized for guided tours and sightseeing, and there are customized applications of the same vehicle platforms for medical transport, mobile clinics, mobile offices, executive transport, etc.

The customer base for these vehicles is split between public and private purchasers, with public funding involving compliance with Buy America, Americans with Disabilities Act (ADA), FTA Bus Testing Program and other requirements for the manufacturers and public transport agencies. Government regulations and incentives related to emissions, safety standards and public transportation can influence the adoption of newer mid-size bus models, while government investments in transportation infrastructure, such as public transit systems and shuttle services, can also drive demand.

Industry volumes over the last five years have been approximately 12,000 per year, produced by several higher volume manufacturers, with a number of others throughout North America producing the balance.

The Challenges

Mid-size bus manufacturers face a range of challenges when upfitting chassis to create safe and functional vehicles for passenger transportation. Meeting regulatory requirements affects every aspect of bus design with passenger safety and accessibility as top priorities, while optimizing passenger capacity. Manufacturers need to incorporate appropriate seating, seatbelts, emergency exits and structural reinforcements to meet safety standards and protect passengers, while also incorporating wheelchair ramps or lifts, securement systems and other features to ensure compliance with accessibility regulations. Seating configurations are also part of the variety of these vehicles, which can include aisle-facing/perimeter seating as well as rear-facing orientations.

Buses purchased with federal funding from the FTA have numerous requirements related to their design and manufacture. An important milestone for manufacturers is obtaining a passing test report from having prototype models evaluated as part of the Altoona Bus Test Program. The entire vehicle, including the chassis, is considered through the various components of the test program, requiring strong support from chassis OEM partners. A newer FTA priority is working with industry to protect drivers from violent passengers. This is a rising concern, particularly in urban transit, and newer enclosure/barrier systems are being developed to help protect bus operators through FTA's Bus Compartment Redesign Program (BCP) and Bus of the Future initiatives. A variety of designs are being explored, and packaging these features while preserving bus passenger compartment layout will lead to newer design challenges.

Optimizing design includes accurate weight distribution, which is crucial for maintaining bus stability and handling characteristics in different loading conditions. Manufacturers need to carefully consider the weight and locations of the bus body, passenger loads and major systems and components of their upfit, while working within the weight capacities and distribution of the base chassis upon which they build, influenced by the different powertrains, fuel tank capacities/locations and other options offered by the OEM.

Modern mid-size buses are incorporating advanced technologies such as GPS tracking, passenger information systems and electronic fare collection. Manufacturers need to ensure seamless integration of these technologies into the bus design. Public transportation has been an early adopter of electric and advanced fuel propulsion, as well as advanced driver assistance systems (ADAS) technologies, including camera mirrors and transparent cockpits.

Occupant comfort and interior functionality add another layer of complexity to developing and producing these vehicles. Accessing chassis heating and air conditioning (AC) systems to heat and cool the passenger compartment has become increasingly difficult as newer refrigerants come into regulation, requiring changes to AC system components, and providing system access from the chassis. Bus manufacturers may also need to incorporate amenities, such as entertainment systems and overhead storage compartments.

Other areas of balance in bus manufacturing include customization to meet specific customer requirements with the benefits of standardization to streamline production, developing cost-effective solutions without compromising safety and quality, and designing for easy access and maintenance. Manufacturers must consider how service technicians will access and repair various systems and components of the base chassis, as well as their own.

Manufacturing mid-size buses involves a combination of technical, regulatory, ergonomic and customization challenges. Manufacturers must carefully balance safety, comfort, functionality and compliance while delivering vehicles that meet the specific needs of their customers and demands of the passenger transportation industry.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insight from the mid-size bus manufacturer's perspective in depiction of ideal chassis products for these vehicles. Some desires may overlap in an effort to emphasize the importance of features in different, but related sections/chassis systems. In general, these considerations are chassis- and propulsion-neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

While not specifically represented here, some elements of this guide can apply to school buses and multifunction school activity buses (MFSABs).

Chassis Features and Functions

Second Unit Body Attachment, Cutaway and Chassis Cab

- **Guidance for Roof Cutout:** The chassis OEM provides detailed guidance on how the roof of a cutaway vehicle can be cut out to accommodate a walk-thru application. This process enables installation of the necessary roof structure to maintain cab structural integrity while accommodating operator access to the passenger compartment.
- **Rear Flange with Weld Nuts (Cutaway):** To ensure efficient attachment of the body to the cab, the rear face of the vehicle features strategically placed weld nuts in the rear-facing flange of the cab structure. These threaded inserts provide secure connection points for joining the body to the cab, enhancing overall stability and reducing the risk of structural issues from alternative means of body attachment.

- **Flat Rear Face and Accommodating Floor Edge:** The rear face of the chassis is flat and seamlessly accommodates the floor edge of the cab. Following cab flange attachment desires, this design consideration facilitates alignment and attachment of the body to the cab, so the floor edge of the rear face of the cab is designed to accommodate the transition to the body, promoting a seamless connection. Matching the cab floor height relative to bus body floor is ideal and factors in the frame kickup behind the cab and height of the bus body mounts relative to the frame.
- **Chassis Frame Dimensional Tolerances:** The chassis design considers dimensional tolerances to ensure proper alignment between the cab and chassis frame. Maintaining accurate orientation and trueness of the cab to the frame is crucial to ensure proper alignment with bus body mounts.

Cab

- **Air Horns:** Ideally, air horns are positioned under the cab to prevent roof-mounted air horns. However, if roof-mounted air horns are unavoidable, the design specifies consistent height and positioning for a given chassis model.
- **Additional Cable Length for Antennae:** For scenarios involving roof cutouts or relocations, the chassis design accommodates additional cable length for shark fin antennae on the cab roof. This ensures relocation can be performed without compromising signal reception or functionality.
- **Removable B-Pillar/RH Door:** The design enables the removal of the B-pillar and righthand (RH) door as part of a bus prep package for the bus manufacturer to provide a forward door opening. This prevents the need for the driver to turn around to view passengers entering the bus on designs where entry doors are positioned rearward of the B-pillar. It's important that the OEM maintain clearance directly behind the passenger step well and B-pillar area from major chassis components and that electric vehicle (EV) battery packs do not extend forward or laterally into this entry area.
- **Passenger Entry Step Positioning:** The design positions passenger entry steps as far forward as possible on the passenger side of the cab. This configuration enhances a forward bus passenger door location through the traditional passenger door opening.

Driver Egress and Clearance

- **Driver's Seat Egress:** The chassis design accommodates the ability for the driver to egress the driver's seat toward the passenger compartment and side entry door. Adequate clearance is provided around the dash and "dog house" area to facilitate this movement. The option to delete a center console between front occupant seats as part of a bus prep package would be highly desired. Additionally, having the cab and bus body floor heights aligned facilitates this movement by not having a transition, requiring the driver to step up into the passenger area.

Frame/Chassis Understructure

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how these modifications can be made while maintaining structural integrity and compliance with vehicle safety standards.
- **Parallel Rails with Flat Top Surface:** The chassis is designed with parallel rails that have a flat top surface. This eliminates steps or offsets along the length of the frame behind the cab. The consistent section height of the parallel rails promotes uniformity for upfit installations.
- **Clean Cab-to-Axle (CA)/Top of Frame Design:** The preferred design aims for a clean CA, where no OEM equipment protrudes above or outboard the frame for the entire length behind the cab. Except for tires, the chassis design ensures that no suspension or other protrusions extend above the top surface of the frame. This eliminates obstructions and simplifies body installation. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, aiding compatibility with mounting designs and reducing potential interference.
- **C-Channel Frames:** Traditional C-channel frames rails are the preferred shape and designed with adequate material thickness, strength and clearance around the frame rails.
- **Timely Chassis Information for Upfitters:** OEMs provide comprehensive and firm chassis information to upfitter facilities before the chassis arrives. This allows upfitters to source long lead-time body components in parallel with chassis production and delivery, streamlining the bus build process.
- **Frame Length Behind Rear Axle (AF):** The frame extends to the rear of typical bus body lengths, eliminating the need for upfitters to extend the frame. Factory options for additional AF dimensions are also highly desirable.

- **Standardized Frame Extension Features and Kits:** For as-built chassis that require frame extension, standardized pre-punched frame holes and common features are provided at the back of the frame to simplify the process of adding frame extensions. This design choice eliminates the need for welding when adding frame extensions, enhancing efficiency and reducing assembly complexity. Additionally, OEMs offer standardized frame extension kits that include potential mating components. These kits provide upfitters with the necessary components and guidelines for extending the chassis frame, ensuring consistent and reliable results.
- **Universal Hole Pattern at Rear of Frame:** A universal hole pattern and locations are established at the rear of the frame, including extensions, across different manufacturers. This ensures uniformity and compatibility when attaching components.
- **Desired Wheelbase, CA and Aft Frame Length (AF) Dimensions:**

Vehicle Class 1–8	Wheelbase (Inches)	AF (Aft Frame) (Inches)
3–7	Current WB offerings have been accommodated by bus industry, but desire options for 190 inches and 210 inches to reduce need for wheelbase changes	Options for additional AF to prevent frame extensions
For existing school bus chassis (SRW) offerings	Desire option for 158 inches	
Desire 16,000-pound GVWR option on existing cutaway chassis		

- **BEV Chassis Considerations:** For battery electric vehicle (BEV) chassis, the design anticipates the potential loss of access to the underside of the chassis. As a solution, weld nuts or equivalent fastening methods are integrated into the top flange of the chassis frame. These weld nuts serve as mounting points for attaching bus body attachments, providing a secure connection without the need for access to the underside of the chassis. Safe clear space is maintained underneath to accommodate fastener protrusion and installation.
  - Also for BEVs, upfitters may need to have the ability to remove the battery to get access to the bus floor from underneath the vehicle (for anti-rust coating and seat installation).

Mounting/Equipment Attachment and Chassis Dimensions

The chassis design includes several considerations to facilitate the attachment of mounting equipment for bus upfit applications. These features ensure upfitters can efficiently and securely attach various components and bodies to the chassis while adhering to industry standards.

- **Outside Frame Rail Width:** The outside width of frame rails is standardized, with chassis cabs featuring a width of 34 inches and cutaway chassis a width of 42 inches. While these are unofficial legacy dimensions, preserving them will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it's critical to preserve those that the industry has used for many decades of development.
  - Further, maintaining these dimensions is important for the ability to design buses to meet ADA requirements for passenger ingress/egress. Step and ramp slope can be affected by wider frame rails making them too steep, especially on cutaway chassis as they're wider than chassis cabs. Chassis cabs are typically used on heavier GVWR applications that require more passengers, so they are not utilized as much as cutaways in the mid-size bus market. However, the 34-inch dimension that must be maintained as space outside the frame rails is occupied with battery boxes and underbody storage for over-the-road bus applications, so wider frame rails would affect these features.
- **Minimum Inboard Clearance Along Frame Rails:** The chassis provides a minimum clearance of 2 inches along the inside of the frame rails, preventing interference with items like fuel cells or batteries and allowing for proper body attachment, while providing access for technicians and tools.
  - If frame clearance is not available for attaching bodies, OEMs ensure that body attachment points are provided. Ideally, these attachment points follow an industry-standard spacing from a defined datum point, such as the axle center line or back of the cab. This standardization allows for universal compatibility, enabling bodies to be produced with mating mounting surfaces pre-installed.

- **Unifying Body Mounting Methods:** The chassis design aims to unify body mounting methods by incorporating the same features across different models. This consistency simplifies the upfitting process for various vocational applications.
- **Floor Mounting and Reinforcement Options:** The chassis design includes provisions for floor mounting equipment and reinforcement options. This allows upfitters to securely attach and reinforce floor-mounted items within the cab.

Auxiliary Power

The chassis design features a range of auxiliary power features and considerations to support various power needs, including both internal combustion engines (ICEs) and battery electric vehicles (BEVs). These features ensure upfitters have access to the necessary power sources for their applications and enable efficient operation and customization.

- **For ICE:** An auxiliary fuel port is integrated into the fuel sender assembly. This feature allows for convenient access to auxiliary fuel sources, catering to applications that require fuel supply from the main tank for heaters, generators, etc.
- **For Hybrid and EV:** Auxiliary electric power up to 22kW at high voltage is needed for AC and heating needs for higher GVWR vehicles.
- **Electrical Access – 12V, 24V, etc.:** While 12V is currently preferred for compatibility with a wide range of auxiliary equipment, 24V is also supported to accommodate specific applications requiring higher voltage levels. The current provisions should continue to cater to applications requiring 30A and less, as well as those exceeding 30A.
- **Availability of Reconditioning Circuit:** The chassis design includes a reconditioning circuit that allows for remote access to power on or warm up the vehicle. This feature enhances convenience and efficiency in preparing the vehicle for operation.

Fuel

- **Fuel Fill for ICE Chassis:** For ICE chassis, provisions are made for fuel filling, ensuring upfitters have easy access to the fuel tank. If the fuel system uses a capless fuel fill, the OEM provides a standardized fuel fill cup (i.e., “sugar scoop”) with an integrated cover/fuel door to prevent dirt/debris from entering the fuel fill cavity.
- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 7 vehicles, aim for a standardized diesel exhaust fluid (DEF) fill location. Ideally located under the hood or at the back of the cab, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.
- **Electrical Charge and Adapters for Hybrid/EV:** The chassis is equipped with the necessary infrastructure to support electrical charging and includes electrical charge and adapters to support compatibility with various power levels and charging connections. This feature ensures compatibility with different charging stations.
- **Off-Gas Protection/Provisions During BEV Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common upfits. The design should be such that large distances of clearance underneath bodies/equipment are not necessary to preserve proper ventilation function. This safeguards against potential hazards with gases becoming trapped or concentrated under/within the vehicle and ensures safe charging operations, contributing to the overall safety of the vehicle and its surroundings. Information to prevent interference with the off-gas provision must be provided in body builder information.
- **Hybrid/EV Battery Isolation:** Electrical architecture provides a safety feature for a crash-triggered isolation of the high voltage systems, conforming to new/future industry standards.

Exhaust for ICE Vehicles

- **Exhaust Considerations for ICE Vehicles:** The chassis design addresses exhaust packaging constraints to ensure compatibility with upfit installations. Detailed guidance is provided for exhaust modification, within limits of emissions compliance, and discharge location to avoid interference with other components. Additionally, a defined clearance zone around the exhaust is communicated in body builder information, with considerations for heat shielding.
- **Discharge Location and Tailpipe Length:** ICE chassis exhaust discharge is positioned outboard beyond the edge of the body. This requirement ensures effective heat dissipation and minimizes the risk of exhaust system intrusion into the bus. Tailpipe length is determined based on the widest body configuration to accommodate various upfit designs. There is a high desire for driver’s side discharge or rear discharge. Exhausting on the passenger side is not acceptable for bus applications. If this is unavoidable in the exhaust packaging, easily adaptable OEM options and guidance are needed to reroute the exhaust for other discharge locations.

Heating, Ventilation and Air Conditioning (HVAC)

- **Auxiliary Heat/AC Provisions and Additional Capacities:** The chassis design includes provisions for auxiliary heat and AC systems. These provisions include taps that allow upfitters to integrate supplementary heating and cooling capabilities as required by different vocational applications. Further, the chassis design considers the potential need for additional HVAC capacities in passenger compartments. The ability to continue to utilize the chassis AC and heating systems will remain a critical need for bus upfits on ICE chassis in the future.
- **Auxiliary Compressor and Condenser Capability/Packaging:** The chassis design acknowledges the need for an auxiliary AC compressor on the high-voltage (HV) system. This feature, available as an OEM option as part of bus prep or other prep packages, enhances the overall cooling capacity and ensures efficient operation of the HVAC system. Otherwise, ICE vehicles need to simplify the installation of a second AC compressor, or have a larger capacity OEM compressor for AC system tie-in.
- **Hydronic Heater Consideration:** The chassis design recognizes that liquid-based hydronic heaters are more efficient than electrical resistance heating methods. As such, the design provides for an OEM-supplied hydronic heater with a minimum capacity of 30,000 BTUs (British thermal units), with a preference for higher capacities up to 70,000 BTUs for larger buses. This ensures adequate heating capability is available for the passenger compartment.
- **Single Shutoff for Cab Noise:** The design recognizes the need for a single shutoff mechanism that silences radio, heat-AC fans or any other sources of noise within the cab. This shutoff can be activated through CAN data, ensuring the driver environment can be quickly muted when required for situations demanding the driver's full attention.

Axles/Suspensions

- **Suspension Travel:** The OEM provides detailed suspension profiles in CAD, including maximum effective and metal-to-metal/full jounce limits. Detailed tire clearance envelopes for each model are also needed. This envelope represents the arc of suspension travel more comprehensively, ensuring tire movement is accounted for in various scenarios. These profiles are supplied before start of production, at the point of design freeze, to facilitate design and engineering integration by suspension system manufacturers. This information is needed to develop auxiliary suspension products and features noted below.
- **Air/Hydraulic Suspension Systems:**
  - **Adaptability:** The suspension design allows for adaptation of air or hydraulic suspension systems based on specific vehicle needs. This adaptability enhances ride quality, load handling and overall performance, which are not typically offered in the original chassis products. Additional package space is needed to facilitate installation of aftermarket suspension components, such as tanks, pumps and compressors. A current BEV chassis trend is to have reduced package space around the rear axle/suspension, which may reduce the ability for bus adaptation.
  - **Lateral Adjustment:** The suspension design provides a method for compensating body lean without affecting crucial systems like electronic stability control (ESC), brakes and alignment.
  - **Kneeling Function:** Additionally, the suspension accounts for kneeling functions required for passenger loading. Brake lines and jounce hoses are designed with additional flexibility to accommodate auxiliary suspension travel necessary for the kneeling feature.
  - **Dual Leveling Valves and Tire Clearance:** The chassis design incorporates dual leveling valves that do not interfere with stability controls (ESC). A minimum of 9.25 inches of clearance is needed between side of chassis frame to inside of rear tire to accommodate these components.
- **Automatic Chain Deployment Device and Tire Chain Clearance:** The design additionally accommodates the installation of automatic chain deployment devices, along with air/hydraulic suspension systems. Consideration is given to tire chain clearance requirements with or without automatic deployment systems. Ambulance applications also require these same special provisions.
- **Wide Track Axles:** OEM options for wide track rear suspensions are necessary for bus applications, as well as other vocational vehicles, where seating layout and aisle width can be affected by wheel wells inside the bus body. Raising the passenger floor height above the chassis frame for additional tire clearance is undesirable and may not be possible within vertical center of gravity (CG) limits for brake system and/or ESC compliance.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide vehicle identification number (VIN)-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.

- **Overall CG Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits are defined for horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having this information available as far in advance as possible prior to chassis order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Electrical (for all Propulsion Methods, Unless Otherwise Noted)

This section describes the desired support of the chassis electrical architecture for bus manufacture, which in many cases can apply to other passenger transport vehicle applications.

Lighting, Wiring, Connectors, Sensors

- **Upfitter Circuits:** The electrical system includes dedicated circuits and accessible connection points for upfitters to integrate additional lighting systems or accessories. The system also accommodates combined or separate rear lighting functions without the need to reflash lighting control modules. This provision simplifies the process of adding customized lighting to the vehicle.
- **Reserve Capacity on Lighting Circuits:** Chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits or exceeding programmed threshold percentages monitored by the system.
- **Industry Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits under Federal/Canada Motor Vehicle Safety Standard (F/CMVSS) 108 (such as turn signals and brake lights) and auxiliary lighting needs (such as roof emergency strobes).
- **LED Compatibility:** The chassis electrical system ensures compatibility with LED lighting and includes proper voltage regulation to support.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches wide.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the completed vehicle. Easy methods for sensor calibration do not require special tools and are provided in body builder information.
- **Connector Type, Quantity and Pin Position Standardization:** Collaboration with the industry drives toward standardization of connector types, quantities and pin positions. This ensures broad compatibility and simplifies the upfitting process.
- **OEM Connector for Back-Up Alarm:** An OEM connector is located near the rear of the chassis for connecting a back-up alarm. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **Approved Power Pickup:** The chassis design offers approved power pickup points for various circuit functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting the cab and running to the rear of the frame, including extended AF options. This organized routing prevents interference with other components and maintains clearance for added wiring.
- **Engine Bay/Front Compartment Pass-Thru Capability:** The chassis design includes dash panel pass-thru capabilities for upfitters, allowing them to easily route necessary wiring and components through the front panel.

Camera Systems

- **Approved Monitor Installation Location:** Where auxiliary monitors are needed (non-FMVSS 111 compliant cameras/monitors), clear OEM guidance is provided on approved locations for installing monitoring displays. This ensures optimal visibility for drivers while preventing wire/cable installation through airbag deployment, head impact or other stay-out zones.

Electrical System Controls

- **Upfitter Switches and Controls:** A minimum of six in-dash upfitter switches are provided, offering various modes of operation such as ignition hot, battery hot, momentary and maintained functions. The wiring for upfitter switches terminates in a non-proprietary, commonly available connector(s). The design enables access to the body control module (BCM) for programming and customization, enhancing chassis adaptability to specific upfit requirements.
- **Advanced Control Abilities Through CAN BUS:** The communications network incorporates an industry-standard CAN BUS interface, such as J1939, to provide a comprehensive connection for bus system controls. This interface allows manufacturers to perform various functions, in particular:
  1) Perform remote engine stop
  2) Control chassis horn
  3) Control transmission interlock
  4) Read e-brake state
  5) Vehicle speed
  6) Park/neutral
  7) Read PTO-related parameters (status, engine RPM, etc.)
  8) Read AUX switch states
- **Remote Start/Stop and Remote Lock/Unlock Function for Passenger Doors:** The communication network incorporates features to facilitate remote start/stop, allowing operators to warm up the vehicle before use. This feature also provides the ability to use the OEM keyfob to lock/unlock all bus doors, so operators can remotely manage the passenger entry and exit points, as well as rear luggage compartment doors.
- **Transmission Interlocks:** The communication network ensures cybersecurity measures are maintained while providing access to transmission interlocks to meet safety standards for wheelchair lifts, ramps and door locks, including rear exit doors for school bus applications, which prevent both vehicle motion while lifts/ramps are deployed and deployment unless all enabling conditions are met.
- **Telematics Integration:** The design aims to eliminate the need for separate telematics systems by integrating telematics between the chassis and body. This streamlines data collection and communication for fleet management purposes. The ability to interface/interoperate with the OEM system to distribute data to the customer-based system is desired to eliminate the need for a separate transmitter system in the vehicle. Customer base has already invested in proprietary, established systems and would not fully use the OEM system.
- **Apps:** The instrument panel offers a touchscreen that, in addition to standard features, enables upfitters and end users to add their own apps to the system.
- **Inverter Integration:** The design includes inverter integration features that offer flexibility for OEM- or customer-selected inverter options. The inverter is supported by the electrical architecture to provide an engine-off operation mode to continue giving power to selected equipment.
- **No Reinitialization After Remote Start:** The chassis design ensures the inverter does not require reinitialization after a remote start. This feature enhances ease of use and minimizes interruptions, allowing equipment powered by the inverter to remain functional without manual intervention.
- **Power Connections for BEV Chassis:** The design offers a standard power connection for upfitters to operate installed equipment, such as an electric power takeoff (ePTO) or electric compressor. Proposed connections include a 48VDC, 150-amp continuous-duty connection, as well as a 12VDC, 100-amp connection for legacy systems. Moreover, for BEV chassis, the design enables operation and control of cab climate while the vehicle is not in transit.
- **Physical Battery Connections for High Electrical Loads:** To accommodate high electrical loads, such as a 5KW inverter, the chassis design provides physical battery connections. These connections ensure the inverter can draw power efficiently from the battery while maintaining electrical safety and stability.
- **EMI/RFI Shielding and Emissions:** The design incorporates necessary electromagnetic interference (EMI) and radio frequency interference (RFI) shielding to mitigate potential interference issues and ensure optimal performance of electronic components added by upfitters, including any additional countermeasures need for BEV applications. Moreover, the design adheres to established limits for emissions, including Canadian Interference-Causing Equipment Standards (ICES), and clear OEM guidance is provided to maintain compliance.

Regulatory/Safety

ADAS and Autonomous Vehicles

- **Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.

F/CMVSS Considerations

- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the chassis OEM provides maximum unloaded vehicle weight (max UVW) values to maximize upfit capacity for different vocational applications. These specifications help upfitters and end-users choose the appropriate chassis configurations to optimize their intended body/equipment upfit.
- **Mirror-Based Clearance Lamps:** If provided on the forward side of the outside rearview mirrors, enable compliance with pass-thru certification for amber lamps to serve as front clearance lamps.
- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Backup Camera Connectivity:** The design features the ability to connect both digital and analog backup cameras, offering flexibility to operators based on camera system preferences. Additionally, a universal backup camera connector is provided, ensuring compatibility across different manufacturers' systems.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an open web location for generic IVDs of each incomplete vehicle model, providing clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.
  - **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the body.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (ICE)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications and without waiting for physical vehicles or vehicle emission control information labels.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.

Additional Body Builder Information

- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published by the OEM, detailing all required compliance data points for each vehicle model. This includes curb weight, max UVM, as-built chassis CG dimensions, top of frame height, seat points, passenger load, and other info needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.
- **Early Access to Information:** Body builder guides and IVDs are made available at least two months before ordering opens for a new model year (MY). This advance access ensures body builders have the necessary information to plan and design their upfit solutions well in advance, streamlining the process. Provide access to lighter CAD files and electrical diagrams at time of vehicle release.

- **Electrical System Control Descriptions:** Comprehensive descriptions for upfitter switches, BCM access/programmability and CAN BUS/internal chassis data stream are provided. This information empowers body builders to integrate electrical components seamlessly while ensuring compliance with safety and operational requirements.
- **Drill/No-Drill Zones:** The design includes details for drill/no-drill zones, especially in critical areas such as the dashboard, near fuel or electrical systems underneath floor sections, within pillars and other likely areas needed for attachment/ modification by upfitters. This information ensures upfitters are aware of permissible areas for modifications.

Fleet Operations

The chassis design includes features and considerations that address fleet operations, ensuring efficiency, information accessibility and operational regulatory compliance.

- **Range:** The chassis design provides real driving range estimates for different scenarios, taking into account both curb weight and fully loaded weight. This information offers fleet operators accurate insights into the vehicle's expected range under various operating conditions, allowing for better route planning and management.
- **Info/Telematics/Communications Needs:** The design facilitates access to vehicle information through telematics and communication systems. Fleet operators can gather data from the vehicle's CAN BUS, enabling remote diagnostics, performance monitoring and predictive maintenance, including integration of their own systems.
- **BEV Recharge Time:** The chassis design accounts for varying temperature conditions and charging rates during BEV recharging. By providing information on recharge times under different scenarios, fleet operators can plan charging schedules more effectively and ensure optimal vehicle utilization.
- **Drive/Duty Cycle:** The chassis design factors in specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, rural transit, highway driving and other unique scenarios.

Other

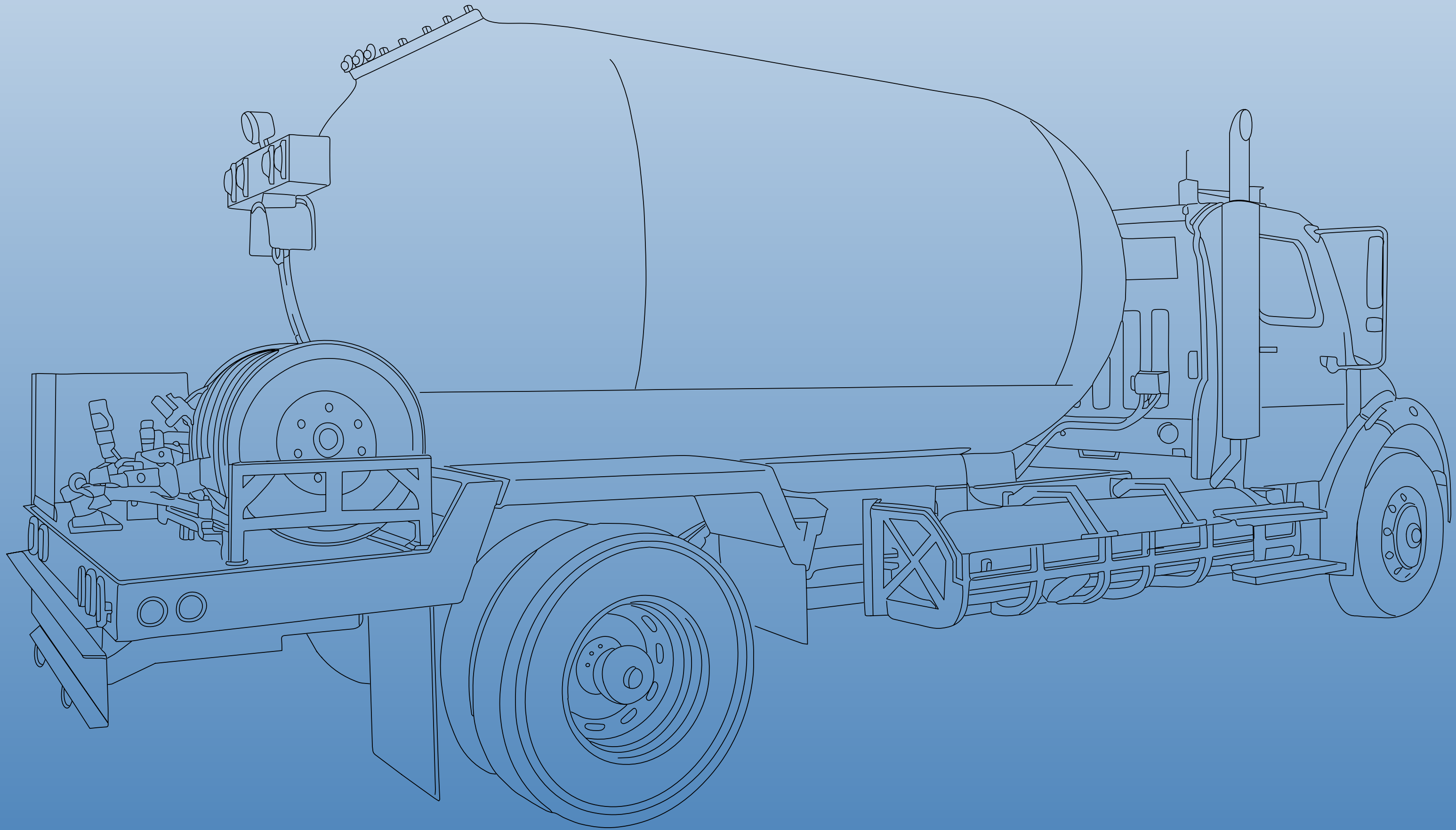
BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

Additional Resources

- Altoona Bus Testing Program information: **altoonabustest.psu.edu**
- Mid-Size Bus Manufacturers Association information: **ntea.com/msbma**

PROPANE TRUCKS



INTRODUCTION

Propane Truck Builder's Association (PTBA)

NTEA's PTBA was formed in 2007 to promote and serve common interests of propane truck builders in the development and use of safe, efficient propane delivery vehicles. Members must meet stringent regulatory requirements in the building, inspection and repair of these hazardous-material vehicles.

The group reviews and addresses the amount and complexity of federal government regulations with which propane truck builders must comply and brings a unified industry response to regulatory initiatives and proposals companies need to meet. In addition, PTBA helps propane truck buyers stay informed regarding regulatory compliance issues and the importance of using qualified builders and repair facilities. Member companies work with chassis manufacturers to best meet customer needs, including on specification development for propane-powered chassis used in delivery segments.

The Propane Truck Industry

Propane trucks (i.e., bobtails in the delivery of liquid propane) are a hazardous material vehicle and subject to specific design requirements for the propane tank under strict federal regulations They are installed primarily on medium- and heavy-duty chassis, typically in Class 7 or Class 8 vehicles. Industry volumes over the last few years have been approximately 2,300 bodies per year, produced by a number of manufacturers.

The Market

The market for propane trucks is specific to companies that deliver propane to homes, businesses and specific transportation industries. Due to the nature of the loads and their delivery, propane bobtails require significant torque to endure steep hills and other off-road situations for delivery. Additionally, power takeoff requirements are significant as they are delivering a compressed gas in a liquid form.

More recently, advanced technologies, such as GPS tracking, telematics and route optimization software have enhanced the efficiency and operational capabilities of all commercial vehicles. But the transport functions of propane trucks have especially benefited transport operations with delivery routes, vehicle performance and location monitoring, and fuel consumption optimization.

The Challenges

Manufacturers (and, in-turn, end users) of propane delivery trucks are affected by the integration of bodies to newer chassis products, as well as additional equipment and/or customization needed by the ultimate customer for their vocational mission. In addition to changes in powertrain with electric and advanced fuels coming to market, the increased electrical content of all vehicles is making upfitting more complex. Further, advanced safety systems required in lighter vehicles are also being incorporated into larger vehicles with regulatory requirements following their introduction to the industry. Some technologies, such as electronic stability control, can be a useful enhancement but will require chassis manufacturer flexibility in programming. Automatic emergency braking (AEB), can also pose challenges based on the custom design of many of these vehicles, which will be an area of continued work with government and industry to safely and responsibly bring these technologies to commercial trucks.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insight from the van body manufacturer's perspective in depiction of ideal chassis products for these work truck bodies. Some desires may overlap in an effort to emphasize the importance of features in different, but related sections/chassis systems. In general, these considerations are chassis and propulsion neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

Chassis Features and Functions

Cab/Passenger Compartment

- **Remote Access and Requirements:** Remote access features are included in the chassis design, with considerations for antennas and telematics control units (TCUs). Additionally, a reconditioning circuit is integrated to facilitate remote power activation or warm-up of the vehicle's systems.
- **Chassis Frame Dimensional Tolerances:** Precise dimensional tolerances are maintained throughout the chassis frame. This includes addressing factors such as maintaining side-side height (i.e., no lean) and cab-frame alignment (trueness).

- **Vehicle Power On – In-Cab Emergency Shutoff Access and Labeling:** This is particularly for keyless ignition/activation systems. The chassis features accessible emergency shut-off mechanisms, which are clearly labeled for quick identification. In critical situations, these shut-off points can be readily accessed by the operator to prevent potential hazards and secure the vehicle. This includes educational materials provided to guide operators on the correct procedures for powering the vehicle on/off. Additional provisions for emergency shutdown switches on the exterior of the vehicle need to be available.

Frame

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how to make these modifications while maintaining structural integrity and compliance with vehicle safety standards.
- **General Dimensions:** The chassis dimensions are detailed, including encumbered width, cab-to-axle (CA) measurements, clean top of frame specifications and other critical measurements. These dimensions ensure compatibility with various body types and allow for accurate upfitting.
- **Pre-Production Chassis Information:** OEMs provide comprehensive and finalized vehicle identification number (VIN)-specific chassis information to upfitters before the chassis arrives at their facilities. This allows upfitters to source long-lead-time body components in parallel with chassis production, streamlining the upfitting process.
- **Industry Standard CA:** Existing wheelbase and CA dimensions have been accommodated by the propane body industry for chassis cab products. Preserving these dimensions is important to many vocational vehicle upfits.
- **Parallel Rails with Flat Top Surface:** The chassis design features parallel rails with a flat top surface, devoid of steps or offsets. This consistent section height and clean design behind the cab facilitate straightforward body attachment and provide a uniform mounting surface.
- **Clean CA/Top of Frame Design:** The preferred design aims for a clean CA, where no OEM equipment protrudes above the frame for the entire length behind the cab. Except for tires, the chassis frame rails ensure that no suspension or other protrusions extend above the top surface of the frame. This design feature eliminates obstructions and simplifies body installation. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, minimizing or eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, ensuring structural stability and compatibility with mounting designs.
- **Frame Rails Channel Shape:** Traditional C-channel frame rails are designed with adequate material thickness, strength and clearance around the frame rails. This accommodates shear plate and other body mounting designs, promoting effective body mounting options.
- **Outside Frame Rail Width:** The outside width of frame rails is standardized, with chassis cabs featuring a width of 34 inches. While these are unofficial legacy dimensions, preserving them will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it’s critical to preserve those that the industry has used for many decades of development.
- **Frame Length Behind Rear Axle (AF):** The frame extends to the rear of typical tank body lengths, optimizing available space for various upfitting applications and eliminating the need for upfitters to extend the frame. Factory options for additional AF dimensions are also highly desirable, especially for hose reels and their cabinetry.
- **Industry Standard Track Width Dimension:** The chassis adheres to an industry-standard track width dimension to ensure compatibility with various bodies and axles with federal width limits.
- **Minimum Clearance Along Frame Rails:** The chassis provides a minimum clearance of 2 inches along the frame rails, preventing interference with items like fuel cells or batteries and allowing for proper body attachment.
- **Ground Clearance and Battery Guarding/Access Points:** Clear definitions for ground clearance and battery guarding/access points are established, promoting safety and efficient upfitting.
- **Charging Port Access and Guarding (Hybrid/EV Powertrain):** If the charging port is located in the frame area, provisions are made for its access, location and guarding.

Mounting/Equipment Attachment

- **Equipment Attachment:** If there is limited clearance along the frame in certain sections due to the chassis configuration, provisions are made for additional attachment points. This ensures bodies and equipment can be securely attached even in cases where traditional attachment methods might be challenging due to space constraints, such as the inside of a C-channel next to a fuel tank or EV battery.

- **Standardized Pre-Punched Frame Holes:** The chassis design includes standardized pre-punched holes at the back of the frame. These holes are strategically placed to facilitate the addition of bolt-on frame extensions, eliminating the need for welding during the extension process and expediting upfitting operations. Ideally, body attachment points are designed with standardized spacing relative to a reference datum, such as the axle center line or the back of the cab. This approach allows body manufacturers to produce bodies with pre-installed mating mounting surfaces, reducing variability and promoting ease of assembly.
- **Standardized Frame Extension Kits:** Options for longer AF dimensions would be preferred, but for chassis not ordered with the proper dimensions, OEMs would provide standardized frame extension kits, which include components that can be easily integrated into the chassis frame. These kits are designed to ensure structural integrity while extending frame length, offering a straightforward solution for specific upfitting needs.
- **Floor Mounting Attachment Points and Ratings:** Dedicated mounting locations are available for floor mounting of components, such as consoles or laptop mounts and meter controls, within the cab in proximity to the driver's seat. These options would include applicable load ratings.
- **Side Walls – Drill and No-Drill Areas:** Guidelines are provided for attaching equipment and components to the cab structure, including fenders, doors, roof and back panel. These guidelines outline areas where drilling is permissible and areas where no-drill methods should be employed to prevent making contact with any components or affecting structural integrity.

Auxiliary Power (see also Electrical Section)

- **Auxiliary Fuel Tap (ICE Powertrains):** An auxiliary fuel port on the fuel tank sending unit or other means of accessing onboard fuel from the tank continues to be needed, now and into the future, for equipment that requires fuel, such as generators and auxiliary heaters. This helps ensure a convenient and standardized method for accessing fuel with a means to prevent drawing the tank to empty.
- **Electrical Access and High Amp Provisions:**
  - **12V, 24V, etc.:** The chassis offers various electrical access points to accommodate different voltage requirements, such as 12V and 24V systems. These access points are strategically placed for convenience and efficiency during upfitting. 12V power will continue to be needed, as products from the industry's component/system manufacturers are heavily 12V based. Wide coordination is needed to transition to higher voltages.
  - **High Amp Provisions (30A and Less/Over 30A):** The chassis design accounts for high amperage demands. Differentiated provisions are made for power requirements under 30A and those exceeding 30A, ensuring reliable power distribution to auxiliary equipment and devices.
- **Location of AUX Power Pickup – End of Frame Preferred:** Ideally, the pickup point for auxiliary power is located at the end of the frame. This placement simplifies routing and connection of auxiliary electrical components, pumps and meter, minimizing interference with other chassis features.
- **Availability of Reconditioning Circuit:** A reconditioning circuit is included in the chassis design. This circuit allows the vehicle's auxiliary power system to automatically recharge or maintain charge in situations where power is drawn from the auxiliary power source extensively.
- **Remote Access for Power-On or Warm-Up:** The chassis incorporates features that enable remote access to power-on or warm-up the vehicle, enhancing convenience and efficiency. This can be particularly beneficial in scenarios where pre-conditioning or pre-warming the vehicle is necessary.

Fuel

- **Fuel Fill for ICE Vehicles:** Fuel fill location that does not interfere with equipment mounted on the sides of the truck frame behind the cab.
- **Electrical Charge and Adapters for Hybrid/EV:** The chassis is equipped with the necessary infrastructure to support electrical charging, accommodating various power levels and connector types. This feature ensures compatibility with different charging stations and contributes to vehicle versatility, especially in hybrid or electric configurations.
- **Off-Gas Protection/Provisions During BEV Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common upfits. The design should be such that large distances of clearance underneath bodies/equipment are not necessary to preserve the proper ventilation function. This safeguards against potential hazards with gases becoming trapped or concentrated under/within the vehicle and ensures safe charging operations, contributing to the overall safety of the vehicle and its surroundings. Details on preventing interference with the off-gas provision must be provided in body builder information. Special concern must be given for these compressed gas hauling vehicles such as propane bobtails.
- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 8 vehicles, aim for a standardized diesel exhaust fluid (DEF) fill location. Ideally located under the hood or at the back of the cab, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.

Exhaust for ICE Vehicles

- **Vertical Exhaust:** In cases of vertical exhaust setups, the exhaust pipe is mounted to the side of the cab, ensuring it doesn't extend beyond the back of the cab. This design prevents protrusions that could affect body installation or interfere with other components, maximizing the clean CA dimension. Vertical exhaust is a preference to keep any additional heat away from the propane tank.

Axles/Suspensions

- **Dimensions and Travel Limits:** Chassis dimensions are designed to accommodate dual tires, with overall width to the exterior sidewalls not exceeding 96 inches. The chassis also includes specified travel, jounce and rebound limits to ensure safe and controlled suspension movement.
- **Air/Hydraulic Suspension Compatibility:** The chassis is adaptable to air and hydraulic suspension systems, allowing for customization based on specific application requirements. As part of this accommodation, the suspension layout ensures components like brake hardware and suspension parts are thoughtfully positioned within the jounce area. A typical propane bobtail uses spring suspension but if air ride is used left to right, air balance must be maintained.
- **Compensating for Body Lean:** The chassis design incorporates a method for compensating for body lean without affecting electronic stability control (ESC), braking systems, wheel alignment or other critical vehicle functions. This ensures a stable and controlled driving experience, even with varying load conditions.
- **Dual Leveling Valves and Stability Controls:** Dual leveling valves are integrated into the suspension system without interfering with stability controls, such as ESC. This preserves vehicle stability and safety during operation.
- **Ability to Add Auxiliary Springs:** The chassis design allows for the addition of higher capacity springs or extra leaves to the suspension system. These modifications can be made without compromising stability controls, ensuring desired load-bearing capabilities can be achieved. For trucks that deliver propane tanks for on-site use, this is important to compensate for the corner-mounted crane incorporated into these vehicles.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide VIN-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.

Gross Vehicle Weight Rating/Gross Axle Weight Ratings (GVWR/GAWRs)

- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits are defined for horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having this information available as far in advance as possible prior to chassis order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

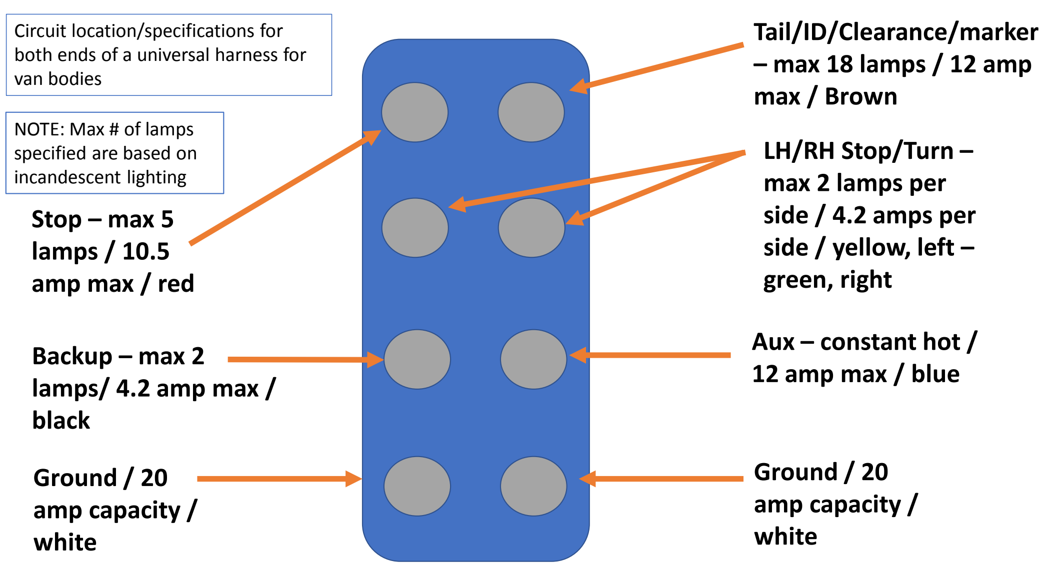
This section describes the desired support of the chassis electrical architecture for body upfits, which in many cases can apply to other vocational vehicle needs.

Lighting

- **Dedicated or Accessible Upfitter Circuits:** The chassis design includes dedicated circuits or accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Separated Stop and Turn Signal Wiring Provisions:** Hazardous material vehicles require separate stop and turn signals for crossing rail roads and other stopped applications.
- **Reserve Capacity on Lighting Circuits:** Chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits, maintaining safety and functionality.
- **Industry Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.

- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits (such as turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes). See additional lighting circuit connector image below.
- **Emergency/Warning/Strobe Lighting:** The chassis includes provisions for emergency, warning or strobe lighting systems on the front and rear of the chassis. These systems enhance the vehicle's visibility and safety when operating in hazardous conditions.
- **LED Compatibility:** The chassis design ensures compatibility with LED lighting for both the vehicle's lighting system and trailer tow lighting circuits. This includes proper voltage regulation to support LED lighting.
- **Standard Trailer Tow Provisions:** Continue providing standard options for trailer towing, including trailer lighting connectors and wiring. A delete option should also be available for units requiring equipment incompatible with towing.
- **Relocating OEM Lights, Antennas and Sensors:** Guidelines are provided to relocate OEM lights, antennas and sensors, especially in applications with aerodynamic devices. This ensures proper placement and functionality when moving components for different body configurations.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the upfitted body. Easy methods for sensor calibration, which do not require special tools, are provided in body builder information.
- **Connector Type, Quantity and Pin Position Standardization:** PTBA agrees with the Van Body Manufacturers Division (VBMD) design driving toward standardization of connector types, quantities and pin positions. This standardization ensures compatibility and simplifies the upfitting process.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches in width.
- **OEM Connector for Back-Up Alarm:** An OEM connector is located near the rear of the chassis for connecting a back-up alarm. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **PTBA Supports the VBMD Generic Lighting Connector:** OEM circuits are provided according to the specifications below, from which van body manufacturers can develop their own universal body harnesses.

VBMD Generic Lighting Connector



Camera Systems

- **Approved Monitor Installation Location:** Where auxiliary monitors are needed (non-Federal Motor Vehicle Safety Standard 111 compliant cameras/monitors), clear OEM guidance is provided on the approved locations for installing monitoring displays. This ensures optimal visibility for drivers while preventing installation in airbag deployment, head impact or other stay-out zones.
- **Approved Power Pickup:** The chassis design offers approved power pickup points for various functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting the cab and running to the rear of the frame. This organized routing prevents interference with other components and maintains clearance for added wiring.

Electrical System Controls

Upfitter Switches

- **OEM Cab Switches:** The OEM cab switches are designed to accommodate common upfit requirements for van bodies. This includes functions like body dome lamps, liftgate cut-off switches, and more.
- **Cab Switch Wiring and Connectors:** Cab switch wiring terminates behind the cab, conveniently accessible with industry-standard connectors. This design facilitates quick and secure connections during upfitting.
- **In-Dash AUX Switches:** A minimum of six AUX in-dash switches are provided. They can be configured or programmed to operate either on battery power or ignition power, offering flexibility in controlling upfit components.
- **Programmable Switch Timed Shut-Off:** Switches are designed to be programmable for timed shut-off intervals. This feature allows upfitters to set time durations for specific functions to automatically turn off, enhancing energy efficiency.
- **Physical Battery Connections:** Physical battery connections capable of handling high electrical loads are included in the chassis design. They enable the connection of powered components, such as a 5KW inverter, supporting various upfit applications. Battery boxes must be large enough to support additional electrical equipment connections.
- **CAN BUS (J1939) Connection:**
  - **BCM Access/Programmability:** The chassis design provides access and programmability to the body control module (BCM) via the CAN BUS (J1939) connection.
  - **CAN BUS/Internal Chassis Data Stream Access:** While maintaining cybersecurity measures, upfitters can access internal chassis data streams via the CAN BUS.
  - **Transmission Interlocks and Control:** The CAN BUS connection enables upfitters to control transmission interlocks for functions like liftgates, ramps and door locks. It also provides control over the power takeoff (PTO) engagement and engine RPM.
  - **Remote Engine Start and Stop:** Propane bobtails require emergency shutdown capability for both the engine and transmission to stop the flow of materials. Upfitters can perform remote engine start and stop functions through the CAN BUS connection, enhancing convenience and operational efficiency.
  - **Chassis Horn and E-Brake State:** Chassis horn control and the ability to read the electronic brake (E-brake) state are accessible via the CAN BUS connection.
  - **PTO-Related Parameters:** The CAN BUS connection allows reading PTO-related parameters such as status and engine RPM.
  - **AUX Switch States:** The states of auxiliary switches can be read through the CAN BUS connection, enabling monitoring and control of additional upfit components.
- **Telematics Integration:** The chassis design includes integration of telematics between the chassis and body, eliminating the need for separate telematics systems.
- **Battery Electric Chassis Power Connections:** For battery electric chassis, standard power connections are provided for upfit equipment operation. A 48VDC, 150-amp continuous-duty connection supports high-power components like electric power takeoff (ePTO) or electric compressors. Additionally, a 12VDC, 100-amp connection is available for legacy systems (lighting, liftgates, etc.).
- **Climate Unit Control (EV):** For battery electric chassis, the design allows the operation and control of the cab climate unit even when the chassis is stationary on a work site. This feature enhances comfort and efficiency during downtime.

Electromagnetic Interference/Radio Frequency Interference (EMI/RFI)

- **Necessary Shielding:** The chassis design includes necessary EMI and RFI shielding to mitigate potential electromagnetic compatibility issues and ensure proper operation of electronic components.
- **Emissions Limits:** The design adheres to emissions limits set by relevant regulatory bodies. Emissions are controlled to meet any relevant standards while maintaining proper vehicle operation.

Regulatory/Safety

ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles

- **Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.

F/CMVSS (Federal/Canada Motor Vehicle Safety Standards) Considerations

- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an IVD website that provides clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.
  - **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the body.
  - **F/CMVSS 111 and Maximum Body Widths:** Clear compliance statements are provided with respect to F/CMVSS 111 and maximum body widths to maintain compliance with standard OEM mirrors. If optional OEM mirrors are available, such as trailer tow, the OEM specifies the maximum body widths for each mirror option. Methods to identify how each chassis is equipped are also provided, allowing upfitters to make informed decisions.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (Internal Combustion Engine)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum unloaded vehicle weight (UVW) limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.

BEV Emission and RFI/EMI Compliance

- **RFI/EMI Transmittance Limits:** For BEVs, upfitters are guided on maintaining RFI and EMI transmittance limits. These guidelines ensure additional upfit equipment does not compromise the overall RFI/EMI compliance of the BEV.

Additional Chassis Information

- **Tire Clearance Envelope:** Detailed information is provided regarding tire clearance envelopes for each chassis model. This information accounts for suspension travel arcs and enables upfitters to design body placement and wheel well dimensions accordingly to prevent tire contact.
- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM's publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published, detailing all required compliance data points for each vehicle model. This includes curb weight, as-built chassis CG dimensions, top of frame height, seat points, passenger load and other information needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.

Fleet Operations

The integration of these features and considerations into the chassis design enhances the suitability of the vehicle for fleet operations. It aims to provide efficient, reliable and adaptable solutions that align with the operational needs of fleet managers and contribute to overall operational success.

- **Range:** The chassis design takes into account the range requirements of fleet operations, especially for battery electric vehicles (BEVs). The vehicle's range capabilities are designed to align with intended use, ensuring it can cover the necessary distances between charging or refueling points. Consideration is given to factors such as vehicle weight, powertrain efficiency, battery capacity and energy consumption to optimize range without compromising performance. Additionally, the power consumption needed to offload propane while still maintain the liquid format (high compression factor) must be factored into actual usable range.

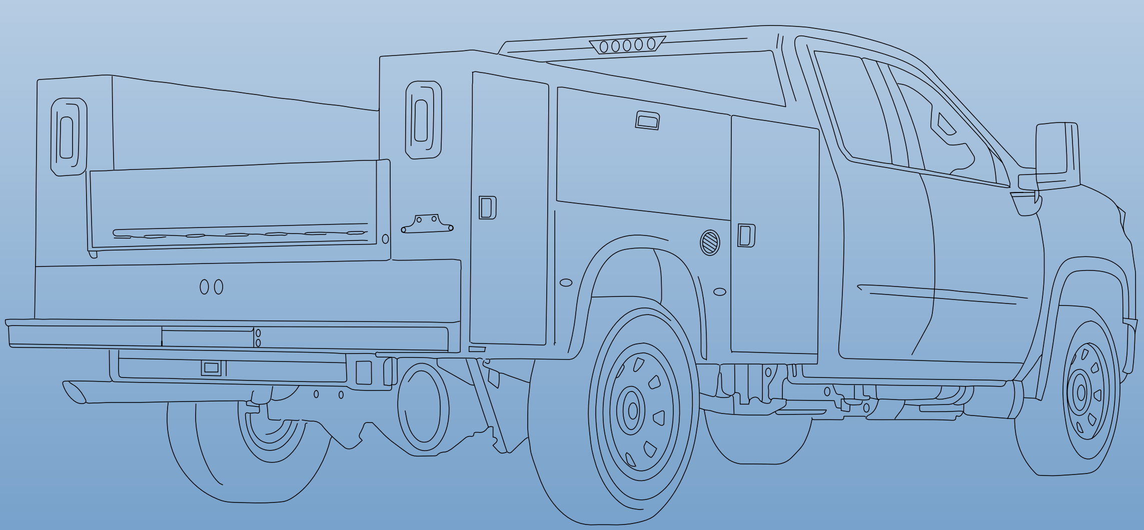
- **Info/Telematics/Communications Needs:** The chassis architecture accommodates existing customer telematics systems to be integrated. Alternatively, an OEM-offered system integrates advanced information, telematics and communication systems to meet the evolving demands of fleet operations. This includes real-time vehicle data tracking, remote diagnostics, predictive maintenance alerts and GPS navigation. Telematics systems provide vehicle performance, diagnostics, maintenance alerts, driver behavior and operational efficiency, enabling fleet managers to make informed decisions for optimal fleet management.
- **BEV Recharge Time:** For BEVs, the chassis architecture addresses recharge time considerations. The design ensures compatibility with various charging standards and infrastructure, allowing fleet operators to recharge vehicles efficiently. Factors such as battery capacity, charging voltage and available charging stations are taken into account to estimate and manage recharge times effectively.
- **Drive/Duty Cycle:** The chassis design factors in the specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, highway driving, off-road use and other unique scenarios. The chassis is engineered to handle the demands of different duty cycles, ensuring the vehicle performs optimally and reliably under various operating conditions.

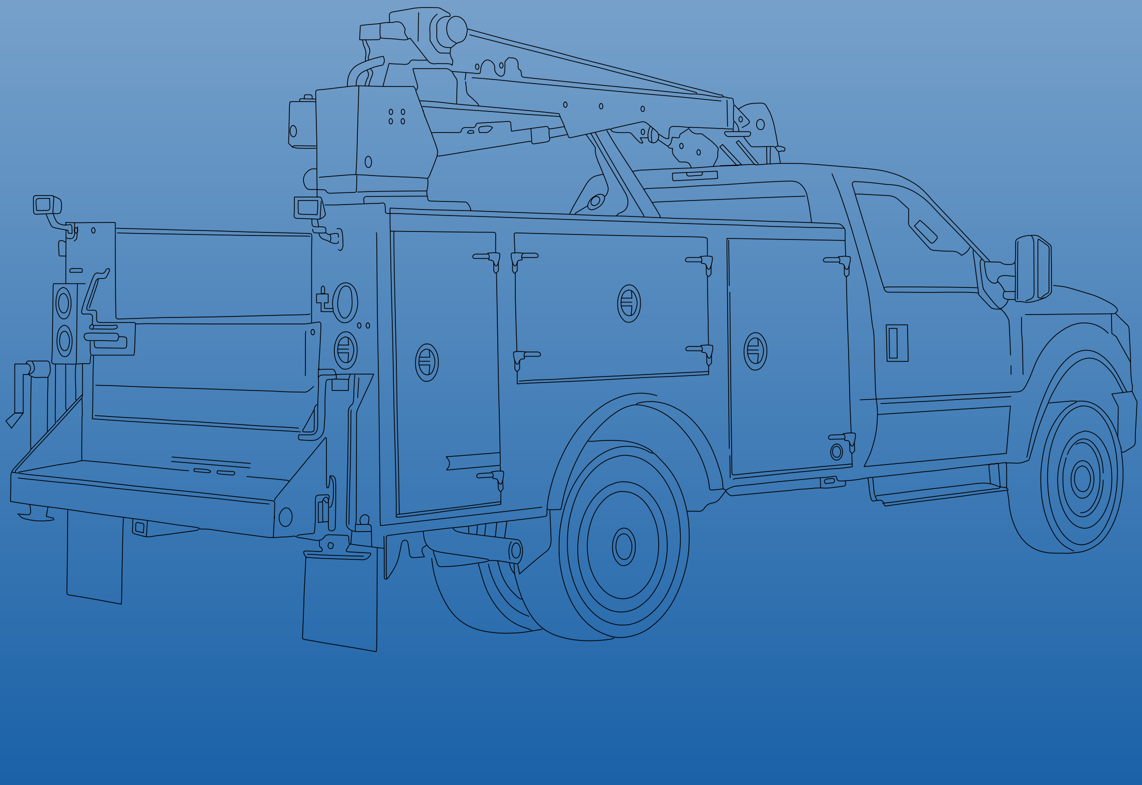
Other

BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

SERVICE BODIES AND TELESCOPIC CRANES





INTRODUCTION

American Institute of Service Body Manufacturers (AISBM)

An NTEA operating division founded 1979, AISBM is primarily composed of utility, service and crane body manufacturers. The group cooperatively works with chassis OEMs to maintain and expand chassis available for pickup box removal. As part of these efforts, members provide insight and support to specific OEMs and their testing programs during their next-generation vehicle development process.

Testing programs cover wide areas of development, such as fuel fill requirements for Environmental Protection Agency and Federal Motor Vehicle Safety Standard (FMVSS) compliance, FMVSS safety testing, electrical interface issues and body mounting techniques. Cooperation between body manufacturers and chassis OEMs enables box removal programs to continue for a variety of pickups in the work truck market. OEM support is imperative as their expertise in vehicle design and safety makes these programs possible. It would be cost-prohibitive for a body manufacturer to perform necessary tests to certify a vehicle to current safety and emissions requirements.

AISBM also conducts a quarterly body shipments survey of its members, the results of which offer insight into the production and sale of service, utility and crane bodies.

Telescopic Service Crane Manufacturers Group (TSCMG)

Formed in 2014, NTEA's TSCMG targets key issues related to service cranes and helps promote more efficient work truck builds. Continuous development of programs to help enhance safe and efficient use of service cranes is a key priority for the group. A service truck crane is identified by its telescopic boom, where the base and mast structure is not integral to the stabilizer/outrigger system. Lifting is typically accomplished via a winch (electric or hydraulic), and its functions (rotation, elevation, telescoping) are either powered or manual. These machines tend to have relatively shorter boom lengths (10–35 feet) and lower capacities (1–7 tons) as compared to other telescopic boom-fixed cab machines (e.g., boom trucks, carry deck cranes). Additionally, operations are usually conducted by the use of radio remote or pendant control with the operator standing on the ground following the load.

The Service Body and Telescopic Crane Industries

The Market

Service bodies are utility-type bodies with a center cargo area surrounded by several side storage compartments. They are installed on a variety of chassis ranging from Class 1–8 vehicles. Industry volumes over the last 10 years have been approximately 65,000 service bodies per year, produced by a number of manufacturers. Of this annual number, about 25,000 service bodies per year are produced from pickup box removal or delete chassis configurations. Pickup box removal is the more common approach to upfitting versus ordering the vehicle with the box deleted.

The crane body (also known as a mechanics body) is a style of service body on which a service crane is mounted to one of the rear corners. The annual market for service cranes is approximately 10,000 units per year, spanning a wide variety of lifting capacities.

The Challenges

A service body vehicle is an efficient work vehicle used in a variety of jobsite applications. It provides secure storage and organization for tools and equipment needed on the jobsite. To ensure an effective and safe application, the service body should be properly matched to the chassis. With a wide selection of chassis sizes and configurations available on the market today, an equally wide selection of service bodies is required. In order to minimize the service body configurations produced in the market, body manufacturers have adopted the practice of designing bodies that are flexible and modular enough to fit on several different chassis configurations. This flexibility reduces needed market inventory and increases production volume, similar to vehicle manufacturer strategy. Although body modularity helps reduce the number of configurations required to fit the market need, it's far from ideal and requires tradeoffs between functionality and commonality.

Body modularity can increase the body price, number of configurations and installation time as the industry tries to adapt the body to a particular chassis. Body modularity also can forfeit some body/vehicle positive features. For example, considerable storage space is sacrificed over the extended wheel housings in order to provide wheel clearance. The cab clearance also needs to be at least the minimum required by the vehicle manufacturer, but not too large, to avoid creating an awkward gap behind the cab.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insight from the service body manufacturer's perspective in depiction of ideal chassis products for these work truck bodies. Some desires may overlap in an effort to emphasize the importance of features in different, but related sections/chassis systems. In general, these considerations are chassis and propulsion neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

Chassis Features and Functions

Cab/Passenger Compartment

- **Remote Access and Requirements:** Remote access features are included in the chassis design, with considerations for antennas and telematics control units (TCUs). Additionally, a reconditioning circuit is integrated to facilitate remote power activation or warm-up of the vehicle's systems.
- **Guidance on Roof Cutout (Cutaway Chassis):** In cases where the chassis is utilized for walk-thru applications, guidelines are provided on how to execute a roof cutout. This process enables installation of the necessary roof structure to maintain cab structural integrity while accommodating operator access to the cargo area.
- **Rear Face Weld Nuts (Cutaway Chassis):** To ensure efficient attachment of the body to the cab, the rear face of the vehicle features strategically placed weld nuts in the rear-facing flange of the cab structure. These threaded inserts provide secure connection points for joining the body to the cab, enhancing overall stability and reducing the risk of structural issues from alternative means of body attachment.
- **Flat Rear Face of Cab (Cutaway Chassis):** The rear face of the chassis is flat and seamlessly accommodates the floor edge of the cab. Following cab flange attachment desires, this design consideration facilitates alignment and attachment of the body to the cab.
- **Top of Frame – Cab Floor Dimension:** Provide a consistent design dimension from the top of the chassis frame to the top of the cab floor. A consistent dimension eases compatibility with different body variations, where body manufacturers can use this standardized dimension in their body understructure design to properly match the body height off of the frame.
- **Chassis Frame Dimensional Tolerances:** Precise dimensional tolerances are maintained throughout the chassis frame. This includes addressing factors such as maintaining side-side height (i.e., no lean) and cab-frame alignment (trueness).
- **Cab Tilt Access and Dimensions (Cab-Over-Engine Chassis):** The chassis design incorporates provisions for cab tilt access. Guidelines are provided regarding proper techniques for tilting the cab, ensuring safe and efficient maintenance access to the engine and other components. Chassis OEM information outlines both recommended practices (dos) and precautions (don'ts).
- **Rear Seat Removal Accommodation:** On crew and extended cabs, allow for rear seat removal to accommodate storage systems for high-value electronics and tools.

Frame

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how these modifications can be made while maintaining structural integrity and compliance with vehicle safety standards.
- **General Dimensions:** The chassis dimensions are detailed, including encumbered width, cab-to-axle (CA) measurements, clean top of frame specifications and other critical measurements. These dimensions ensure compatibility with various body types and allow for accurate upfitting.
- **Pre-Production Chassis Information:** OEMs provide comprehensive and finalized vehicle identification number (VIN)-specific chassis information to upfitters before the chassis arrives at their facilities. This allows upfitters to source long-lead-time body components in parallel with chassis production, streamlining the upfitting process.
- **Industry Standard CA:** Existing wheelbase and CA dimensions have been accommodated by the service body industry for chassis cab, cutaway and stripped chassis products. Preserving these dimensions is important to many vocational vehicle upfits.

- **Parallel Rails with Flat Top Surface:** The chassis design features parallel rails with a flat top surface, devoid of steps or offsets. This consistent section height and clean design behind the cab facilitate straightforward body attachment and provide a uniform mounting surface.
- **Clean CA/Top of Frame Design:** The preferred design aims for a clean CA, where no OEM equipment protrudes above the frame for the entire length behind the cab. Except for tires, the chassis design ensures that no suspension or other protrusions extend above the top surface of the frame. This eliminates obstructions and simplifies body installation. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, minimizing or eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, ensuring structural stability and compatibility with mounting designs.
- **Frame Rails Channel Shape:** Traditional C-channel frame rails are designed with adequate material thickness, strength and clearance around the frame rails. This accommodates shear plate and L bracket mounting designs, promoting cost-effective body mounting options.
- **Outside Frame Rail Width:** The outside width of frame rails is standardized, with chassis cabs featuring a width of 34 inches and cutaway chassis a width of 42 inches. While these are unofficial legacy dimensions, preserving them will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it's critical to preserve those that the industry has used for many decades of development.
- **Encumbered Width:** Encumbered width (EW) directly affects storage compartment size capability of a service body. For a service body to universally fit all available chassis, it must clear the widest point on the widest chassis. Some components adversely affecting encumbered width are spring hangers, DEF tanks, sidesaddle fuel tanks, exhaust, emergency and frame-mounted battery boxes.

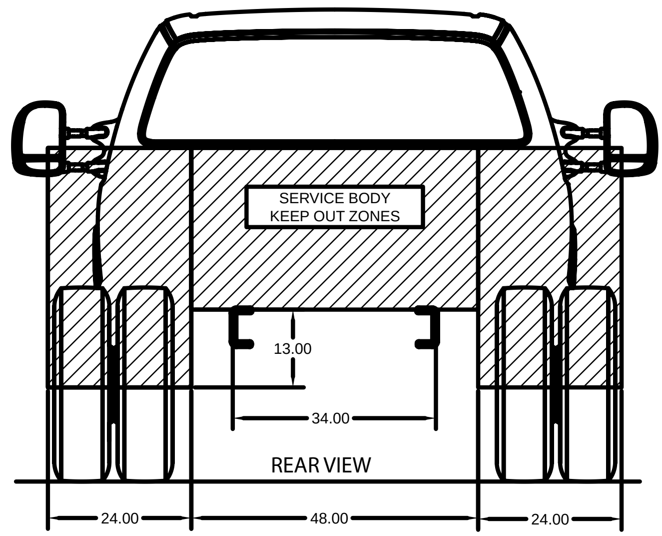
Following are examples of service bodies typical to each chassis type. The keep-out-zones show where service body side packs are usually present. Each diagram lists maximum encumbered width (EW) allowable before interferences would be present.

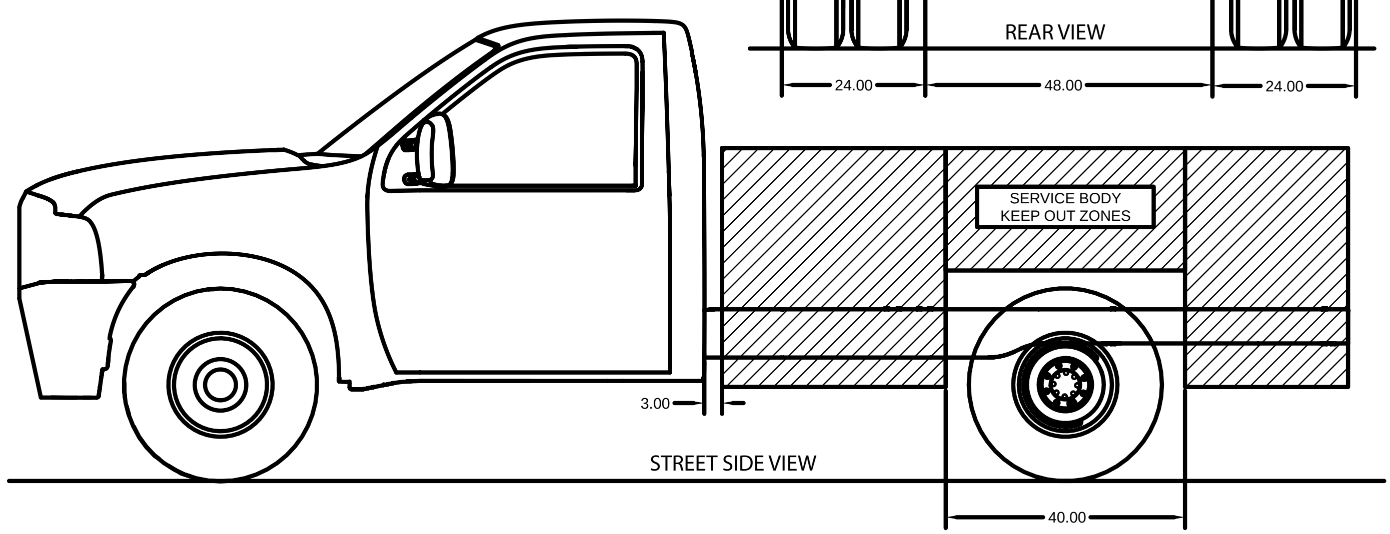
Preferred EWs for various chassis:

Chassis Configuration	Proposed Maximum Encumbered Width (EW) (Inches)
Compact Truck Chassis	43
Pickup Box Delete	47
Euro-Style Van Cutaway Chassis	54
Full Size Truck Chassis	47
Classic Cutaway Van Chassis	54

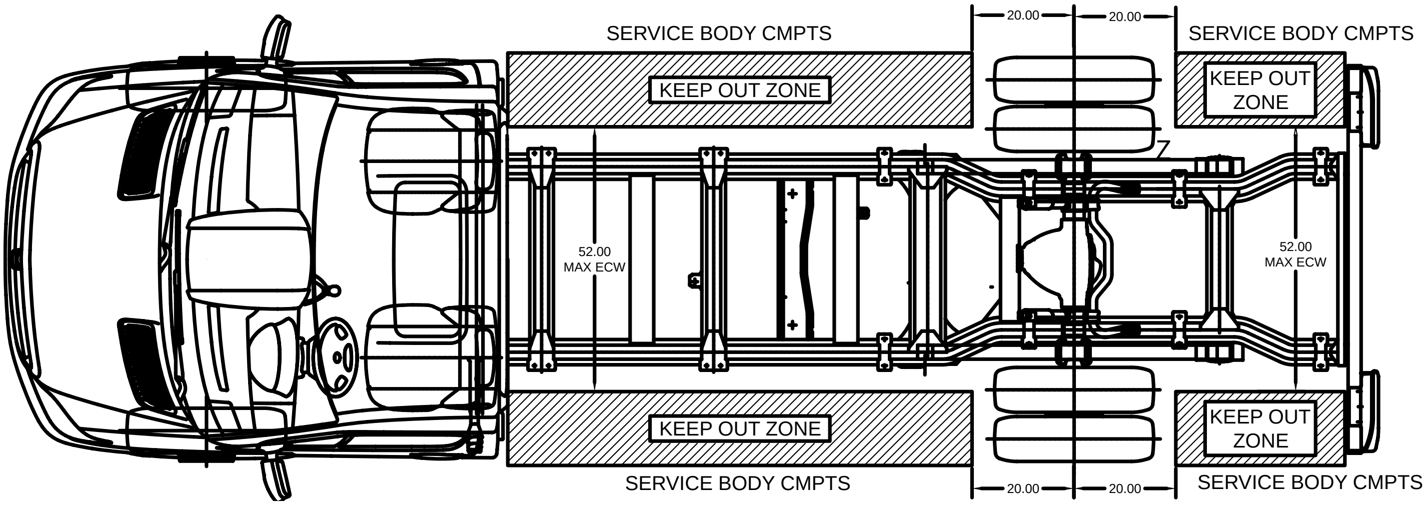
Note: Preferred maximum EW takes into account ½ inch of clearance per side for a mounted body.

TYPICAL SERVICE BODY ARRANGEMENT SHOWN TO DEFINE KEEP OUT ZONES.



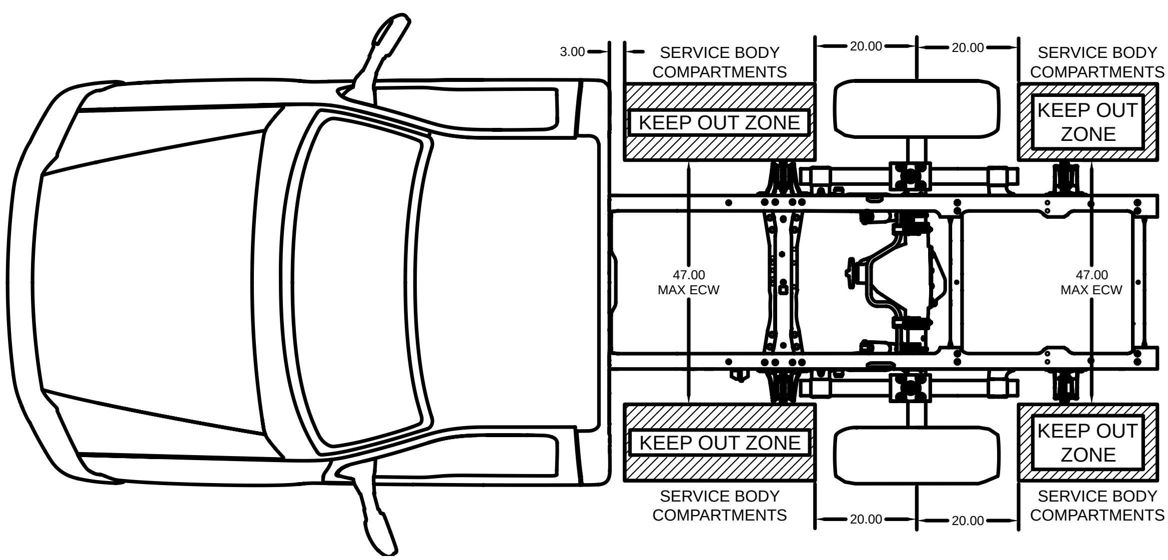


VAN-BASED CUTAWAY CHASSIS ENCUMBERED WIDTH



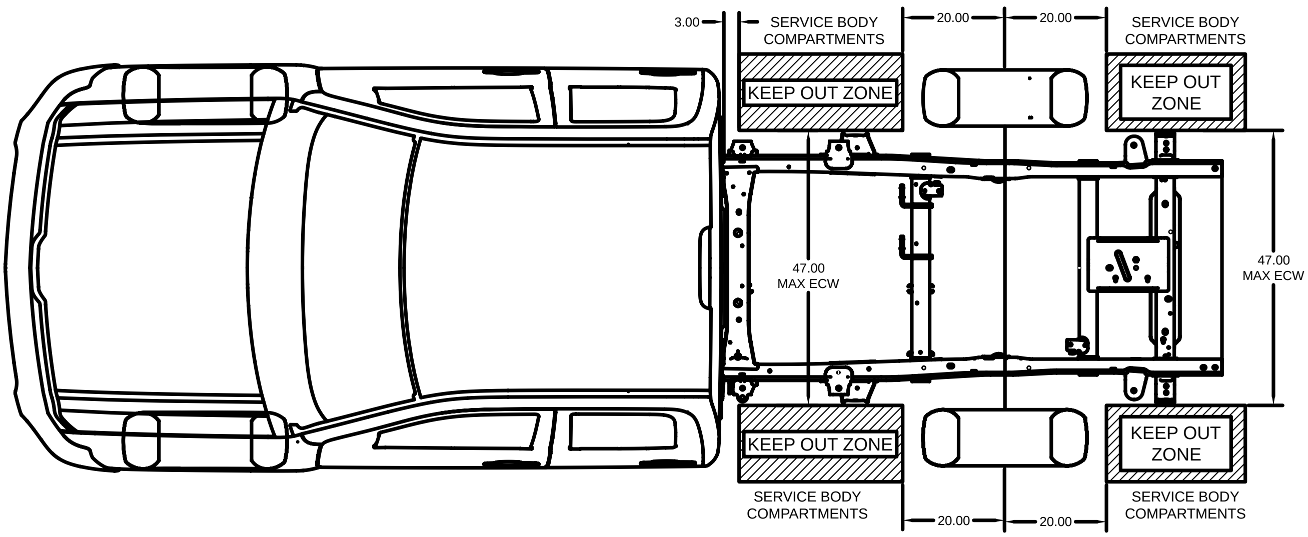
NOTE: VAN KEEP OUT ZONES START 13" BELOW TOP OF FRAME RAILS AND EXTEND UPWARD INDEFINITELY.

FULL SIZE CHASSIS CAB ENCUMBERED WIDTH



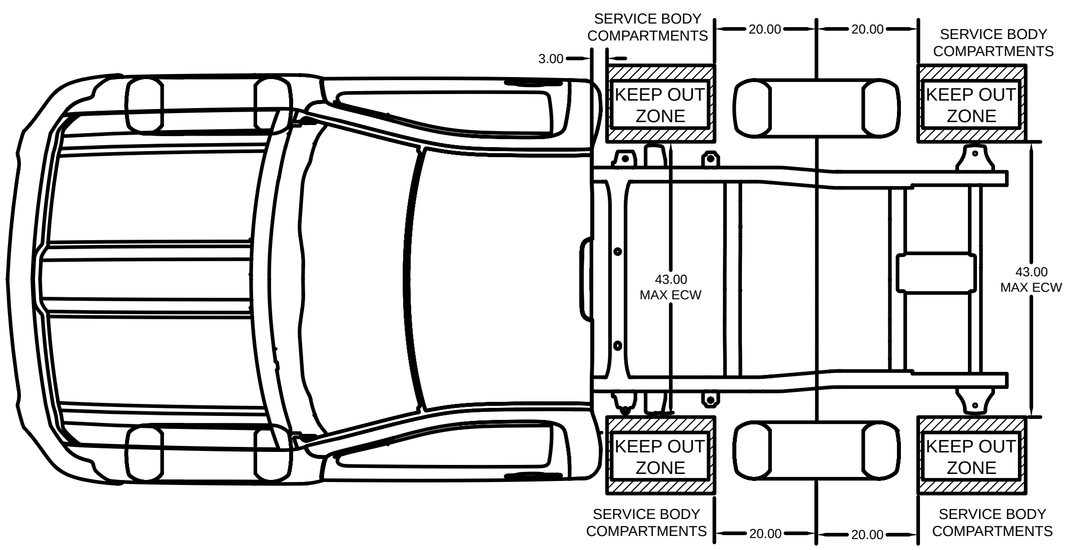
NOTE: FULL SIZE TRUCK KEEP OUT ZONES START 13" BELOW TOP OF FRAME RAILS AND EXTEND UPWARD INDEFINITELY.

FULL SIZE TRUCK BOX REMOVAL ENCUMBERED WIDTH



NOTE: FULL SIZE BOX REMOVAL TRUCK KEEP OUT ZONES START 13" BELOW TOP OF FRAME RAILS AND EXTEND UPWARD INDEFINITELY.

MID-SIZE TRUCK BOX REMOVAL ENCUMBERED WIDTH



NOTE: MID-SIZE TRUCK KEEP OUT ZONES START 13" BELOW TOP OF FRAME RAILS AND EXTEND UPWARD INDEFINITELY.

CAB-TO-AXLE (CA)

Cab-to-axle is the nominal distance from the rearmost point of the cab to the centerline of the rear axle on a single axle chassis.

CA Dimensions Based on Current OEM Offerings and Proposed CAs that Maximize Efficiencies for Service Bodies

Vehicle Size (Description)	Current OEM CA Offering (Inches)	Service Body CA per Body (Inches)	Proposed CA (Inches)
Compact / Mid-Size Pickup Box Removal / Delete			
Class 1	31–36	40: 7 ft. Body	40
Full Size Pickup Box Removal / Delete			
Class 1 (1/2 ton)	56	40: 7 ft. Body 56: 8 ft. Body	40 56
Class 2 (3/4 ton)	36–56		
Class 2–Class 3 (1 ton)	36–56		56
Full Size Chassis Cab			
Class 2–Class 3 SRW (1 ton)	60	60: 9 ft. Body	60
Class 3 DRW (1 ton)	60–84	60: 9 ft. Body 84: 11 ft. Body	60 84
Class 4–Class 5 (1.5–2 ton)	60–120	108: 13 ft. Body 120: 14 ft Body	108 120
Van Based Chassis Cab			
Class 2 SRW (3/4 ton)	81.1–100.2	84: 11 ft. Body 108: 13 ft. Body	84 108
Class 2–Class 3 DRW (1 ton)	82.5–22.2	84: 11 ft. Body 108: 13 ft. Body 120: 14 ft. Body	84 108 120
Cutaway			
Class 2–Class 4	80–118	80: 10–11 ft. Body 100: 12–13 ft. Body 118: 14–15 ft. Body	80 100 118
Van Based Cutaway			
Class 2 SRW (3/4 ton)	81.1–100.2	80: 10–11 ft. Body 100: 12–13 ft. Body	80 100
Class 2–Class 3 DRW (1 ton)	82.5–122.6	80: 10–11 ft. Body 100: 12–13 ft. Body 118: 14–15 ft. Body	80 100 118
Low Cab Forward (Imported & Domestic)			
Class 3–Class 5	79–182 UCA	84 UCA: 11 ft. Body 108 UCA: 13 ft. Bod 120 UCA: 14 ft. Body	84 UCA 108 UCA 120 UCA

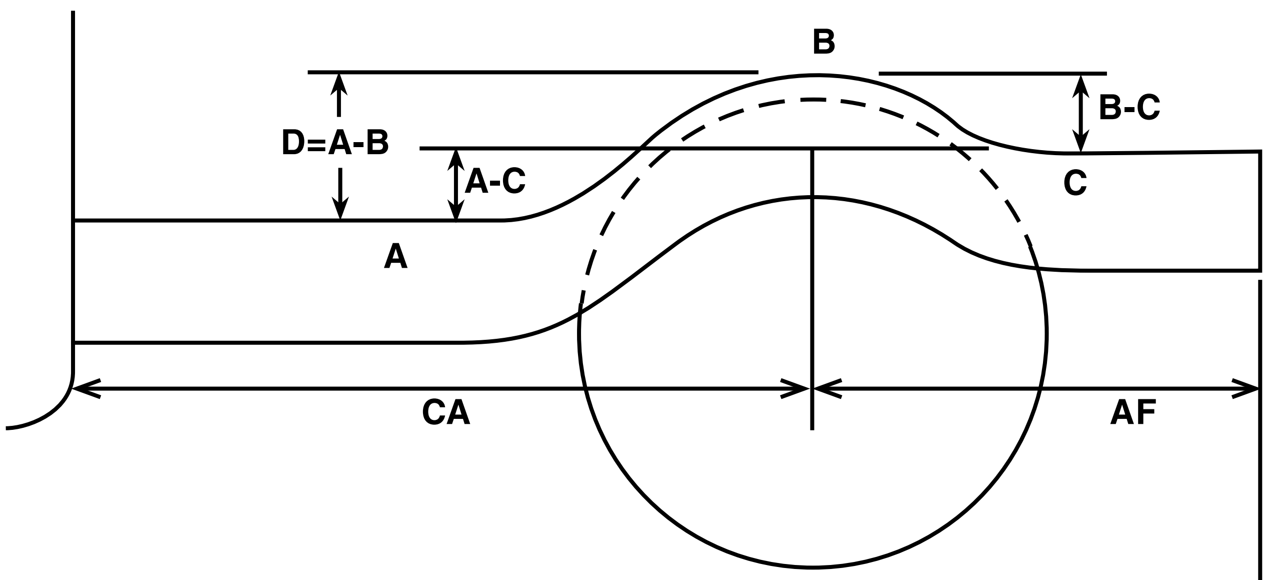
- **CA and After-Frame Dimensions for Typical Service Body Application by GVWR Class**
  - 56 inches CA at 101.5 inches (45.5 inches AF)
  - 60 inches CA at 111.5 inches (51.5 inches AF)
  - 84 inches CA at 135.5 inches (51.5 inches AF)
  - 108 inches CA at 171.5 inches (63.5 inches AF)
  - 120 inches CA at 170 inches (50 inches AF)
- **Frame Drop:** The frame kick-up and varying height differences drive the necessary hours for installation higher than desired for mounting service bodies. There are two important frame drop locations: 1) from the cab to the axle, and 2) from the axle to the rear of frame. The two points, A and C (see diagram below), must be level (or filled to be equal) so that a mounted body is level. Both the central body compartment and body long sill must clear the B point; therefore, the height difference between A and B should be as small as possible. The A–B difference is, by definition, the frame drop (D). It's common practice to weld on an additional length of frame or cut off several inches. Additional frame length adds significantly to the cost of body installation. This represents the present situation based on current model years. Ideally, no frame drop on any chassis is recommended.

Present Situation Based on Current Model Years

Chassis Configuration	Frame Rail Width Range (FW) (Inches)	Additional Comments
Compact Pick Up	32.83-41.34	
Full Size Pick Up	34.0-52.0 (inclusive of mounting pedestals)	Not all chassis widths are uniform along length of frame
Van Based Chassis Cab/Cutaway	41.1-52.2	

Recommended Frame Drop

Ideally, no frame drop is desired on any chassis.



- **Charging Port Access and Guarding (Hybrid/EV Powertrain):** If the charging port is located in the frame area, provisions are made for its access, location and guarding.

Mounting/Equipment Attachment

- **Equipment Attachment:** If there is limited clearance along the frame in certain sections due to the chassis configuration, provisions are made for additional attachment points. This ensures bodies and equipment can be securely attached even in cases where traditional attachment methods might be challenging due to space constraints, such as the inside of a C-channel next to a fuel tank or EV battery.

- **Standardized Pre-Punched Frame Holes:** The chassis design includes standardized pre-punched holes at the back of the frame. These holes are strategically placed to facilitate the addition of bolt-on frame extensions, eliminating the need for welding during the extension process and expediting upfitting operations. Ideally, body attachment points are designed with standardized spacing relative to a reference datum, such as the axle center line or the back of the cab. This approach allows body manufacturers to produce bodies with pre-installed mating mounting surfaces, reducing variability and promoting ease of assembly.
- **Standardized Frame Extension Kits:** Options for longer AF dimensions would be preferred, but for chassis that are not ordered with the proper dimensions, OEMs would provide standardized frame extension kits, which include components that can be easily integrated into the chassis frame. These kits are designed to ensure structural integrity while extending frame length, offering a straightforward solution for specific upfitting needs.
- **Floor Mounting Attachment Points and Ratings:** Dedicated mounting locations are available for floor mounting of components, such as consoles or laptop mounts, within the cab in proximity to the driver's seat. These options would include applicable load ratings.
- **Side Walls – Drill and No-Drill Areas:** Guidelines are provided for attaching equipment and components to the cab structure, including fenders, doors, roof and backpanel. These guidelines outline areas where drilling is permissible and areas where no-drill methods should be employed to prevent contact with any components or affecting structural integrity.

Auxiliary Power (see also Electrical Section)

- **Auxiliary Fuel Tap – Internal Combustion Engine (ICE) Powertrains:** An auxiliary fuel port on the fuel tank sending unit or other means of accessing onboard fuel from the tank continues to be needed, now and into the future, for equipment that requires fuel, such as generators, welders, compressors and auxiliary heaters. This helps ensure a convenient and standardized method for accessing fuel with a means to prevent drawing the tank to empty.
- **Electrical Access and High Amp Provisions:**
  - **12V, 24V, etc.:** The chassis offers various electrical access points to accommodate different voltage requirements, such as 12V and 24V systems. These access points are strategically placed for convenience and efficiency during upfitting. 12V power will continue to be needed, as products from the industry's component/system manufacturers are heavily 12V based. Wide coordination is needed to transition to higher voltages.
  - **High Amp Provisions (30A and Less/Over 30A):** The chassis design accounts for high amperage demands. Differentiated provisions are made for power requirements under 30A and those exceeding 30A, ensuring reliable power distribution to auxiliary equipment and devices.
- **Location of AUX Power Pickup – End of Frame Preferred:** Ideally, the pickup point for auxiliary power is located at the end of the frame. This placement simplifies routing and connection of auxiliary electrical components, such as liftgates, minimizing interference with other chassis features.
- **Availability of Reconditioning Circuit:** A reconditioning circuit is included in the chassis design. This circuit allows the vehicle's auxiliary power system to automatically recharge or maintain charge in situations where power is drawn from the auxiliary power source extensively.
- **Remote Access for Power-On or Warm-Up:** The chassis incorporates features that enable remote access to power-on or warm-up the vehicle, enhancing convenience and efficiency. This can be particularly beneficial in scenarios where pre-conditioning or pre-warming the vehicle is necessary.
- **Rear Trailer Hitch:** Make rear trailer hitch bolt-on to allow it to be reusable when mounting service/utility bodies, not welded into the frame.

Fuel

- **Fuel Fill for ICE Vehicles:** If the fuel system uses a capless fuel fill, the OEM provides a standardized fuel fill cup (i.e., "sugar scoop") with an integrated cover/fuel door to prevent dirt/debris from entering the fuel fill cavity.
- **Electrical Charge and Adapters for Hybrid/EV:** The chassis is equipped with the necessary infrastructure to support electrical charging, accommodating various power levels and connector types. This feature ensures compatibility with different charging stations and contributes to vehicle versatility, especially in hybrid or electric configurations.
- **Off-Gas Protection/Provisions During BEV Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common upfits. The design should be such that large distances of clearance underneath bodies/equipment are not necessary to preserve proper ventilation function. This safeguards against potential hazards with gases becoming trapped or concentrated under/within the vehicle and ensures safe charging operations, contributing to the overall safety of the vehicle and its surroundings. Information to prevent interference with the off-gas provision must be provided in body builder information.

- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 8 vehicles, aim for a standardized diesel exhaust fluid (DEF) fill location. Ideally located under the hood or at the back of the cab, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.

Exhaust for ICE Vehicles

- **Horizontal Exhaust:** For horizontal exhaust configurations, the exhaust system is contained entirely within or underneath the frame for the whole length behind the cab. This design approach optimizes space utilization and reduces the risk of interference with upfitted bodies.
- **Exhaust Discharge Placement:** Exhaust system discharge is directed outboard, beyond the edge of the body by 1–2 inches. This placement prevents the need for exhaust modifications to meet regulatory requirements, ensuring compliance while maintaining compatibility with various upfitted bodies. Define clearance area (zone) around exhaust required for adequate heat dissipation. Should have heat shielding or accommodation for heat to protect from/deflect falling debris, particularly between box/upfit and cab.

Axles/Suspensions

- **Dimensions and Travel Limits:** Chassis dimensions are designed to accommodate dual tires, with the overall width to the exterior sidewalls not exceeding 96 inches. The chassis also includes specified travel, jounce and rebound limits to ensure safe and controlled suspension movement.
- **Air/Hydraulic Suspension Compatibility:** The chassis is adaptable to air and hydraulic suspension systems, allowing for customization based on specific application requirements. As part of this accommodation, the suspension layout ensures components like brake hardware and suspension parts are thoughtfully positioned within the jounce area.
- **Compensating for Body Lean:** The chassis design incorporates a method for compensating for body lean without affecting electronic stability control (ESC), braking systems, wheel alignment or other critical vehicle functions. This ensures a stable and controlled driving experience, even with varying load conditions. Mechanics trucks with corner-mounted telescopic service cranes need to compensate for the unbalanced weights involved.
- **Ability to Add Auxiliary Springs:** The chassis design allows for the addition of higher capacity springs or extra leaves to the suspension system. These modifications can be made without compromising stability controls, ensuring desired load-bearing capabilities can be achieved (as previously regarding the mechanics truck with service crane issue).

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide VIN-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.

Gross Vehicle Weight Rating/Gross Axle Weight Ratings (GVWR/GAWRs)

- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits are defined for horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having this information available as far in advance prior to chassis order is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

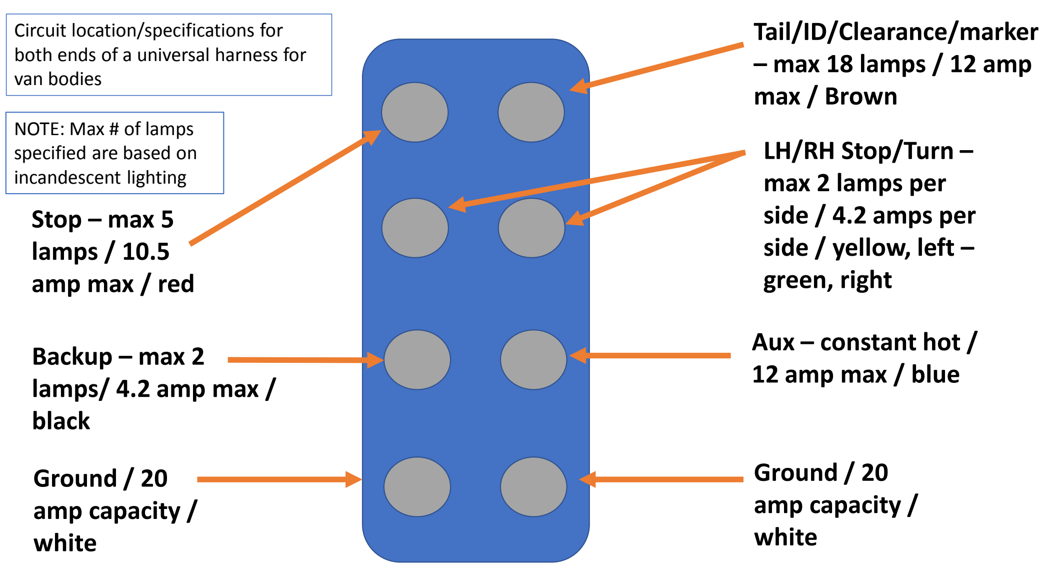
This section describes the desired support of the chassis electrical architecture for service body upfits, which in many cases can apply to other vocational vehicle needs.

Lighting

- **Dedicated or Accessible Upfitter Circuits:** The chassis design includes dedicated circuits or accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Reserve Capacity on Lighting Circuits:** Chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits, maintaining safety and functionality.

- **Industry Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits (such as turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes). See additional lighting circuit connector image below.
- **Emergency/Warning/Strobe Lighting:** The chassis includes provisions for emergency, warning, or strobe lighting systems on the front and rear of the chassis. These systems enhance the vehicle's visibility and safety when operating in hazardous conditions.
- **LED Compatibility:** The chassis design ensures compatibility with LED lighting for both the vehicle's lighting system and trailer tow lighting circuits. This includes proper voltage regulation to support LED lighting.
- **Standard Trailer Tow Provisions:** Continue providing standard options for trailer towing, including trailer lighting connectors and wiring. A delete option should also be available for units requiring equipment incompatible with towing, such as some liftgate configurations.
- **Relocating OEM Lights, Antennas and Sensors:** Guidelines are provided to relocate OEM lights, antennas and sensors, especially in applications with aerodynamic devices. This ensures proper placement and functionality when moving components for different body configurations.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the upfitted body. Easy methods for sensor calibration, which do not require special tools, are provided in body builder information.
- **Connector Type, Quantity and Pin Position Standardization:** Universal connectors that are not model- or chassis-specific are desired for all vocational requirements, especially lighting.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches wide.
- **OEM Connector for Back-Up Alarm:** An OEM connector is located near the rear of the chassis for connecting a back-up alarm. This feature ensures consistent installation and functionality of alarms for safety purposes.
- **Service Body Manufacturers Support Van Body Manufacturers Division Generic Lighting Connector:** OEM circuits are provided according to the specifications below, from which body manufacturers can develop their own universal body harnesses.

VBMD Generic Lighting Connector



Camera Systems

- **Approved Monitor Installation Location:** Where auxiliary monitors are needed (non-FMVSS 111 compliant cameras/ monitors), clear OEM guidance is provided on the approved locations for installing monitoring displays. This ensures optimal visibility for drivers while preventing installation in airbag deployment, head impact or other stay-out zones. Allow integration into 360-degree view camera systems for both chassis cabs and pickup box removal.
- **Approved Power Pickup:** The chassis design offers approved power pickup points for various functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.

- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting from the cab and running to the rear of the frame. This organized routing prevents interference with other components and maintains clearance for added wiring.

Electrical System Controls

Upfitter Switches

- **OEM Cab Switches:** The OEM cab switches are designed to accommodate common upfit requirements for service bodies. This includes functions like body interior lamps, crane power switches and more.
- **Cab Switch Wiring and Connectors:** Cab switch wiring terminates behind the cab, conveniently accessible with industry-standard connectors. This design facilitates quick and secure connections during upfitting.
- **In-Dash AUX Switches:** A minimum of six AUX in-dash switches are provided. They can be configured or programmed to operate either on battery power or ignition power, offering flexibility in controlling upfit components.
- **Programmable Switch Timed Shut-Off:** Switches are designed to be programmable for timed shut-off intervals. This feature allows upfitters to set time durations for specific functions to automatically turn off, enhancing energy efficiency.
- **Physical Battery Connections:** Physical battery connections capable of handling high electrical loads are included in the chassis design. They enable the connection of powered components, such as a 5KW inverter, supporting various upfit applications.
- **Electrical Needs for Service Cranes:**
  - 210–250 amps for short duration (less than 1 minute)
  - 125–210 amps for longer duration (2 minutes)
- **CAN BUS (J1939) Connection:**
  - **BCM Access/Programmability:** The chassis design provides access and programmability to the body control module (BCM) via the CAN BUS (J1939) connection.
  - **CAN BUS/Internal Chassis Data Stream Access:** While maintaining cybersecurity measures, upfitters can access internal chassis data streams via the CAN BUS.
  - **Transmission Interlocks and Control:** The CAN BUS connection enables upfitters to control transmission interlocks for functions like liftgates, ramps and door locks. It also provides control over power takeoff (PTO) engagement and engine RPM.
  - **Remote Engine Start and Stop:** Upfitters can perform remote engine start and stop functions through the CAN BUS connection, enhancing convenience and operational efficiency.
  - **Chassis Horn and E-Brake State:** Chassis horn control and the ability to read the electronic brake (e-brake) state are accessible via the CAN BUS connection.
  - **PTO-Related Parameters:** The CAN BUS connection allows reading PTO-related parameters, such as status and engine RPM.
  - **AUX Switch States:** The states of auxiliary switches can be read through the CAN BUS connection, enabling monitoring and control of additional upfit components.
- **Telematics Integration:** The chassis design includes integration of telematics between the chassis and body. This eliminates the need for separate telematics systems.
- **Battery Electric Chassis Power Connections:** For battery electric chassis, standard power connections are provided for upfit equipment operation. A 48VDC, 150-amp continuous-duty connection supports high-power components like electric power takeoff (ePTO) or electric compressors. Additionally, a 12VDC, 100-amp connection is available for legacy systems (lighting, liftgates, etc.).
- **Climate Unit Control (EV):** For battery electric chassis and ICE, the design allows the operation and control of the cab climate unit even when the chassis is stationary on a work site. This feature enhances comfort and efficiency during downtime.

Electromagnetic Interference/Radio Frequency Interference (EMI/RFI)

- **Necessary Shielding:** The chassis design includes necessary electromagnetic interference (EMI) and radio frequency interference (RFI) shielding to mitigate potential electromagnetic compatibility issues and ensure proper operation of electronic components.
- **Emissions Limits:** The design adheres to emissions limits set by relevant regulatory bodies. Emissions are controlled to meet any relevant standards while maintaining proper vehicle operation.

Regulatory/Safety

ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles

- **Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.
- **Current ADAS Sensors:** Ability to utilize OEM sensors is desired.
- **Ability to Remove OEM Backup Sensors from Bumpers and Reinstall:** Preference is for OEMs to select sensors and place them on the vehicle in a way that aftermarket can recover them for body installation.

F/CMVSS (Federal/Canada Motor Vehicle Safety Standards) Considerations

- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the chassis OEM provides maximum unloaded vehicle weight (UVW) values to maximum upfit capacity for different vocational applications. These specifications help fleet managers and upfitters choose the appropriate chassis configurations to accommodate their intended body/equipment upfit.
- **Pickup Box Removal Capability:** Include on all GVWR classes with ample reserve capacity to accommodate a minimum 1,000-pound body with proper payload left over.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an IVD website that provides clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.
  - **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the body.
  - **F/CMVSS 111 and Maximum Body Widths:** Clear compliance statements are provided with respect to F/CMVSS 111 and maximum body widths to maintain compliance with standard OEM mirrors. If optional OEM mirrors are available, such as trailer tow, the OEM specifies the maximum body widths for each mirror option. Methods to identify how each chassis is equipped are also provided, allowing upfitters to make informed decisions.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (ICE)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.

BEV Emission and RFI/EMI Compliance

- **RFI/EMI Transmittance Limits:** For BEVs, upfitters are guided on maintaining RFI and EMI transmittance limits. These guidelines ensure additional upfit equipment does not compromise the overall RFI/EMI compliance of the BEV.

Additional Chassis Information

- **Tire Clearance Envelope:** Detailed information is provided regarding tire clearance envelopes for each chassis model. This information accounts for suspension travel arcs and enables upfitters to design body placement and wheel well dimensions accordingly to prevent tire contact.
- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.

- **Universal Table Layout for Compliance Data:** A universal table layout is published, detailing all required compliance data points for each vehicle model. This includes curb weight, as-built chassis CG dimensions, top of frame height, seat points, passenger load and other information needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.

Fleet Operations

The integration of these features and considerations into the chassis design enhances vehicle suitability for fleet operations. It aims to provide efficient, reliable, and adaptable solutions that align with the operational needs of fleet managers and contribute to overall operational success.

- **Range:** The chassis design takes into account the range requirements of fleet operations, especially for battery electric vehicles (BEVs). Vehicle range capabilities are designed to align with intended use, ensuring it can cover the necessary distances between charging or refueling points. Consideration is given to factors such as vehicle weight, powertrain efficiency, battery capacity and energy consumption to optimize range without compromising performance.
- **Info/Telematics/Communications Needs:** The chassis architecture accommodates existing customer telematics systems to be integrated. Alternatively, an OEM-offered system integrates advanced information, telematics and communication systems to meet the evolving demands of fleet operations. This includes real-time vehicle data tracking, remote diagnostics, predictive maintenance alerts and GPS navigation. Telematics systems provide vehicle performance, diagnostics, maintenance alerts, driver behavior and operational efficiency, enabling fleet managers to make informed decisions for optimal fleet management.
- **BEV Recharge Time:** For BEVs, the chassis architecture addresses recharge time considerations. The design ensures compatibility with various charging standards and infrastructure, allowing fleet operators to recharge vehicles efficiently. Factors such as battery capacity, charging voltage and available charging stations are taken into account to estimate and manage recharge times effectively.
- **Drive/Duty Cycle:** The chassis design factors in the specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, highway driving, off-road use and other unique scenarios. The chassis is engineered to handle the demands of different duty cycles, ensuring the vehicle performs optimally and reliably under various operating conditions.

Other

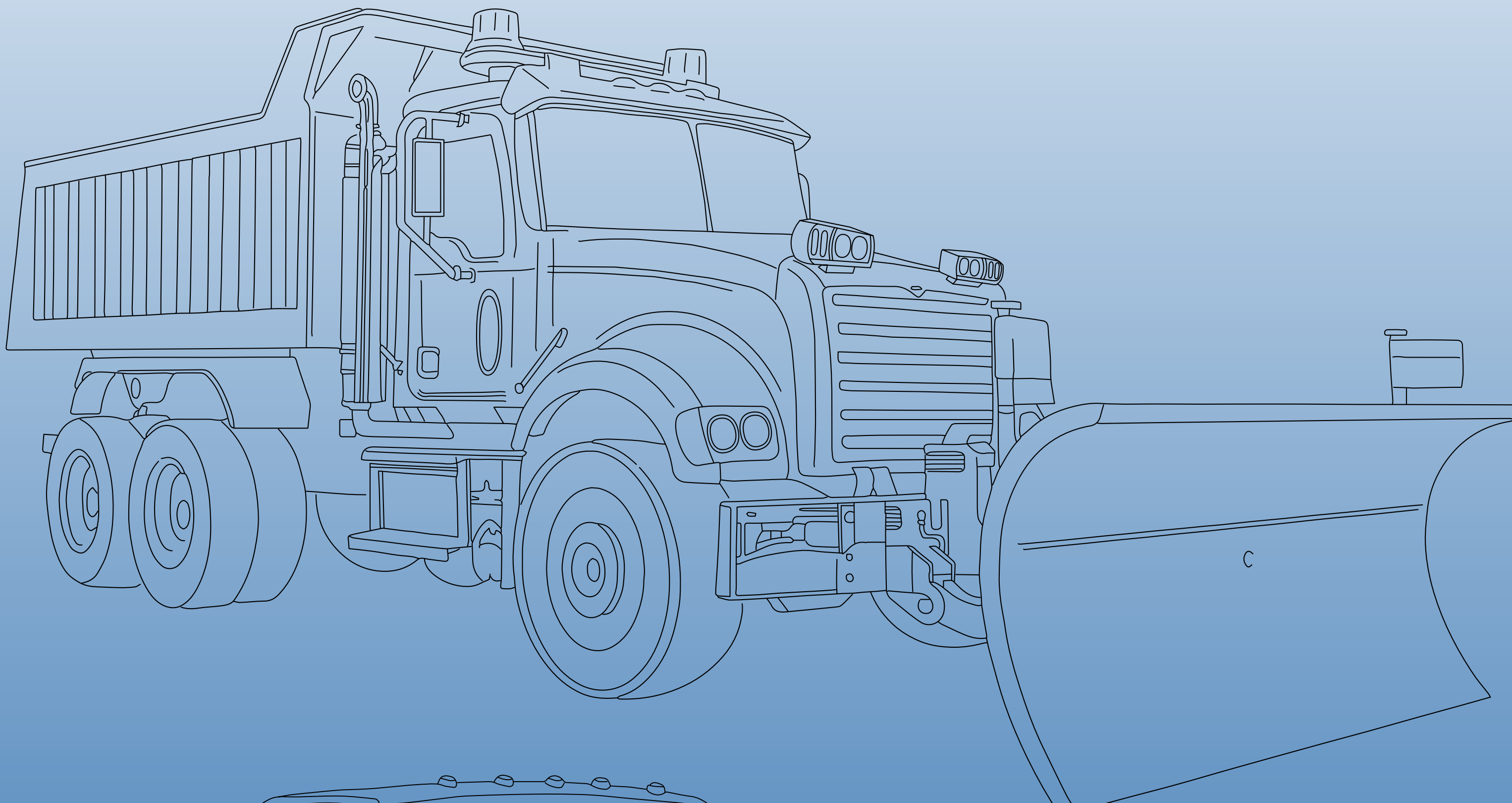
BEV Considerations for Upfitters

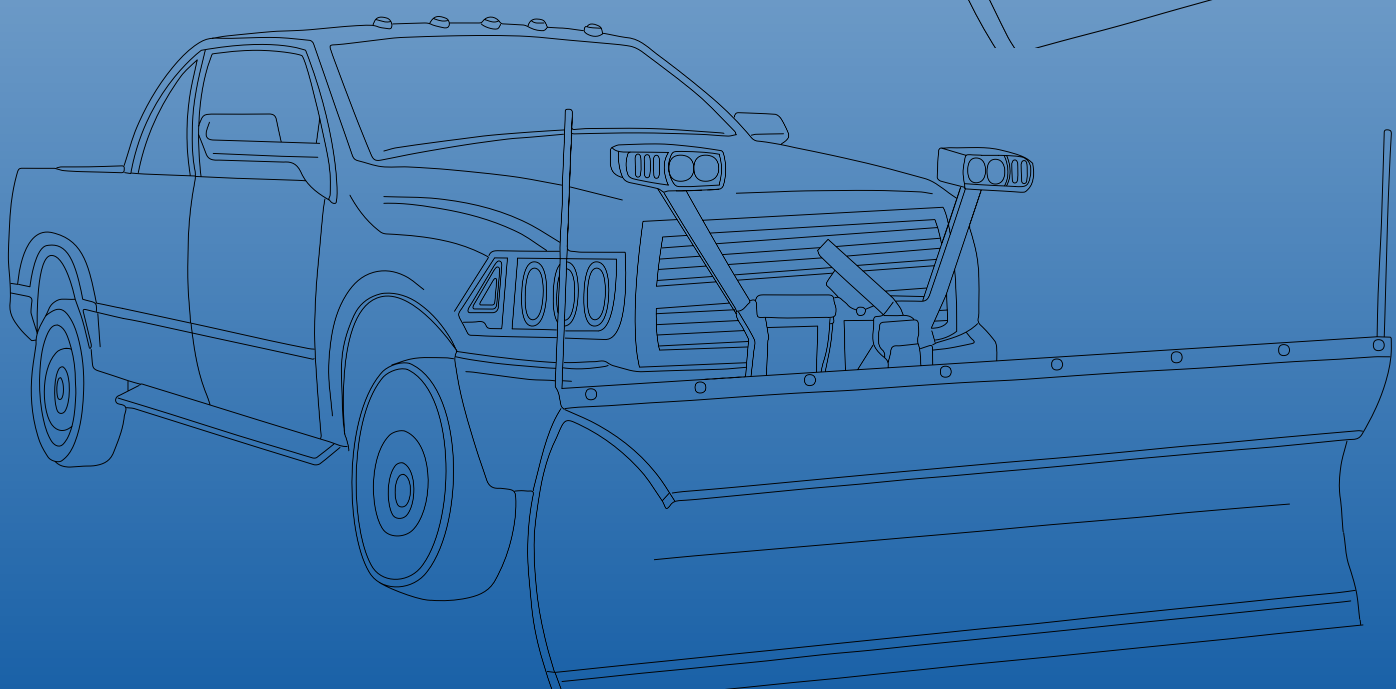
- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

Additional Resources

- American Institute of Service Body Manufacturers information: **ntea.com/aisbm**
- Telescopic Service Crane Manufacturers Group information: **ntea.com/tscmg**

SNOWPLOWS





INTRODUCTION

Snow Control Equipment Manufacturers Committee (SCEMC)

NTEA's SCEMC, in operation since 1979, includes manufacturers of snowplows, salt and sand spreaders, and related snow and ice removal equipment. The group engages OEMs on issues related to snowplow installation on pickups and vocational trucks.

SCEMC's most significant contribution is its development of strong relationships with chassis manufacturers, communicating with them during early stages of vehicle creation in an effort to continue OEM programs allowing snowplow installation. These programs encompass Federal Motor Vehicle Safety Standard compliance, safety assessment, electrical interface issues, plow mounting locations and vehicle durability testing. SCEMC works with the next generation of trucks from chassis OEMs to maintain the variety of snowplow-capable vehicles for the work truck marketplace.

The Snowplow Industry

Snowplows and snow control equipment (spreaders, blowers, prewetting systems, etc.) are vital to maintain safe roads and parking lots in areas of North America that see snow and ice conditions. Snowplows are traditionally mounted to the front of trucks on a wide variety of chassis ranging from Class 1–8 vehicles. In the larger class of vehicle (typically Class 6–8), both underbody scrapers and wing plows (plows mounted to the side of the vehicle) are additional configurations. Industry volumes over the last five years have been approximately 120,000 plows per year, produced by a number of manufacturers.

The Market

The market for snowplows and snow control trucks encompasses a wide range of commercial vehicles from pickups to medium- and heavy-duty trucks. Additionally, spreaders will be mounted on the rear of the vehicle for many applications. These spreaders can be mounted directly to the truck frame or in an existing body (typically a dump body) inside the pickup box or tailgate-mounted.

Plow trucks are utilized by a wide array of vocations, but most commonly landscape and municipal. In the pickup application, private owners will also install snowplows to clear their driveways, which accounts for many of the class half-ton pickups using snowplows.

More recently, advanced technologies, such as GPS tracking, telematics and other route optimization software, have enhanced the efficiency and operational capabilities of all commercial vehicles. The more sophisticated municipal plow trucks will use these features for clearing roads by identifying the lanes and shoulders of the snow-covered roadway.

The Challenges

Manufacturers of plows and other snow control equipment have specific needs that are unique due to their special vocation. The plow blade, which is not typically mounted as permanently attached equipment, can interfere with some technologies, such as automatic emergency braking (AEB), and can be in direct conflict with the vehicle's upfit. The ability to turn off these functions while the plow is attached is imperative to proper vehicle function. It's important that the chassis OEM and government and industry work together to safely and responsibly bring these technologies to commercial trucks for these mission-critical vehicles.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insights from the snow control equipment manufacturer's perspective regarding ideal chassis products for these work truck components. Some desires may overlap in an effort to emphasize the importance of features in different, but related sections/chassis systems. In general, these considerations are chassis- and propulsion-neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

Chassis Features and Functions

Cab/Passenger Compartment

- **Ignition Power Access for Plow Control Systems:** Plow and spreader controls need to be close to the driver, and access to switched power in the cab will be essential for these control systems.
- **Heating, Ventilation and Air Conditioning (HVAC) Systems Capable of Maintaining Clear Windshield:** Snow control equipment operates in harsh environments of blowing ice and snow, and operators typically have long 8–12-hour shifts clearing snow.

- **Front Grille:** The ability to pass snowplow power and headlamp control harnesses from the engine compartment through the grille to the front of the vehicle.
- **Accessible, Pass-Thru Opening:** With cuttable plug/grommet through front-of-dash (i.e., the firewall) to the engine compartment. Up to 25mm square plug to pass-thru opening. For power and control system wiring.
- **Vehicle Outside Air Temp Sensing:** Located in an area where not affected by plow being attached.

Frame

- **Holes in Frame for Front and Rear Plow Mount Bolts:** The mounting of the plow frame/receiver at the front of the truck makes for tight areas to drill. Manufacturers prefer to use the existing front frame. If boxed front frame, they prefer one mounting hole larger than the other to allow for a crush tube to be inserted in the frame with the mounting hardware. If not, allow access openings for frame bolt insertion or tightening. Preferable to not remove bumper and use opening in side of frame for bolt-on-handle insertion.
- **Holes in Frame Sides Preferable; Holes in Frame Bottom May be Usable:** If there are holes in the bottom of the frame, allow access to bolt the plow frame in place.
- **Tow Hook Bolts:** Should be of sufficient length to allow for plow frame mounting.
- **Clearance From Top of Frame and Below in Front Frame:** Items like radiators, transmission coolers and their related hoses and fittings in the front frame section can cause interference with plow mounting hardware.
- **Standardized Pre-Punched Frame Holes:** The chassis design includes standardized snowplow industry pre-punched holes at the front of the frame.

Mounting/Equipment Attachment

- **Drill Areas:** Clearly note no drill areas in front of frame. This can be noted in the body builder information.
- **Removable, Bolt-On Lower Bumper Valence:** To enable installation of plow mounts without modifying the bumper. Allow for articulated air dam removal and/or modification without warning light activation for snowplow-equipped vehicles.
- **Snowplow Headlamps/Turn Signals and Tail Lamps:** Underhood blunt cut wires available in vehicle headlamp harness that give discrete/constant/continuous 12V+ or ground signal when each headlamp function is active (high-beam, low-beam, left-turn, right-turn, park and snowplow present). Signal voltage low current draw for signals to be detected. Vehicle harness described above may have a connector to facilitate easy upfit. Consider offering a standard connector across makes/models as an SAE spec. Connector should be easily accessible, with no tools required to access.

Axles/Suspensions

- **Dimensions and Travel Limits:** Displacement of stabilizer bar (when present) desires an allowable 6–10mm for rear mount attachment by sandwiched plate between frame and stay-bar mount.
- **Sufficient Front Axle Capacity to Allow for Weight of Plow Attached:** The chassis design allows for the addition of higher capacity springs or as originally designed to allow for sufficient plow reserve capacity on vehicles up to Class 5 to support plows up to 1,200 pounds with the allotment of reasonable ballast weight behind the rear axle.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

This section describes the desired support of chassis electrical architecture for snowplow industry upfits, which in many cases, can apply to other vocational vehicle needs.

Lighting

- **Dedicated or Accessible Upfitter Circuits:** The chassis design includes dedicated circuits or accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Reserve Capacity on Lighting Circuits:** The chassis design accounts for reserve capacity on available lighting circuits. This capacity ensures upfitters can add auxiliary lighting without overloading existing circuits, maintaining safety and functionality.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits (such as turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes). See additional lighting circuit connector image in the Van Body section of this document.
- **Emergency/Warning/Strobe Lighting:** The chassis design includes provisions for emergency, warning or strobe lighting systems on the front and rear of the chassis. These systems enhance the vehicle's visibility and safety when operating in hazardous conditions.
- **LED Compatibility:** The chassis design ensures compatibility with LED lighting for both the vehicle's lighting system and trailer tow lighting circuits. This includes proper voltage regulation to support LED lighting.

Electrical System Controls

Upfitter Switches

- **Snowplow Amperage Needs:** 12V power connection specified. Can handle 150–230A.
- **Snowplow Charging/System Requirements:** Vehicle charging system can handle unanticipated plow motor load-dump when plow function is stopped. Other vehicle systems are not affected by snowplow load dump (HVAC, radio, dash lights, etc.)
- **In-Cab 12V Switched Accessory:** Wire specified to enable snowplow system with key-on.
- **OEM Cab Switches:** Designed to accommodate common upfit requirements for plow equipment.
- **Cab Switch Wiring and Connectors:** Cab switch wiring terminates behind the cab, conveniently accessible with industry-standard connectors. This design facilitates quick and secure connections during upfitting.
- **In-Dash AUX Switches:** A minimum of six AUX in-dash switches are provided. These switches can be configured or programmed to operate either on battery power or ignition power, offering flexibility in controlling upfit components.
- **Programmable Switch Timed Shut-Off:** Switches are designed to be programmable for timed shut-off intervals. This feature allows upfitters to set time durations for specific functions to automatically turn off, enhancing energy efficiency.
- **Physical Battery Connections:** Physical battery connections capable of handling high electrical loads are included in the chassis design. They enable the connection of powered components, supporting various plow and spreader upfit applications.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting the cab and running to the rear of the frame. This organized routing prevents interference with other components and maintains clearance for added wiring.
- **Vehicle Speed Control:** The ability to easily determine ground speed for spreader and prewetting systems discharge control with an easily found and readable signal and wiring.
- **CAN BUS (J1939) Connection:**
  - **BCM Access/Programmability:** The chassis design provides access and programmability to the body control module (BCM) via the CAN BUS (J1939) connection.
  - **CAN BUS/Internal Chassis Data Stream Access:** While maintaining cybersecurity measures, upfitters can access internal chassis data streams via the CAN BUS.
- **Emergency/Warning/Strobe Lighting:** The chassis includes provisions for emergency, warning or strobe lighting systems on the front and rear of the chassis. These systems enhance the vehicle's visibility and safety when operating in hazardous conditions.
- **Telematics Integration:** The chassis design includes integration of telematics between the chassis and body. This eliminates the need for separate telematics systems.
- **Battery Electric Chassis Power Connections:** For battery electric chassis, standard power connections are provided for upfit equipment operation. A 48VDC, 150-amp continuous-duty connection supports high-power components like electric power takeoff (ePTO) or electric compressors. Additionally, a 12VDC, 100-amp connection is available for legacy systems (lighting, spreaders, etc.).
- **Climate Unit Control (EV):** For battery electric chassis, the design allows the operation and control of the cab climate unit even when the chassis is stationary on a work site. This feature enhances comfort and efficiency during downtime.

Electromagnetic Interference/Radio Frequency Interference (EMI/RFI)

- **Necessary Shielding:** The chassis design includes necessary EMI and RFI shielding to mitigate potential electromagnetic compatibility issues and ensure proper operation of electronic components.
- **Emissions Limits:** The design adheres to emissions limits set by relevant regulatory bodies. Emissions are controlled to meet any applicable standards while maintaining proper vehicle operation.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide vehicle identification number (VIN)-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration, and powertrain combination, enabling accurate weight calculations for different configurations.

Gross Vehicle Weight Rating/Gross Axle Weight Ratings (GVWR/GAWRs)

- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the CG per loading condition, rather than formulas to arrive at these values. These limits are defined for both horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/Center of Gravity (CG) Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral), corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having this information available as far in advance, prior to chassis order, is ideal in ensuring a particular chassis configuration will be suitable for the customer's application.

Regulatory/Safety

ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles

- **Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions. As previously noted, this is critical to the proper function of snowplow vehicles, and automatic disablement when the plow is attached is preferred.

F/CMVSS (Federal/Canada Motor Vehicle Safety Standards) Considerations

- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring and compatibility with ADAS systems that rely on camera inputs.
- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the chassis OEM provides maximum unloaded vehicle weight (UVW) values to maximize upfit capacity for different vocational applications. These specifications help fleet managers and upfitters choose the appropriate chassis configurations to accommodate their intended body/equipment upfit.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an IVD website that provides clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.
  - **Overall CG and Weight Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the plow like maximum percentage of total weight on any axle for braking purposes.
  - **F/CMVSS111 and Maximum Body Widths:** Clear compliance statements are provided with respect to F/CMVSS 111 and maximum body widths to maintain compliance with standard OEM mirrors. If optional OEM mirrors are available, such as trailer tow, the OEM specifies the maximum body widths for each mirror option. Methods to identify how each chassis is equipped are also provided, allowing upfitters to make informed decisions.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (Internal Combustion Engine)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to enable upfitters to prevent unsuitable chassis from being matched to customer applications.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.

BEV Emission and RFI/EMI Compliance

- **RFI/EMI Transmittance Limits:** For BEVs, upfitters are guided on maintaining RFI and EMI transmittance limits. These guidelines ensure additional upfit equipment does not compromise the BEV's overall RFI/EMI compliance.

Additional Chassis Information

- **Tire Clearance Envelope:** Detailed information is provided regarding tire clearance envelopes for each chassis model. This information accounts for suspension travel arcs and enables upfitters to design body placement and wheel well dimensions accordingly to prevent tire contact.
- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published, detailing all required compliance data points for each vehicle model. This includes curb weight, as-built chassis CG dimensions, top of frame height, seat points, passenger load and other information needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.

Fleet Operations

The integration of these features and considerations into the chassis design enhances vehicle suitability for fleet operations. It aims to provide efficient, reliable and adaptable solutions that align with the operational needs of fleet managers and contribute to overall operational success.

- **Range:** The chassis design takes into account the range requirements of fleet operations, especially for battery electric vehicles (BEVs). Vehicle range capabilities are designed to align with intended use, ensuring it can cover the necessary distances between charging or refueling points. Consideration is given to factors such as vehicle weight, powertrain efficiency, battery capacity and energy consumption to optimize range without compromising performance.
- **Info/Telematics/Communications Needs:** The chassis architecture accommodates existing customer telematics systems to be integrated. Alternatively, an OEM-offered system integrates advanced information, telematics and communication systems to meet the evolving demands of fleet operations. This includes real-time vehicle data tracking, remote diagnostics, predictive maintenance alerts and GPS navigation. Telematics systems provide vehicle performance, diagnostics, maintenance alerts, driver behavior and operational efficiency, enabling fleet managers to make informed decisions for optimal fleet management.
- **BEV Recharge Time:** For BEVs, the chassis architecture addresses recharge time considerations. The design ensures compatibility with various charging standards and infrastructure, allowing fleet operators to recharge vehicles efficiently. Factors such as battery capacity, charging voltage and available charging stations are taken into account to estimate and manage recharge times effectively.
- **Drive/Duty Cycle:** The chassis design factors in the specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, highway driving, off-road use and other unique scenarios. The chassis is engineered to handle the demands of different duty cycles, ensuring the vehicle performs optimally and reliably under various operating conditions.

Other

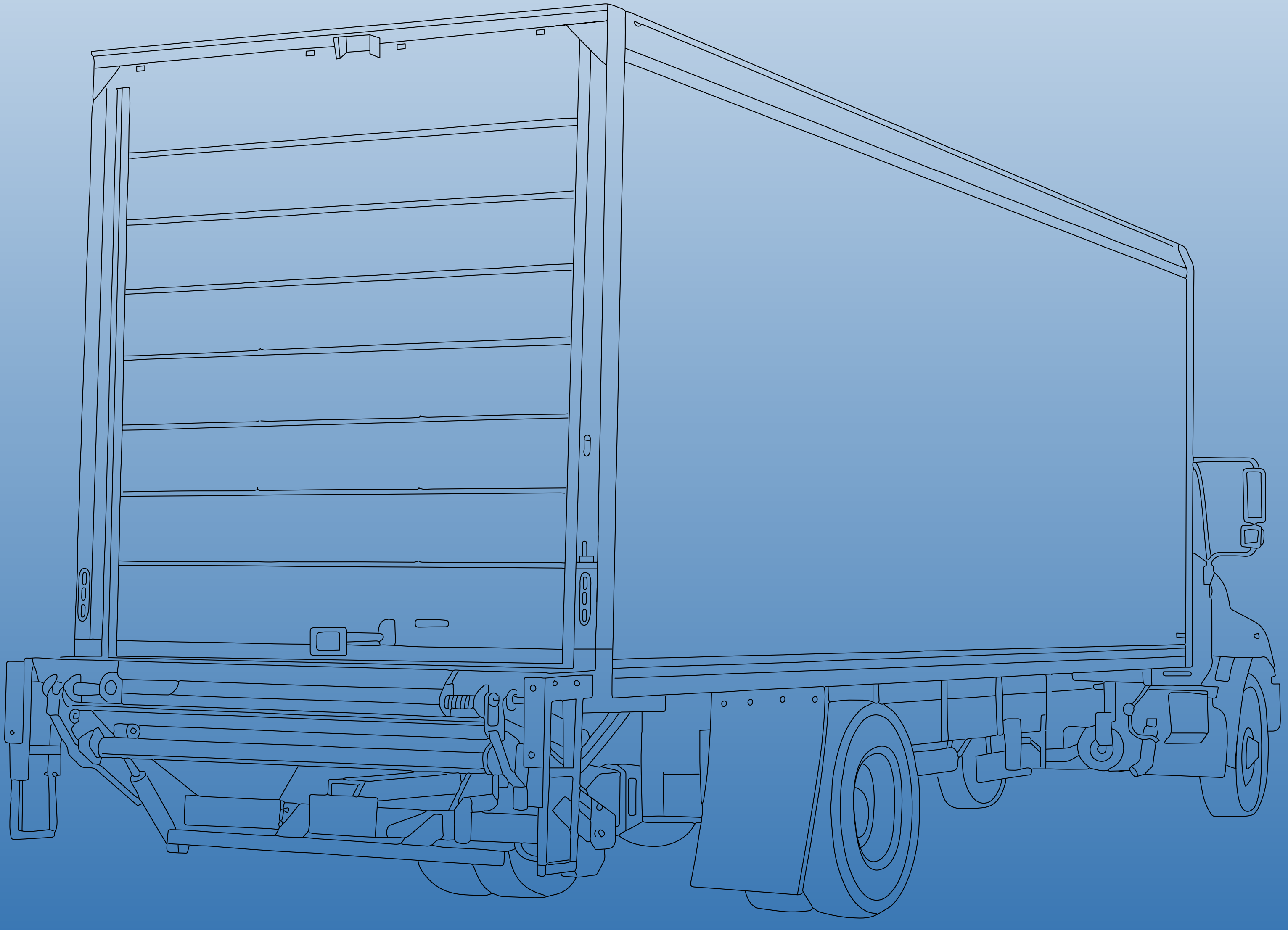
BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

Additional Resources

- Snow Control Equipment Manufacturers Committee information: **ntea.com/scemc**

VAN BODIES



INTRODUCTION

Van Body Manufacturers Division (VBMD)

VBMD, an NTEA operating division, was formed in 1992 to provide a neutral forum that fosters open communication among active members, suppliers and chassis OEMs on design and manufacturing matters relating to the work truck industry. VBMD's main focus is keeping up-to-date with chassis and regulatory changes to help forecast effects on future vehicle products. Areas of interest include electric chassis adaptation and opportunities to commonize chassis electrical connections.

The Van Body Industry

Van bodies (i.e., box truck bodies, box vans, cargo bodies and variations such as hi-cube and refrigerated) are a long-standing, traditional style of work truck body used heavily in the delivery of commodities. Refined over many years to optimize weight, durability and functionality, they are installed on a wide variety of chassis from Class 1–8 vehicles. Industry volumes over the last five years have been approximately 140,000 bodies per year, produced by a number of manufacturers.

The Market

The market for van body trucks encompasses a broad range of commercial vehicles that feature an enclosed cargo area mounted on a truck chassis. These vehicles are widely used across various industries for transporting goods, equipment and materials. They also serve specialized applications for mobile work operations and services. As with many other vocational vehicle types, the delayed replacement of older vehicles in existing fleets (due to the pandemic-driven shutdown of commercial chassis production) should lead to continued steady demand for van body trucks.

Van body trucks are utilized by many industries, including delivery and logistics, retail, construction, catering, moving services and more. Their enclosed cargo space makes them suitable for transporting a variety of items, such as packages or furniture, and variations with temperature-controlled cargo areas allow transport of perishable goods.

The growth of e-commerce has increased demand for last-mile delivery solutions. Van body trucks are well-suited for urban and suburban environments on shorter wheelbase chassis where smaller and more maneuverable vehicles are needed to navigate congested streets for goods delivery to commercial and retail customer locations (see also Cargo Van Interiors section).

Van body trucks offer a well-established platform for customization with equipment and features to suit the unique needs of various businesses. Liftgates are almost synonymous with van bodies for cargo loading/unloading, and are routinely coupled with additional features such as specialized cargo securement, refrigeration units and more.

More recently, advanced technologies, such as GPS tracking, telematics and route optimization software have enhanced the efficiency and operational capabilities of all commercial vehicles. But the transport functions of van body trucks have especially benefited transport operations with delivery routes, vehicle performance and location monitoring, and fuel consumption optimization.

Similar to other vocational vehicle markets, a growth area in the van body industry involves use of electric and hybrid van body trucks to reduce emissions and carbon footprint. Van body manufacturers have been taking advantage of lighter weight materials in body construction to offset heavier electric batteries in electric chassis powertrains in efforts to preserve/maximize cargo capacity compared to internal combustion engine (ICE) chassis counterparts.

The Challenges

Manufacturers (and, in-turn, end users) of van body trucks are affected by the integration of bodies to newer chassis products, as well as additional equipment and/or customization needed by the ultimate customer for their vocational mission. In addition to changes in powertrain with electric and advanced fuels coming to market, the increased electrical content of all vehicles is making upfitting more complex. Further, advanced safety systems required in lighter vehicles are also being incorporated into larger vehicles with regulatory requirements following their introduction to the industry. Some technologies, such as automatic emergency braking (AEB), may directly conflict with the vehicle's vocational upfit, which will be an area of continued work with government and industry to safely and responsibly bring these technologies to commercial trucks.

Van body manufacturers are constantly challenged to navigate these trends while preserving customization of products and innovation of features to improve overall and niche applications, incorporating technology for specific customer applications. Manufacturers use various materials, such as traditional sheet/post construction with fiberglass reinforced panels and steel or aluminum framework, and newer composites. Material selection depends on factors like durability, weight, cost and specific application requirements.

Van body chassis installations may seem straightforward with considerations for weight distribution and other basic chassis integration taken into account for compliance with motor vehicle safety and emissions compliance. But the array of diverse applications compounds these challenges in engineering variations across many industries and businesses, including delivery services, contractors, plumbers, electricians, HVAC (heating, ventilation and air conditioning) technicians, mobile workshops, food vendors, mobile healthcare units and others.

Chassis integration by van body manufacturers and other final-stage manufacturers involves preserving the ability to maintain the vehicle, including maintaining access to areas of the vehicle. For example, van bodies with attic compartments are generally incompatible with cab-over-engine (COE)/tilt cab chassis or chassis that would require cab removal for maintenance.

DESIGN CONSIDERATIONS

The following sections provide wants/needs and insight from the van body manufacturer's perspective in depiction of ideal chassis products for these work truck bodies. Some desires may overlap in an effort to emphasize the importance of features in different, but related sections/chassis systems. In general, these considerations are chassis and propulsion neutral, unless otherwise noted as specific recommendations to a particular type of chassis or powertrain system.

Chassis Features and Functions

Cab/Passenger Compartment

- **Air Horns:** Ideally, air horns are positioned under the cab to avoid cab roof mounting. In cases where cab roof air horns are inevitable, they are positioned at a consistent height and location across a specific chassis model. This approach ensures uniformity and avoids potential interference with body installation or operation.
- **Cab Roof-Mounted Catwalk/Refrigeration Unit Service Platform:** Provisions and reinforcement are integrated into the chassis design to accommodate cab roof-mounted catwalks or service platforms for refrigeration units. Collaboration with the van body manufacturer's design is needed to determine the details of these accommodations, ensuring safety and structural integrity.
- **Remote Access and Requirements:** Remote access features are included in the chassis design, with considerations for antennas and telematics control units (TCUs). Additionally, a reconditioning circuit is integrated to facilitate remote power activation or warm-up of the vehicle's systems.
- **Guidance on Roof Cutout (Cutaway Chassis):** In cases where the chassis is utilized for walk-thru applications, guidelines are provided on how to execute a roof cutout. This process enables installation of the necessary roof structure to maintain cab structural integrity while accommodating cargo area operator access.
- **Rear Flange Weld Nuts (Cutaway Chassis):** To ensure efficient body to cab attachment, the rear flange features strategically placed weld nuts in the rear-facing flange of the cab structure. These threaded inserts provide secure connection points for joining the body to the cab, enhancing overall stability and reducing the risk of structural issues from alternative means of body attachment.
- **Flat Rear Flange of Cab (Cutaway Chassis):** The rear flange of the chassis is flat and seamlessly accommodates the floor edge of the cab. Following the cab flange attachment desires, this design consideration facilitates alignment and attachment of the body to the cab.
- **Top of Frame – Cab Floor Dimension:** Provide a consistent design dimension from the top of the chassis frame to the top of the cab floor. A consistent dimension eases compatibility with different body variations, where body manufacturers can use this standardized dimension in their body understructure design to properly match the body height off of the frame.
- **Chassis Frame Dimensional Tolerances:** Precise dimensional tolerances are maintained throughout the chassis frame. This includes addressing factors such as maintaining side-side height (i.e., no lean) and cab-frame alignment (trueness).
- **Cab Tilt Access and Dimensions (Cab-Over-Engine Chassis):** The chassis design incorporates provisions for cab tilt access. Guidelines are provided regarding proper cab tilting techniques, helping ensure safe and efficient maintenance access to the engine and other components. Chassis OEM information outlines both recommended practices (dos) and precautions (don'ts).
- **Vehicle Power On – In-Cab Emergency Shutoff Access and Labeling:** This is particularly for keyless ignition/activation systems. The chassis features accessible emergency shut-off mechanisms, which are clearly labeled for quick identification. In critical situations, these shut-off points can be readily accessed by the operator to prevent potential hazards and secure the vehicle. This includes educational materials provided to guide operators on the correct procedures for powering the vehicle on/off.

Frame

- **Wheelbase Changes/Upfitter Guidance:** The chassis design allows for wheelbase adjustments, and clear guidelines are provided to upfitters on how these modifications can be made while maintaining structural integrity and compliance with vehicle safety standards.
- **General Dimensions:** The chassis dimensions are detailed in body builder information, including encumbered width, cab-to-axle (CA) measurements, clean top of frame specifications and other critical measurements. These dimensions ensure compatibility with various body types and allow for accurate upfitting.
- **Pre-Production Chassis Information:** OEMs provide comprehensive and finalized vehicle identification number (VIN)-specific chassis information to upfitters before the chassis arrives at their facilities. This allows upfitters to source long-lead-time body components in parallel with chassis production, streamlining the upfitting process.
- **Industry Standard CA:** Existing wheelbase and CA dimensions have been accommodated by the van body industry for chassis cab, cutaway and stripped chassis products. Preserving these dimensions is important to many vocational vehicle upfits.
- **Parallel Rails with Flat Top Surface:** The chassis design features parallel rails with a flat top surface, devoid of steps or offsets. This consistent section height and clean design behind the cab facilitate body attachment and provide a uniform mounting surface.
- **Clean CA/Top of Frame Design:** The preferred design aims for a clean CA where no OEM equipment protrudes above the frame for the entire length behind the cab. Except for tires, the chassis design ensures that no suspension or other protrusions extend above the top surface of the frame. This eliminates obstructions and simplifies body installation. If this is not possible, detailed diagrams must illustrate potential variations, allowing upfitters to plan and predict attachment methods.
- **Crossmembers and Flange Width:** Crossmembers are attached to the frame web, minimizing or eliminating rivet protrusion in the flanges – following suit with clean CA. The flange width, including reinforced areas, falls within the range of 3–3.5 inches, ensuring structural stability and compatibility with mounting designs.
- **Frame Rails Channel Shape:** Traditional C-channel frame rails are designed with adequate material thickness, strength and clearance around the frame rails. This accommodates shear plate and U-bolt mounting designs, promoting cost-effective body mounting options.
- **U-Bolt and J-Bolt Designs:** If U-bolt or J-bolt designs are not feasible, OEMs provide appropriate body mounting brackets or other solutions, including frame rail holes and mounting instructions.
- **Outside Frame Rail Width:** The outside width of frame rails is standardized, with chassis cabs featuring a width of 34 inches and cutaway chassis a width of 42 inches. While these are unofficial legacy dimensions, preserving them will help prevent chassis OEMs from inventing new frame widths to suit their specific needs. If there are a variety of different widths, the rest of the commercial vehicle industry cannot standardize body and equipment designs. Since there are no new dimensions around which to standardize, it's critical to preserve those that the industry has used for many decades of development.
- **Frame Length Behind Rear Axle (AF):** The frame extends to the rear of typical van body lengths, optimizing available space for various upfitting applications and eliminating the need for upfitters to extend the frame. Factory options for additional AF dimensions are also highly desirable.
- **Industry Standard Track Width Dimension:** The chassis adheres to an industry-standard track width dimension to ensure compatibility with various bodies and axles with federal width limits.
- **Minimum Inboard Clearance Along Frame Rails:** The chassis provides a minimum clearance of 2 inches along the inside of the frame rails, preventing interference with items like fuel cells or batteries and allowing for proper body attachment.
- **Ground Clearance and Battery Guarding/Access Points:** Clear definitions for ground clearance and battery guarding/access points are established, promoting safety and efficient upfitting.
- **Charging Port Access and Guarding (Hybrid/Electric Vehicle (EV) Powertrain):** If the charging port is located in the frame area, provisions are made for its access, location and guarding.

Chassis Class 1–8 Body Length, CA and AF

- **Body Length, CA and AF Dimensions:** For van body applications, the traditional body length, CA and AF dimensions currently offered by OEMs are adequate.
- **CA Dimensions:** As a rule of thumb, suitable CA dimensions are approximately 60–70% of a given body length for an intended application.

Mounting/Equipment Attachment

- **Equipment Attachment:** If there is limited clearance along the frame in certain sections due to the chassis configuration, provisions are made for additional attachment points. This ensures bodies and equipment can be securely attached even in cases where traditional attachment methods might be challenging due to space constraints, such as the inside of a C-channel next to a fuel tank or EV battery.
- **Standardized Pre-Punched Frame Holes:** The chassis design includes standardized pre-punched holes at the back of the frame. These holes are strategically placed to facilitate the addition of bolt-on frame extensions, eliminating the need for welding during the extension process and expediting upfitting operations. Ideally, body attachment points are designed with standardized spacing relative to a reference datum, such as the axle center line or the back of the cab. This approach allows body manufacturers to produce bodies with pre-installed mating mounting surfaces, reducing variability and promoting ease of assembly.
- **Standardized Frame Extension Kits:** Options for longer AF dimensions would be preferred, but for chassis that are not ordered with the proper dimensions, OEMs would provide standardized frame extension kits, which include components that can be easily integrated into the chassis frame. These kits are designed to ensure structural integrity while extending the frame length.
- **Floor Mounting Attachment Points and Ratings:** Dedicated mounting locations are available for floor mounting of components, such as consoles or laptop mounts, within the cab in proximity to the driver's seat. These options would include applicable load ratings.
- **Side Walls – Drill and No-Drill Areas:** Guidelines are provided for attaching equipment and components to the cab structure, including fenders, doors, roof and backpanel. These guidelines outline areas where drilling is permissible and areas where no-drill methods should be employed to prevent making contact with any components or affecting structural integrity.

Auxiliary Power (see also Electrical Section)

- **Auxiliary Fuel Tap (ICE Powertrains):** An auxiliary fuel port on the fuel tank sending unit or other means of accessing onboard fuel from the tank continues to be needed (now and into the future) for equipment that requires fuel, such as generators and auxiliary heaters. This helps ensure a convenient and standardized method for accessing fuel with a means to prevent drawing the tank to empty.
- **Standardized Fuel Tap for Diesel Refrigerated (Reefer) Units:** A standardized fuel tap is integrated into the chassis to facilitate easy connection of diesel-powered refrigeration units. This ensures consistent compatibility across various reefer units and simplifies the process of powering and maintaining temperature-controlled van bodies. The method and design of the port for this application could be applied to a gas engine auxiliary fuel tap to harmonize components for both fuel applications.
- **Electrical Access and High Amp Provisions:**
  - **12V, 24V, etc.:** The chassis offers various electrical access points to accommodate different voltage requirements, such as 12V and 24V systems. These access points are strategically placed for convenience and efficiency during upfitting. 12V power will continue to be needed, as products from the industry's component/system manufacturers are heavily 12V based. Wide coordination is needed to transition to higher voltages.
  - **High Amp Provisions (30A and Less/Over 30A):** The chassis design accounts for high amperage demands. Differentiated provisions are made for power requirements under 30A and those exceeding 30A, ensuring reliable power distribution to auxiliary equipment and devices.
- **Location of AUX Power Pickup – End of Frame Preferred:** Ideally, the pickup point for auxiliary power is located at the end of the frame. This placement simplifies routing and connection of auxiliary electrical components, such as liftgates, minimizing interference with other chassis features.
- **Availability of Reconditioning Circuit:** A reconditioning circuit is included in the chassis design. This circuit allows the vehicle's auxiliary power system to automatically recharge or maintain charge in situations where power is drawn from the auxiliary power source extensively.
- **Remote Access for Power-On or Warm-Up:** The chassis incorporates features enabling remote access to power-on or warm-up the vehicle, enhancing convenience and efficiency. This can be particularly beneficial in scenarios where pre-conditioning or pre-warming the vehicle is necessary.

Fuel

- **Fuel Fill for ICE Vehicles:** If the fuel system uses a capless fuel fill, the OEM provides a standardized fuel fill cup (i.e., "sugar scoop") with an integrated cover/fuel door to prevent dirt/debris from entering the fuel fill cavity.
- **Electrical Charge and Adapters for Hybrid/EV:** The chassis is equipped with the necessary infrastructure to support electrical charging, accommodating various power levels and connector types. This feature ensures compatibility with different charging stations and contributes to vehicle versatility, especially in hybrid or electric configurations.
- **Off-Gas Protection/Provisions During Battery Electric Vehicle (BEV) Recharging:** Attention must be given to the method/design of off-gas protection during battery charging to prevent conflict with the necessary function of this feature with common upfits. The design should be such that large distances of clearance underneath bodies/equipment are not necessary to preserve the proper ventilation function. This safeguards against potential hazards with gases becoming trapped or concentrated under/within the vehicle and ensures safe charging operations, contributing to the overall safety of the vehicle and its surroundings. Details on preventing interference with the off-gas provision must be provided in body builder information.
- **Common DEF Fill Location:** Chassis manufacturers, including those up to Class 8 vehicles, aim for a standardized diesel exhaust fluid (DEF) fill location. Ideally located under the hood or at the back of the cab, this consistent placement streamlines the refilling process and promotes uniformity across different chassis models.

Exhaust for ICE Vehicles

- **Horizontal Exhaust:** For horizontal exhaust configurations, the exhaust system is contained entirely within or underneath the frame for the whole length behind the cab. This design approach optimizes space utilization and reduces the risk of interference with upfitted bodies.
- **Vertical Exhaust:** In cases of vertical exhaust setups, the exhaust pipe is mounted to the side of the cab, ensuring it doesn't extend beyond the back of the cab. This design prevents protrusions that could affect body installation or interfere with other components, maximizing the clean CA dimension.
- **Exhaust Discharge Placement:** The exhaust discharge should terminate beyond the edge of the body, ideally 1–2 inches outboard. This design should discourage exhaust modifications to meet applicable requirements.

HVAC – Refrigerated Van Bodies

- **Auxiliary Heat/AC Provisions (Taps):** The chassis design includes provisions for auxiliary heating and air conditioning (AC) systems, especially relevant for applications such as mobile workshops. These provisions allow the integration of supplemental heating or cooling to maintain comfortable working conditions. This same feature is needed for other vocational vehicles that may be using the same chassis platform.
- **AUX Compressor/Condenser Capability/Packaging:** The chassis accommodates installation of auxiliary compressors and condensers for refrigerated van bodies. This ensures temperature-controlled cargo spaces can be efficiently cooled or heated, maintaining the quality of transported goods.
- **Electrical Reserve for Standalone Heat/AC Systems:** Chassis design factors in the need for additional electrical reserve to support standalone heating or air conditioning systems. This ensures the chassis can provide the necessary power to keep the auxiliary systems running smoothly.

Axles/Suspensions

- **Dimensions and Travel Limits:** Chassis dimensions are designed to accommodate dual tires, with overall width to the exterior sidewalls not exceeding 96 inches. The chassis also includes specified travel, jounce and rebound limits to assure safe and controlled suspension movement.
- **Air/Hydraulic Suspension Compatibility:** The chassis is adaptable to air and hydraulic suspension systems, allowing for customization based on specific application requirements. As part of this accommodation, the suspension layout ensures components like brake hardware and suspension parts are thoughtfully positioned within the jounce area.
- **Compensating for Body Lean:** The chassis design incorporates a method for compensating for body lean without affecting electronic stability control (ESC), braking systems, wheel alignment or other critical vehicle functions. This assures a stable and controlled driving experience, even with varying load conditions.
- **Dual Leveling Valves and Stability Controls:** Dual leveling valves are integrated into the suspension system without interfering with stability controls, such as ESC. This preserves vehicle stability and safety during operation.
- **Ability to Add Auxiliary Springs:** The chassis design allows for the addition of higher capacity springs or extra leaves to the suspension system. These modifications can be made without compromising stability controls, ensuring desired load-bearing capabilities can be achieved.

Weight Information

- **Four-Corner Weight Analyses:** Body builder information provides all necessary variables for conducting four-corner weight analyses. This data is crucial for evaluating weight distribution and ensuring compliance with regulations.
- **Curb Weight:** Chassis manufacturers provide VIN-specific curb weight values for each chassis model. These values are separated by factors such as wheelbase, cab type, drive configuration and powertrain combination, enabling accurate weight calculations for different configurations.

Gross Vehicle Weight Rating/Gross Axle Weight Ratings (GVWR/GAWRs)

- **Overall Center of Gravity (CG) Dimensional Limits:** Body builder information provides dimensional limits or envelopes for the center of gravity (CG) per loading condition, rather than formulas to arrive at these values. These limits are defined for horizontal, vertical and lateral dimensions. They are based on the vehicle's unloaded state and when fully loaded to the GVWR.
- **Curb Weight/CG Dimensions:** The chassis OEM provides the VIN-specific chassis curb weight and CG dimensions (horizontal, vertical and lateral) corrected for full fluids. This information is necessary for upfitters to perform accurate compliance calculations of the final vehicle configuration. Having this information available as far in advance as possible prior to chassis order is ideal in ensuring suitability of a particular chassis configuration to the customer's application.

Electrical System (for all Propulsion Systems, Unless Otherwise Noted)

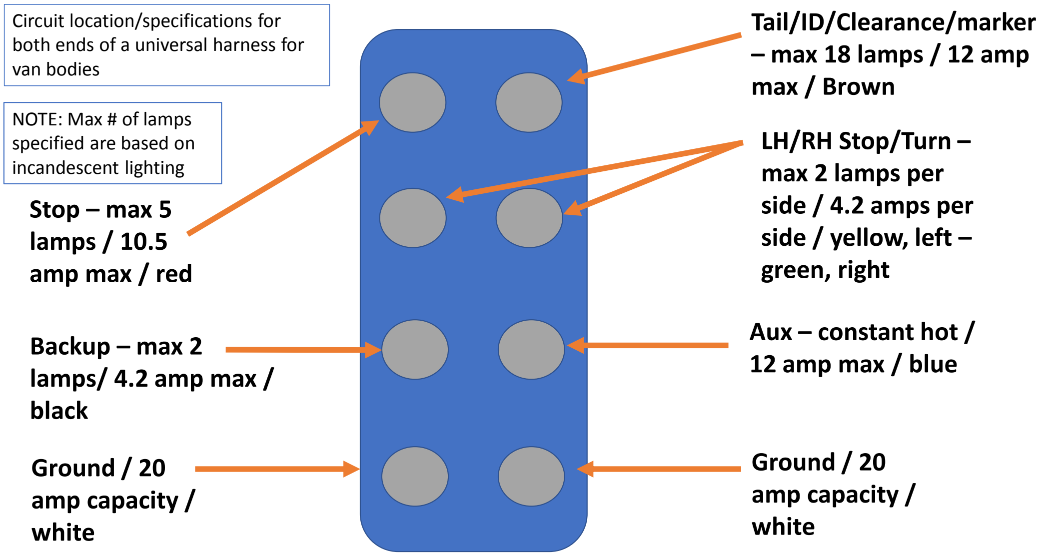
This section describes the desired support of the chassis electrical architecture for van body upfits, which in many cases can apply to other vocational vehicle needs.

Lighting, Wiring, Connectors and Sensors

- **Upfitter Circuits:** The chassis design includes dedicated circuits and accessible connection points for upfitters to integrate additional lighting systems or accessories. This provision simplifies the process of adding customized lighting elements to the vehicle.
- **Reserve Capacity on Lighting Circuits:** The chassis design accounts for reserve capacity on available lighting circuits. This ensures upfitters can add auxiliary lighting without overloading existing circuits or exceeding programmed threshold percentages monitored by the system.
- **Industry Standard Plug/Interface for Door Lock/Unlock Signal:** An industry-standard plug or interface is provided to allow upfitters to receive door lock/unlock signals to remote lock/unlock access doors on the body.
- **Required and Auxiliary Lighting Circuit Needs:** The chassis design accommodates both required lighting circuits (such as turn signals and brake lights) and auxiliary lighting needs (such as work lights or emergency strobes). See additional lighting circuit connector image below.
- **Emergency/Warning/Strobe Lighting:** The chassis design includes provisions for emergency, warning, or strobe lighting systems on the front and rear of the chassis. These systems enhance vehicle visibility and safety when operating in hazardous conditions.
- **LED Compatibility:** The chassis design ensures compatibility with LED lighting for both the vehicle's lighting system and trailer tow lighting circuits. This includes proper voltage regulation to support LED lighting.
- **Standard Trailer Tow Provisions:** Continue providing standard options for trailer towing, including trailer lighting connectors and wiring. A delete option should also be available for units requiring equipment incompatible with towing, such as some liftgate configurations.
- **Relocating OEM Lights, Antennas and Sensors:** Guidelines are provided to relocate OEM lights, antennas and sensors, especially in applications with aerodynamic devices. This ensures proper placement and functionality when moving components for different body configurations.
- **Relocation/Reinstallation of OEM Sensors for Installation in Bodies:** The design allows upfitters to remove, relocate and reinstall OEM backup sensors, cameras, lane departure warning, etc., from bumpers, mirrors and other chassis locations, and reinstall them on the upfitted body. Easy methods for sensor calibration, which do not require special tools, are provided in body builder information.
- **Connector Type, Quantity and Pin Position Standardization:** Collaboration with the industry drives toward standardization of connector types, quantities and pin positions. This helps ensure broad compatibility and simplifies the upfitting process.
- **Sufficient Wiring Length for Tail Lamp Connectors:** The chassis design includes sufficient wiring length to allow tail lamp connectors to be repositioned or extended from the frame to body extremes, up to 102 inches wide.
- **OEM Connector for Back-Up Alarm:** An OEM connector for a back-up alarm is located near the rear of the chassis. This feature ensures consistent installation and functionality of alarms for safety purposes.

- **Approved Power Pickup:** The chassis design offers approved power pickup points for various circuit functions, including reverse lights, turn signals, ignition hot, battery hot and ground. These designated points streamline the wiring process and ensure reliable connections.
- **Approved Wire Routing Location:** Guidelines are established for approved wire routing locations, particularly for wires exiting from the cab and running to the rear of the frame, including extended AF options. This organized routing prevents interference with other components and maintains clearance for added wiring.
- **Engine Bay/Front Compartment Pass-Thru Capability:** The chassis design includes dash panel pass-thru capabilities for upfitters, allowing them to easily route necessary wiring and components through the front panel.
- **VBMD Generic Lighting Connector:** OEM circuits are provided according to the following specifications, from which van body manufacturers can develop their own universal body harnesses.

VBMD Generic Lighting Connector



Camera Systems

- **Approved Monitor Installation Location:** Where auxiliary monitors are needed (non-Federal Motor Vehicle Safety Standard 111 compliant cameras/monitors), clear OEM guidance is provided on the approved locations for installing monitoring displays. This ensures optimal visibility for drivers while preventing installation in airbag deployment, head impact or other stay-out zones.

Electrical System Controls

Upfitter Switches

- **OEM Cab Switches:** The OEM cab switches are designed to accommodate common upfit requirements for van bodies. This includes functions like body dome lamps, liftgate cut-off switches and more.
- **In-Dash AUX Switches:** A minimum of six in-dash upfitter switches are provided. They can be configured or programmed to operate either on battery power or ignition power, offering flexibility in controlling upfit components.
- **Upfitter Switch Wiring and Connectors:** Upfitter switch wiring terminates in a conveniently accessible location, such as in lower portion of the dash console, with industry-standard connectors. This design facilitates quick and secure connections during upfitting.
- **Programmable Switch Timed Shut-Off:** Switches are designed to be programmable for timed shut-off intervals. This feature allows upfitters to set time durations for specific functions to automatically turn off, enhancing energy efficiency.
- **Physical Battery Connections:** Physical battery connections capable of handling high electrical loads are included in the chassis design. They enable the connection of powered components, such as a 5KW inverter, supporting various upfit applications.

- **CAN BUS (J1939) Connection:**
  - **BCM Access/Programmability:** The chassis design provides access and programmability to the body control module (BCM) via the CAN BUS (J1939) connection.
  - **CAN BUS/Internal Chassis Data Stream Access:** While maintaining cybersecurity measures, upfitters can access internal chassis data streams via the CAN BUS.
  - **Transmission Interlocks and Control:** The CAN BUS connection enables upfitters to control transmission interlocks for functions like liftgates, ramps and door locks. It also provides control over the power takeoff (PTO) engagement and engine RPM.
  - **Remote Engine Start and Stop:** Upfitters can perform remote engine start and stop functions through the CAN BUS connection, enhancing convenience and operational efficiency.
  - **Chassis Horn and E-Brake State:** Chassis horn control and the ability to read the electronic brake (e-brake) state are accessible via the CAN BUS connection.
  - **PTO-Related Parameters:** The CAN BUS connection allows reading of PTO-related parameters, such as status and engine RPM.
  - **AUX Switch States:** The states of auxiliary switches can be read through the CAN BUS connection, enabling monitoring and control of additional upfit components.
- **Telematics Integration:** The chassis design includes integration of telematics between the chassis and body, eliminating the need for separate telematics systems.
- **Battery Electric Chassis Power Connections:** For battery electric chassis, standard power connections are provided for upfit equipment operation. A 48VDC, 150-amp continuous duty connection supports high-power components like electric power takeoff (ePTO) or electric compressors. Additionally, a 12VDC, 100-amp connection is available for legacy systems (lighting, liftgates, etc.).
- **Climate Unit Control (EV):** For battery electric chassis, the design allows the operation and control of the cab climate unit even when the chassis is stationary on a work site. This feature enhances comfort and efficiency during downtime.
- **Cybersecurity Specifics:** Addressing cybersecurity concerns is critical, with a focus on protecting end-user telematics systems and data from unauthorized access and cyber threats.

Regulatory/Safety

- **ADAS (Advanced Driver Assistance Systems) and Autonomous Vehicles Upfit Compatibility:** The chassis safety systems take into account the compatibility of ADAS and autonomous technologies with upfit installations. Provisions are made to ensure upfitted components do not interfere with proper system function. In cases where upfits could potentially impact ADAS or autonomous features, the chassis design allows for the shut-off of non-regulatory system functions to maintain safety and system integrity. NTEA is tracking these developments to seek responsible rollout of requirements that enhance work truck mission safety, while preserving vital vehicle functions.

F/CMVSS (Federal/Canada Motor Vehicle Safety Standards) Considerations

- **Cameras vs. Mirrors:** The chassis design considers the use of cameras instead of traditional mirrors for rearward visibility. Provisions are made for camera integration, ensuring optimal positioning, wiring, and compatibility with ADAS systems that rely on camera inputs.
- **Max UVW/Min Upfit Capacities for Various Vocations:** For vehicles with a GVWR of 10,000 pounds or less, the chassis OEM provides maximum unloaded vehicle weight (max UVW) values to maximize upfit capacity for different vocational applications. These specifications help upfitters and end-users choose the appropriate chassis configurations to optimize their intended body/equipment upfit.
- **OEM Compliance Guidance:**
  - **Published Incomplete Vehicle Document (IVD) on Website:** The OEM establishes an open web location for generic IVDs of each incomplete vehicle model, providing clear compliance statements well in advance of new chassis becoming available for purchase. This platform serves as a resource for upfitters to establish compliant builds for customer orders and prevent improper chassis selection for a given upfit.
  - **Overall Center of Gravity (CG) and Body Height Limitations:** The OEM provides clear compliance guidance regarding CG and any additional limitations specific to the body.
  - **F/CMVSS 111 and Maximum Body Widths:** Clear compliance statements are provided with respect to F/CMVSS 111 and maximum body widths to maintain compliance with standard OEM mirrors. If optional OEM mirrors are available, such as trailer tow, the OEM specifies maximum body widths for each mirror option. Methods to identify how each chassis is equipped are also provided, allowing upfitters to make informed decisions.

Environmental Protection Agency/Environment and Climate Change Canada/California Air Resources Board Emission Compliance (Internal Combustion Engine)

- **Frontal Area Limits:** The OEM provides maximum frontal area limits to enable body widths and heights up to 102 inches. Limits are provided in the IVD ahead of production to help upfitters prevent unsuitable chassis from being matched to customer applications.
- **Max UVW/Min Upfit Capacities:** Just as with F/CMVSS considerations, the OEM provides maximum UVW limits that maximize upfit capacities. These values need to be harmonized to prevent different max UVW limits for safety and emissions compliance for the same chassis model. Only one value should be communicated for compliance with both sets of regulatory requirements per model variation.
- **EMI/RFI Shielding and Emissions:** The design incorporates necessary EMI and RFI shielding to mitigate potential interference issues and ensure optimal performance of electronic components added by upfitters, including any additional countermeasures need for BEV applications. Moreover, the design adheres to established limits for emissions, including Canadian Interference-Causing Equipment Standards (ICES), and clear OEM guidance is provided to maintain compliance.

Additional Chassis Information

- **Tire Clearance Envelope:** Detailed information is provided regarding tire clearance envelopes for each chassis model. This information accounts for suspension travel arcs and enables upfitters to design body placement and wheel well dimensions accordingly to prevent tire contact.
- **Consistent Nomenclature/Placement of Guidance:** OEM information provides consistent nomenclature and placement of compliance guidance across OEM's publications. Standard terminology is established, preventing confusion between different OEM guidelines.
- **Universal Table Layout for Compliance Data:** A universal table layout is published, detailing all required compliance data points for each vehicle model. This includes curb weight, as-built chassis CG dimensions, top of frame height, seat points, passenger load and other information needed for safety and emissions compliance calculations and evaluation.
- **Published Top of Frame/Load Height Dimension:** Clear information is published regarding top of frame/load height dimensions for vehicles at curb weight and at GVWR.

Fleet Operations

The integration of these features and considerations into the chassis design enhances vehicle suitability for fleet operations. It aims to provide efficient, reliable and adaptable solutions that align with the operational needs of fleet managers and contribute to overall operational success.

- **Range:** The chassis design takes into account the range requirements of fleet operations, especially for BEVs. Vehicle range capabilities are designed to align with intended use, ensuring it can cover the necessary distances between charging or refueling points. Consideration is given to factors such as vehicle weight, powertrain efficiency, battery capacity and energy consumption to optimize range without compromising performance.
- **Info/Telematics/Communications Needs:** The chassis architecture accommodates existing customer telematics systems to be integrated. Alternatively, an OEM-offered system integrates advanced information, telematics and communication systems to meet the evolving demands of fleet operations. This includes real-time vehicle data tracking, remote diagnostics, predictive maintenance alerts and GPS navigation. Telematics systems provide vehicle performance, diagnostics, maintenance alerts, driver behavior and operational efficiency, enabling fleet managers to make informed decisions for optimal fleet management.
- **BEV Recharge Time:** The chassis architecture addresses recharge time considerations for BEVs. The design ensures compatibility with various charging standards and infrastructure, allowing fleet operators to recharge vehicles efficiently. Factors such as battery capacity, charging voltage and available charging stations are taken into account to estimate and manage recharge times effectively.
- **Drive/Duty Cycle:** The chassis design factors in the specific drive and duty cycle requirements of fleet operations. This includes considerations for stop-and-go urban routes, highway driving, off-road use and other unique scenarios.

Other

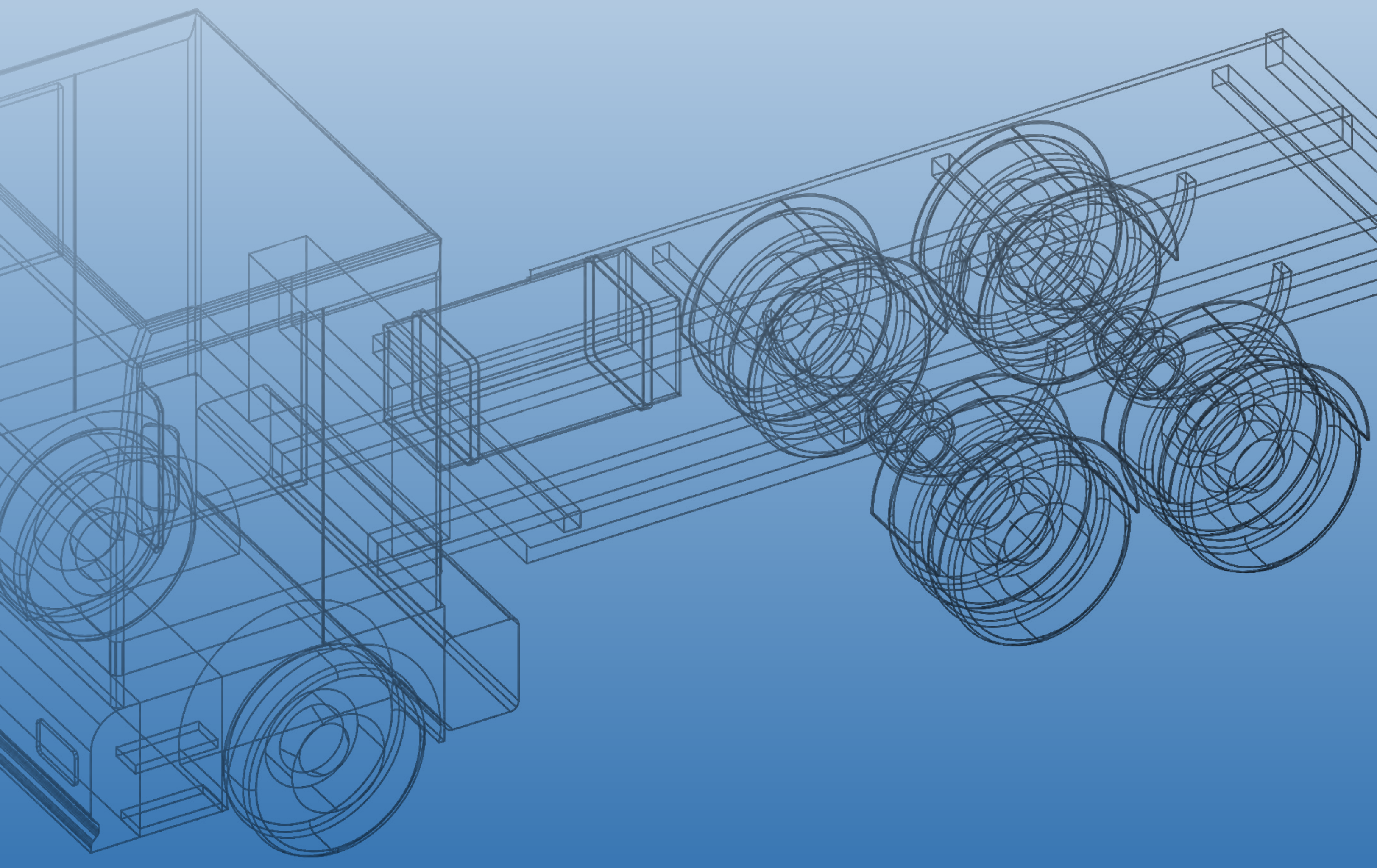
BEV Considerations for Upfitters

- **Unique Precautions for BEV Upfitting and Storage:** The OEM provides specific precautions and care instructions for upfitting BEV models, including unique measures needed for safe performance of common installation practices. Additional information is provided for safe storage of BEVs on-site at manufacturer facilities. Upfitters are guided on necessary fire safety precautions, including minimum distances between BEVs and exposure times for outside lots. This also includes necessary guidance on whether/how often BEV chassis need to be powered up and moved at different intervals compared to ICE chassis. In addition, considerations for maintaining battery health and ensuring proper functionality during storage are included.

Additional Resources

- Van Body Manufacturers Division information: **ntea.com/vbmd**

Model Template for Chassis Suitability and Conformance Input Values



INTRODUCTION

Building on the ideas expressed in this guide, a model template has been developed to consolidate the numerous, critical elements of OEM chassis information that manufacturers of vocational truck bodies and equipment and multistage vehicle manufacturers require for their vehicle certification responsibilities.

Basic chassis suitability and evaluations for various motor vehicle safety standards, as well as emissions compliance, include calculations requiring OEM vehicle data that is often published in multiple documents. There are currently no best practices established for publication of this vital information, and chassis OEMs provide this information in corporately-unique formats.

A constant challenge for multistage manufacturers is locating this information across different publications for each chassis OEM, as well as having this information made available at the same time and with adequate time ahead of production for a given model year.

Having a consolidated data table containing the essential dimension, weight, ratings/limits and other information for a given vehicle make, model and model year would enable multistage manufacturers to perform these necessary compliance evaluations more thoroughly and efficiently. In addition, having a universal table with such information several months ahead (ideally) of new model production launch would provide adequate lead time for multistage manufacturers to determine the range of buildable combinations of body and equipment they can represent to customers and prevent expectations for vehicles that cannot be offered.

The model template offers a starting point to a best practice chassis OEMs can use to consolidate and publish their respective model data. For example, each individual OEM can use this model template to gather all relevant data for their specific vocational models and publish the same range of data in the same manner on their own respective body builder websites. Ideally, this would occur several months before production so that the data would be less likely to change, while still providing adequate lead time to the upfitting community that relies upon it.

There are many potential benefits of a common reference table like this, including making it easier/more efficient for upfitters to fulfill their federal certification obligations, providing early identification of vehicle configurations that should not be considered for customer proposals/restricted by upfitter order systems, and proper management of dealer/customer expectations. Ultimately, everyone from the OEMs to their end-user customers would benefit from giving upfitters the ability to more easily identify suitable chassis options and likely reducing the downside associated with involved parties pursuing improper applications for a given chassis.

View the model template on pages 101–104 or download in Excel format at ntea.com/chassistemplate (NTEA member login required).

OEM Chassis Reference Guide for Industry-Requested Vocational Model Year Vehicle Data

This reference guide consolidates the numerous, critical elements of OEM chassis information that manufacturers of vocational truck bodies and equipment and multistage vehicle manufacturers require for their vehicle certification responsibilities. Each individual OEM can use this model template to gather all relevant data for their specific vocational models and publish the same range of data in the same manner on their own respective body builder websites.

(Columns 1–8)

Vehicle Input:	Model Year	OEM	Model	Base Vehicle Type	VIN Characters 4–8	Cab/Van Type	Drive	Rear Axle Type
Description of Input:				Chassis cab, cab-over engine, cutaway, stripped chassis, pickup, van, etc.	Description of base vehicle as contained in VIN characters 4 through 8	Regular, extended, crew, low roof, high roof, etc., or other as applicable for the specific base vehicle	4x2, 4x4, AWD, 4x6, etc., as applicable for the specific base vehicle	Single rear wheel (SRW) or dual rear wheel (DRW)
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 9–16)

Vehicle Input:	Powertrain Details	Fuel Type	Fuel Capacity	Wheelbase (inches)	Actual CA or CT (inches)	AF (inches)	Transmission PTO Availability	Transmission Type
Description of Input:	ICE displacement/ hybrid/BEV kW unique to the specific base vehicle	Gas, diesel, CNG, LPG, EV, etc.	Fuel volume for ICE powertrains or kW for BEV (both for hybrid) as configured for the specific base vehicle		Cab-to-axle/ trunnion dimension or effective/clear dimension to rear axle center	Aft frame: center of axle/trunnion to end of frame dimension	Yes/no for specific base vehicle	Automatic, manual, automated manual, etc.
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 17–24)

Vehicle Input:	Frame Width (inches)	Track Width - Front (inches)	Track Width - Rear (inches)	Ground to Top-of-Frame (or Load Bed for Completed Vehicles) Height at Curb Weight (inches)	Ground to Top-of-Frame (or Load Bed for Completed Vehicles) Height at Design Load Weight (inches)	GVWR (lbs.)	Front GAWR (lbs.)	Rear GAWR (lbs.)
Description of Input:	Outside–outside frame rail dimension	Center–center distance between tires on the front axle	Center–center distance between tires on the rear axle	Dimension measured at rear axle under loading condition	Dimension measured at rear axle under loading condition	Gross vehicle weight rating	Front gross axle weight rating	Rear gross axle weight rating
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 25–32)

Vehicle Input:	Front Base Curb Weight (lbs.)	Rear Base Curb Weight (lbs.)	Total Base Curb Weight (lbs.)	Maximum Payload (lbs.)	Front Max Option Weight (lbs.)	Rear Max Option Weight (lbs.)	Total Curb Weight With Max Options (lbs.)	Min Payload (lbs.)
Description of Input:	Front curb weight as produced by OEM for specific vehicle	Rear curb weight as produced by OEM for specific vehicle	Total curb weight as produced by OEM for specific vehicle	GVWR minus total base curb weight of specific base vehicle	Heaviest curb weight on the front axle resulting from the maximum available option content	Heaviest curb weight on the rear axle resulting from the maximum available option content	Total max curb weight as produced by OEM for specific vehicle	GVWR minus total curb weight with max option content of specific base vehicle
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 33–40)

Vehicle Input:	Min UVW (lbs.)	Min SUB Weight (lbs.)	Max UVW (lbs.)	Max SUB Weight	Max Frontal Area (sq. ft.)	Base Vehicle Frontal Area (sq. ft.)	Remaining Frontal Area (sq. ft.)	Rear Axle Ratio
Description of Input:	Minimum total weight of unloaded vehicle needed for brake system or other F/CMVSS compliance	Minimum weight of second unit body and/or equipment needed for brake system or other F/CMVSS compliance	Maximum unloaded vehicle weight within pass-thru for F/CMVSS and EPA certification, whichever regulatory requirements establish the lower limit for the specific base vehicle	Maximum weight of second unit body and/or equipment within pass-thru for F/CMVSS and EPA certification, whichever regulatory requirements establish the lower limit for the specific base vehicle	Maximum frontal area of completed vehicle for pass-thru of EPA certification	Frontal area occupied by the specific vehicle type as produced by the OEM	Remaining frontal area that can be added by multistage manufacturers in addition to that of the specific base vehicle	
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 41–48)

Vehicle Input:	GCWR (lbs.)	Max Loaded Trailer Weight (lbs.)	Max Allowable CG F/CMVSS Horizontal (inches)	Max Allowable CG F/CMVSS Vertical (inches)	Max Allowable CG F/CMVSS Lateral (inches)	CG Horizontal Chassis Base Vehicle (inches)	CG Vertical Chassis Base Vehicle (inches)	CG Lateral Chassis Base Vehicle (inches)
Description of Input:	Gross combination weight rating, based on powertrain, rear axle and other factors as established by OEM for the specific base vehicle	Maximum weight of trailer that can be pulled by the specific base vehicle	Horizontal range of overall CG location for pass-thru certification of completed vehicle as measured from the centerline of the front axle	Maximum value of overall CG location for pass-thru certification of completed vehicle as measured from the ground	Lateral range of overall CG location for pass-thru certification of completed vehicle as measured from the vehicle centerline	Horizontal CG dimension of base vehicle as represented by OEM for pass-thru compliance calculations	Vertical CG dimension of base vehicle as represented by OEM for pass-thru compliance calculations	Lateral CG dimension of base vehicle as represented by OEM for pass-thru compliance calculations
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 49–56)

Vehicle Input:	CG Horizontal Passenger(s) - Front (inches)	CG Vertical Passengers - Front (inches)	CG Lateral Passengers - Front (inches)	CG Horizontal Passengers - Rear (inches)	CG Vertical Passengers - Rear (inches)	CG Lateral Passengers - Rear (inches)	CG Horizontal Passengers - Additional Rear Seating [Passenger Vans/SUVs] (inches)	CG Vertical Passengers - Additional Rear Seating [Passenger Vans/SUVs] (inches)
Description of Input:	Horizontal distance from centerline of front axle to Design H-point or similar dimension of front seat passengers as represented by OEM for pass-thru compliance calculations	Vertical distance from ground to Design H-point or similar dimension of front seat passengers as represented by OEM for pass-thru compliance calculations	Lateral distance from vehicle centerline to Design H-point or similar dimension of front seat passengers as represented by OEM for pass-thru compliance calculations	Horizontal distance from centerline of front axle to Design H-point or similar overall dimension of all rear seat passengers as represented by OEM for pass-thru compliance calculations	Vertical distance from ground to Design H-point or similar overall dimension of all rear seat passengers as represented by OEM for pass-thru compliance calculations	Vertical distance from vehicle centerline to Design H-point or similar overall dimension of all rear seat passengers as represented by OEM for pass-thru compliance calculations	See previous	See previous
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

(Columns 57–60)

Vehicle Input:	CG Lateral Passengers - Additional Rear Seating [Passenger Vans/SUVs] (inches)	Number of Designated Seating Positions - Front Occupants	Number of Designated Seating Positions - Rear Occupants	Passenger Weight (lbs.)				
Description of Input:	See previous			Overall weight of driver/passengers represented by OEM for compliance calculations for specific vehicle type				
Vehicle 1								
Vehicle 2								
Vehicle 3, etc.								

NTEA

THE WORK TRUCK ASSOCIATION

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