Side windows shall be Arow Global Stormtite or approved equal full fixed framed windows with black anodized frames. Side windows shall extend from the shoulder height of a seated 5th percentile female passenger to the eye level of a standing 95th percentile male passenger. Vertical mullions between windows, including the trim, shall not exceed 13 inches in width. All side windows shall be fixed in position, except as necessary to meet the emergency escape requirements. All side windows shall be easily replaceable without disturbing adjacent windows and shall be mounted so that flexing or vibration from electric drive train operation or normal road excitation is not apparent.

2.2.14.2.1 Materials

Side window glazing material shall be ¼ inch tempered or laminated safety glass with 20 – 35 percent light transmittance. The window over the side destination sign shall have essentially clear glazing. Glazing materials shall be in accordance with the latest revision of ANSI Z26.1. Sash is to be black anodized aluminum.

The window sill, seal rubber and/or any sash, or sash frame mounting rubber must be installed so that passengers cannot remove it. The body sash construction shall be such that the sash drain will prevent the entrance or back up of water into the coach. Drains shall be incorporated at the bottom of the sash, which will drain interior condensation of the sash to the exterior of the coach. All windows shall be sealed to prevent the entrance of air and water. Materials used shall be designed to withstand varying temperature extremes, road splash and salt and other exterior elements without cracking, leaking, loosening and deteriorating.

Emergency escape windows shall be top hinged and captive, and shall not fall out on the street after being pushed open. The sash frame shall be installed to prevent the sash frame from being released unless it is intentionally pushed out in an emergency. It shall also be equipped with a positive lock device that must be manually released before the window can be pushed out.

An "Emergency Push Out" instruction plate shall be furnished and installed by the Contractor in accordance with the requirements of FMVSS 217. The instruction plate shall be a permanent metal label riveted to the wall of the coach and shall not be a decal or of “paint on metal” design.

2.2.15 INSULATION

2.2.15.1 Material

Any insulation material used between the inner and outer panels shall be fire-resistant and sealed to minimize entry of moisture and to prevent its retention in sufficient quantities to impair insulation properties. Insulation properties shall be unimpaired by vibration compacting or settling during the life of the coach. The insulation material shall be non-asbestos, non-hygroscopic, and resistant to fungus and breeding of insects. Any insulation material used inside the electric drive train compartment shall be fire-resistant and shall not absorb or retain oils or water.

2.2.15.2 Performance

2.2.15.2.1 Thermal Insulation

The combination of inner and outer panels on the sides, roof, and ends of the coach, and any material used between these panels shall provide a thermal insulation sufficient to meet the interior temperature requirements. The coach body shall be thoroughly sealed so that drafts cannot be felt by the driver or passengers during normal operations with the passenger doors closed.

Proposer shall provide a summary of insulation materials and total R-values achieved in side, top, front, and rear body panels as well as in floor.

2.2.15.2.2 Sound Insulation (Interior of Bus)

The combination of inner and outer panels and any material used between them shall provide sufficient sound insulation so that a sound source with a level of 80 dBA measured at the outside skin of the coach shall have a sound level of 65 dBA or less at any point inside the coach. These conditions shall prevail with all openings, including doors and windows, closed and with the electric drive train and accessories switched off.

The coach-generated noise level experienced by a passenger at any seat location in the coach shall not exceed 80 dBA and the driver shall not experience a noise level of more than 75 dBA under the following test conditions:

1) The coach shall be empty except for test personnel, not to exceed 4 persons, and the test equipment.
2) All openings shall be closed and all accessories shall be operating during the test.
3) The coach shall accelerate at full throttle from a standstill to 35 mph on level commercial asphalt or concrete pavement in an area free of large reflecting surfaces within 50 feet of the coach path.
4) During the test, the ambient noise level in the test area shall be at least 10 dBA lower than the coach under test. Instrumentation and other general requirements shall conform to SAE Standard J366. If the noise contains

an audible discrete frequency, a penalty of 5 dBA shall be added to the sound level measured.

2.2.15.2.3 Sound Insulation (Exterior of Bus)

Airborne noise generated by the bus and measured from either side shall not exceed 70 dBA under full power acceleration when operated at 0 to 35 mph at curb weight. The maximum noise level generated by the bus pulling away from a stop at full power shall not exceed 80 dBA. The bus-generated noise at curb idle shall not exceed 70 dBA. If the noise contained an audible discrete frequency, a penalty of 5 dBA shall be added to the sound level measured. The Contractor will comply with SAEJ366 and the exterior noise requirements defined in local laws and ordinances in the Procuring Agency's service area.

2.2.16 CLIMATE CONTROL SYSTEM

The HVAC unit may be rear-mounted or roof-mounted. In any design, the dimension requirements shall be met.

It shall be a design goal to limit the HVAC system's drain on the propulsion energy storage system by utilizing other onboard energy sources, such as regenerative braking, cooling devices, compressed air and hydraulic system heat, etc. There is a preference for oil heat, but alternative fuel sources such as LPG, may be proposed. For non-electric HVAC, bidder to provide details on heating capacity, fuel storage, expected bus range implications, direct Criteria Air Pollutant (NOx and PM) emissions per unit of fuel, and hourly energy or fuel consumption at varying low ambient temperatures.

Manufacturers are encouraged to submit recommendations for climate control system specifications, including power and fuel source, that provide the desired level of passenger and operator comfort and maximize operating range of the bus.

2.2.16.1 HVAC Capacity and Performance

The Heating, Ventilating, and Air Conditioning (HVAC) climate control system shall be capable of controlling the temperature and humidity levels of the interior of the bus as defined in the following paragraphs.

The HVAC shall provide an integrated solution for passenger heating and cooling along with a sufficient heating and cooling capacity to be used for traction battery cooling if required. Heating system total maximum power demand from the high voltage battery

shall not exceed that of the cooling system. The maximum impact of the cabin heating system energy use on range shall not exceed that of the cabin cooling system.

With the bus running at the design operating profile with corresponding door opening cycle and carrying a number of passengers equal to 150% of the seated load, the HVAC system shall maintain the average passenger compartment temperature within a range between 65°F and 80 °F, while maintaining the relative humidity to a value of 50% or less. The system shall maintain these conditions while subjected to any outside ambient temperatures within a range of 10°F to 95°F and at any ambient relative humidity levels between 5 and 50%.

When the bus is operated in outside ambient temperatures of 95°F to 120°F, the interior temperature of the bus shall be permitted to rise 0.5° for each degree of exterior temperature in excess of 95°F.

When bus is operated in outside ambient temperatures in the range of -10°F to 10°F, the interior temperature of the bus shall not fall below 55°F while the bus is running on the design operating profile.

The air conditioning portion of the HVAC system shall be capable of reducing the passenger compartment temperature from 110°F to 90°F in less than 20 minutes after system start-up. Propulsion system component temperatures shall be within the normal operating range at the time of start-up of the cool-down test. During the cool-down period, the refrigerant pressure shall not exceed safe high-side pressures, and the condenser discharge air temperature, measured 6 in. from the surface of the coil, shall be less than 45°F above the condenser inlet air temperature.

System capacity testing, including pull-down/warm-up, stabilization, and profile shall be conducted in accordance with APTA's "Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System." The recommended locations of temperature probes are only guidelines and may require slight modifications to address actual bus design. Care must be taken to avoid placement of sensing devices in the immediate path of an air duct outlet. In general, the locations are intended to accurately represent the interior passenger area.

2.2.16.2 Controls and Temperature Uniformity

The HVAC system (excluding the operator's heater/defroster) shall be centrally controlled with an advanced electronic/diagnostic control system with provisions for extracting/reading data. The system shall be compliant with J1939 Communication Protocol for receiving and broadcasting of data.

The operator shall have full control over the defroster and operator's heater. The operator shall be able to adjust the temperature in the operator's area through air distribution and fans.

The interior climate control system shall switch automatically to the ventilating mode if the refrigerant compressor or condenser fan fails.

Interior temperature distribution shall be uniform to the extent practicable to prevent hot and/or cold spots. After stabilization with doors closed, the temperatures between any two points in the passenger compartment in the same vertical plane, and 6 inches to 72 inches above the floor, shall not vary by more than 5ºF with doors closed. The interior temperatures, measured at the same height above the floor, shall not vary more than ± 5ºF, from the front to the rear, from the average temperature determined in accordance with APTA's "Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System". Variations of greater than +/- 5ºF will be allowed for limited, localized areas provided the majority of the measured temperatures fall within the specified requirement. HVAC system shall be capable of automatically reducing the rate of introduction of outdoor air in proportion to the number of passengers present, while maintaining temperature and humidity within specified ranges.

2.2.16.3 Air Flow

2.2.16.3.1 Passenger Area

The cooling mode of the interior climate control system shall be capable of introducing air into the bus at or near the ceiling height at a minimum rate of 25 cubic feet per minute (cfm) per passenger based on the standard configuration bus carrying a number of passengers equal to 150% of the seated load. Airflow shall be evenly distributed throughout the bus with air velocity not exceeding 100 feet per minute on any passenger. The ventilating mode shall provide air at a minimum flow rate of 20 cfm per actual onboard passenger.

Airflow may be reduced to 15 cfm per actual onboard passenger when operating in the heating mode. The fans shall not activate until the heating element has warmed sufficiently to assure at least 70ºF air outlet temperature. The heating air outlet temperature shall not exceed 120ºF under any normal operating conditions.

2.2.16.3.2 Driver's Area

The bus interior climate control system shall deliver at least 100 cfm of air to the operator's area when operating in the ventilating and cooling modes. Adjustable nozzles shall permit variable distribution or shutdown of the airflow. Airflow in the heating mode shall be reduced proportionally to the reduction of airflow into the passenger area.

The windshield defroster unit shall meet the requirements of SAE Recommended Practice J382 “Windshield Defrosting Systems Performance Requirements”, and shall have the capability of diverting heated air to the operator's feet and legs. The defroster or interior climate control system shall maintain visibility through the operator's side window. Use of electric resistance heat for windshield defroster shall be minimized as much as feasible.

2.2.16.4 Driver’s Compartment Requirements

A separately-controlled heating, ventilation, and defroster system for the operator's area shall be provided and shall be controlled by the operator. The system shall meet the following requirements:

1) The heater and defroster system shall provide heating for the operator and heated air to completely defrost and defog the windshield, operator's side window, and the front door glasses in all operating conditions. Fan(s) shall be able to draw air from the bus body interior and pass it through the defroster system and to the operator's area. A minimum capacity of 100cfm shall be provided. The operator shall have complete control of the heat for their area.
2) The defroster supply outlets shall be located at the lower edge of the windshield. These outlets shall be durable and shall be free of sharp edges that can catch clothes during normal daily cleaning. The system shall be such that foreign objects such as coins or tickets cannot fall into the defroster air outlets. Adjustable ball vents shall be provided at the left of the operator's position to allow direction of air onto the side windows.

A ventilation system shall be provided, which can be integrated as part of the defroster system, to ensure operator comfort and shall be capable of providing fresh air in the foot and/or head areas. Vents shall be controllable by the operator from the normal driving position. Decals shall be provided indicating "operating instructions" and "open" and "closed" positions as well. When closed, vents shall be sealed to prevent the migration of water or air into the bus.

The requirements for operator's cooling shall be consistent with specifications noted. There shall be no dedicated evaporator for drivers cooling.

2.2.16.5 Controls for the Climate Control System (CCS)

The operational modes of the interior climate control system shall be controlled by a 2-position toggle switch conveniently located to the operator. Any under-seat or auxiliary heaters, if used, shall be operated by this switch.

The controls for the operator's compartment for heating, ventilation, and cooling systems shall be integrated and shall meet the following requirements:

1) The operator shall be provided independent control of the defroster and operator's heater. The heat/defrost system shall include an "On-Off" switch located near the main Defroster switch. Controls for the heat/defrost system shall include:
    - MODE: Heat or defrost.
    - TEMP: Air outlet temperature.
    - FAN: Airflow fan speed control (at least two positions).
2) All switches and controls shall preclude the possibility of clothing becoming entangled.
3) A manually operated control valve shall not be required since the electric heater will not use heated water.

2.2.16.6 Air Filtration

Air shall be filtered before entering the AC system and being discharged into the passenger compartment. The filter shall meet the ANSI/ASHRAE 52.1 requirement for 5% or better atmospheric dust spot efficiency, 50% weight resistance, and a minimum dust holding capacity of 120 grams per 1,000 cfm cell. Air filters shall be easily removable for service and cleanable.

All intake openings shall be baffled to prevent entry of snow, sleet, or water. Moisture drains from air intake openings shall be located to prevent clogging from road dirt.

2.2.16.7 HVAC Service Requirements

Manual or automatically controlled shutoff valves in the refrigerant lines shall allow isolation of the compressor and dehydrator filter for service. To the extent practicable, couplings utilizing O-ring seals shall be used to break and seal the refrigerant lines during removal of major components, such as the refrigerant compressor. The refrigerant compressor shall be semi-hermetic and re-buildable. The condenser shall be located on the roof to efficiently transfer heat to the atmosphere, and shall not ingest air warmed above the ambient temperature by the bus mechanical equipment, or to discharge air into any other system of the bus. All access shall be hinged with captive fasteners.

2.2.16.8 HVAC Fuel System Requirements (If Used)

The following requirements shall be met for any proposed HVAC system which utilizes diesel fuel or Liquid Propane Gas (LPG) as part of its operation.

2.2.16.8.1 General Fuel Tank Requirements (All Fuel Types)

The fuel tank shall be properly sized to provide sufficient fuel for heated operation of the bus for at least 18 hours at -20°F. The fuel tank shall be securely mounted to the coach to prevent movement during coach maneuvers, but shall be easily removable for cleaning or replacement. Removal of the tank shall not be required for refueling.

2.2.16.8.2 Diesel Fuel Tank

If diesel is used, fuel tank shall be equipped with an external, socket head, stainless steel drain plug. It shall be at least a 3/8-inch size and shall be located at the lowest point of the tank. The tank shall have an inspection plate or removable filler neck to permit cleaning and inspection. The tank shall be baffled internally to prevent fuel-splashing noise regardless of fill level.

2.2.16.8.3 Diesel Fuel Lines

Diesel fuel lines shall be rigidly supported and shall be composed of steel tubing where practicable except in locations where flexible lines are specifically required. Flexible fluid lines shall be kept at a minimum and shall be as short as practicable.

Lines shall be routed or shielded so that failure of a line shall not allow fuel or oil to spray on or drain onto any component operable above the auto ignition temperature of the fluid. Flexible lines shall be Teflon hoses with braided stainless steel jackets (except in applications where premium hoses are required) and shall have standard SAE or JIC brass or steel, reusable, swivel, end fittings. Hoses shall be individually supported and shall not touch one another, or any part of the coach. The system shall be equipped with a fuel-priming pump or a check valve fitted in the fuel suction line to aid restarting after fuel filter changes.

2.2.17 ANCILLARY FEATURES

2.2.17.1 Driver’s Area

The driver’s area shall contain all apparatus and controls necessary for operation of the coach. The layout shall maximize the use of available space and shall employ sound human factors and industrial design principles. The operator's area and equipment shall be designed to ensure safe and optimal performance for operators in the range of the 5th percentile female to the 95th percentile male. The operator’s area shall be free of sharp edges, protruding objects, safety hazards and floor obstructions.

Contractor should follow SAE J833, “Human Physical Dimensions,” in the design of the Driver’s Area. Switches and controls shall be divided into basic groups and assigned to specific areas, in conformance with SAE Recommended Practice J680, Revised 1988, “Location and Operation of Instruments and Controls in Motor Truck Cabs,” and be essentially within the hand reach envelope described in SAE Recommended Practice J287, “Driver Hand Control Reach.”

The driver's work area shall be designed to minimize glare to the greatest extent possible. Objects within and adjacent to this area shall be matte black or dark gray in color wherever possible to reduce the reflection of light onto the windshield. The use of polished metal and light-colored surfaces within and adjacent to the driver's area shall be avoided.

Bidder shall submit drawings detailing the layout of the Driver's Area including controls and instrumentation.

2.2.17.1.1 Dash Panels

To the extent practical, areas that are visible from outside the coach in the vicinity of the dash panel and cowl shall be configured to preclude use for storage of items. The dash panel shall be designed so that liquid spilled on the surface will not damage or interfere with the operation of components or back panel wiring. The dash panel face shall be constructed of painted flat black metal, colored flat black composite material, or black acrylic plastic, designed to last the life of the bus and not degrade due to weathering or exposure to sunlight. The dash panel face shall be arranged to facilitate replacing switches or repairing wiring. The dash panel cabinet shall match adjacent lining materials.

Provide and install a single driver's dash fan. Procuring Agency shall have option to purchase dual driver's fans.

2.2.17.1.2 Sun Shades

Two adjustable Silent Gliss (or approved equal) sun shades shall be provided for the operator's side. Sun shade on driver's side window shall have a vertical split for mirror viewing. The sun shades shall be shaped to minimize light leakage between the visors and windshield pillars. Sun shades shall be stored out of the way and shall not obstruct airflow from climate control system or interfere with other equipment such as radio headset or destination sign controls. Deployment of the sun shades shall not restrict vision of the rear view mirrors. Sun shade adjustment shall be made easily by hand with positive locking releasing devices and shall not be subject to damage. Sun shade construction and materials shall be strong enough to resist breakage during adjustments. Sun shades shall not allow a visible light transmission in excess of 10%. The sun shades, when deployed, shall be effective in the operator's field of view at angles more than 5° above horizon.

Procuring Agency shall have option to remove sun shade from right side of windshield.

2.2.17.1.3 Passenger Stop Request/Exit Signal

A passenger chime signal audible to the driver and to passengers anywhere inside the coach shall be provided. The chime shall be activated by yellow pull cords located in the passenger seating area. Yellow tape switches shall be located adjacent to the mobility aid locations or, if “flip up” seats are used, on the underside of the seats for use by passengers with disabilities. Tape switches located adjacent to wheelchair or mobility aid securement areas shall be mounted no higher than 48 inches and no lower than 15 inches above the floor. Tape switches shall require a force of 5 pounds or less to activate the chime signal.

A “Stop Requested” passenger sign shall be mounted in a position visible to the seated operator and seated passengers. The sign shall be illuminated when the passenger chime signal is activated and shall remain illuminated until one of the passenger doors is opened. The sign shall normally appear white when not illuminated and when activated the sign letters shall be white on a black background. The passenger chime shall sound only once when the sign is first illuminated. The chime for the mobility aid passenger locations shall chime twice and not be prevented from activation when the initial single chime was activated from another location. A driver-controlled switch shall deactivate both chime systems.

2.2.17.1.4 Operator’s Storage

Contractor shall provide an operator’s storage box. Storage box door shall have latches. Keyed door locks will not be accepted. The proposal shall show the location and size of the operator’s storage box.

2.2.17.2 Mirrors

2.2.17.2.1 Exterior Mirrors (Electrically Remote Controlled and heated)

The coach shall be equipped with two Safe Fleet 8“ x 15” two-piece (or approved equal) outside review mirrors mounted on both sides of the coach. Mirrors and brackets shall be corrosion-resistant and mounted with stable supports to minimize vibration. Mirrors shall be firmly attached to the bus to minimize vibration and to prevent loss of adjustment with a breakaway mounting system. Mirrors shall permit the driver to view the roadway along the sides of the bus, including the rear wheels. Mirrors should be positioned to prevent blind spots. Mounting shall be sufficient to prevent damage to coach or its structure when the mirror is struck in an accident. Mirror brackets shall be stainless steel. Mirrors shall retract or fold sufficiently to allow coach-washing operations.

All exterior mirrors shall be heated, electronic units and button controls shall be used for remote positioning of both mirrors. The driver shall be able to adjust the mirrors on both sides of the bus remotely while seated in the driving position.

2.2.17.2.2 Interior Mirrors

Mirrors shall be provided for the driver to observe passengers throughout the coach without leaving their seat and without shoulder movement. With a full standee load, including standees in the vestibule, they shall be able to observe passengers in the front and rear step wells, anywhere in the aisle, and in the rear seats. Interior mirrors shall not be in the line of sight to the right outside mirror. Interior mirror shall be 8” x 15” with protected edges.

There shall be a 12” convex mirror mounted inside to the upper right side of the rear entrance door to enable the driver to see inside the step well from the driver seat through the above interior mirror.

2.2.17.3 Passenger Assists

2.2.17.3.1 General Requirements

Passenger assists in the form of full grip, vertical stanchions or handholds shall be provided for the safety of standees and for ingress/egress. Passenger assists shall be convenient in location, shape, and size for both the 95th percentile male and the 5th percentile female standee. Starting from the entrance door, moving anywhere in the coach and out the exit door, a vertical assist shall be provided either as the vertical portion of a seat back assist or as a separate item. They shall be designed so that a 5th percentile female passenger may easily move from one assist to another using one hand and the other without losing support.

The assists shall be between 1¼ and 1½ inches in diameter or width with radii no less than ¼ inch and shall permit a full hand grip with no less than 1½ inches of knuckle clearance around the assist. A crash resulting in a 1-foot intrusion shall not produce sharp edges, loose rails, or other potentially dangerous conditions associated with a lack of structural integrity of the assist. Any joints in the assist structure shall be underneath supporting brackets and securely clamped to prevent passengers from moving or twisting the assists. All areas of the passenger assists that are handled by passengers including functional components used as passenger assists, shall be stainless steel. Assists shall withstand a force of 300 pounds applied over a 12-inch lineal dimension in any direction normal to the assist without permanent visible deformation. All passenger assist components, including brackets, clamps, screw heads, and other fasteners used on the passenger assists, shall be designed to be vandal-proof and designed to eliminate any pinch points, snagging, and cutting hazards and shall be free from burrs or rough edges. Allen-headed fasteners are considered to meet this requirement. All passenger assists, this section notwithstanding, shall comply with the ADA requirements outlined in 49 CFR Part 38.29.

2.2.17.3.2 Front Door

Front door assists shall be as far outward as practical, but shall be no further than 6 inches inward from the outside edge of doorway tread and shall be easily grasped by a 5th percentile female boarding from street level. Door assists shall include a vertical section at the outboard door edge and an upward slope across the door panel that is functionally continuous with the horizontal front passenger assist and the vertical assists on the modesty panels. Door entry assists shall be no less than ¾-inch in width and provide a minimum knuckle clearance of 1½ inches.

2.2.17.3.3 Vestibule

The aisle side of the driver's barrier shall be fitted with a vertical passenger assist that is functionally continuous with the overhead assist and that extends to within 36 inches of the floor. The assist shall have sufficient clearance from the barrier to prevent inadvertent wedging of a passenger's arm. A horizontal passenger assist shall be located across the front of the coach and shall prevent passengers from sustaining injuries on the fare collection device or windshield in the event of a sudden deceleration. Without restricting the vestibule space, the assist shall provide support for the boarding passenger from the front door through the fare collection procedure. Passengers may be able to lean against the assist for stability while paying fares. The assist shall be no less than 36 inches above the floor.

2.2.17.3.4 Front Wheel Housings

The front wheel housings shall have vertical assists at the rearmost aisle-side corners that are continuous with the overhead horizontal assists. A horizontal assist approximately 36 inches above the floor and on top of the wheel housing shall be installed along the aisle side of the curbside wheel housing. A similar assist shall be provided on the streetside wheel housing if it does not preclude opening the doors of the electronics locker.

Where applicable, passenger assists shall be provided around exposed sides of propulsion compartments.

2.2.17.3.5 Overhead

A continuous, full grip, overhead assist shall be provided on both sides of the aisle. This assist shall be convenient to standees anywhere in the coach and shall be located over the center of the aisle seating position of the transverse seats. The assist shall be no less than 70 inches above the floor except over the curbside front wheel housings where the height shall be no less than 60 inches. A similar assist shall be provided over the streetside wheel housing if it does not preclude opening the doors of the electronics locker. Overhead assists shall simultaneously support 150 pounds on a 12-inch length. No more than 5% of the full grip feature shall be lost due to assist supports.

2.2.17.3.6 Seats

Longitudinal seats shall have vertical assists located between every other designated seating position except for seats that fold/flip up to accommodate wheelchair securement and the two most rearward seats on each side, which shall have vertical assists at the rearward edge. Assists shall extend from near the leading edge of the seat and shall be functionally continuous with the overhead assist.

Every other transverse seat shall have a vertical assist attached to the seat back assist extending to the overhead assist. In addition, seats rearward of the mobility aid parking area shall have vertical assists. Assists shall be staggered across the aisle from each other where practical, shall be no more than 52 inches apart, and shall be functionally continuous for a 5th percentile female passenger.

2.2.17.3.7 Rear Step Area

Assists shall be provided on both sides of the aisle steps in the rear of the bus. Assists shall be no less than 36 inches above the floor and step tread surface, and shall be functionally continuous with vertical assists in the low floor area and on the modesty panels in the high floor area.

2.2.17.4 Exterior Route Displays

2.2.17.4.1 Electronic Destination Signs

A destination sign system shall be furnished on the front, right side near the front door. All signs shall be controlled via a single human-machine interface (HMI). In the absence of a single mobile data terminal (MDT), the HMI shall be conveniently located for the bus driver within reach of the seated driver.

Destination signs shall be Twin Vision “Smart Series” or approved equal and, in interest of standardization, shall utilize the following components (or approved equals):

1) Front Destination sign
2) Side Destination sign
3) Driver's Membrane pad control console and display
4) All cables and accessories

The Front Destination Sign shall be 16x160 matrix configuration. Sign shall be mounted on the front of the bus near the top edge of the body, behind windshield protection, and in an enclosed but accessible compartment provided by the bus manufacturer.

The Side Destination Sign shall be 14x112 matrix configuration. Sign shall be located on the right side of the bus near the front door, either mounted near the top of an existing window or in a separate enclosed but accessible weather-proof compartment provided by the bus manufacturer.

The entire display area of all signs shall be readable in direct sunlight, at night, and in all lighting conditions between those two lighting extremes, with evenly distributed illumination appearance to the un-aided eye.

Flash memory integrated circuits shall be capable of storing and displaying up to 10,000 message lines. Message memory shall be changeable by the use of a USB drive of not less than one (1) megabyte memory capacity but sized according to the message listing noted herein.

The system shall have the ability to sequentially display multi-line destination messages, with the route number portion remaining in a constant “on” mode at all times, if so programmed. It shall also be capable of accepting manual entry of route alphanumeric information on any or all signs.

The various signs shall be programmable to display independent messages or the same messages, and up to two destination messages and one public relations message shall be pre-selectable. The operator shall be able to quickly change between the pre-selected messages without re-entering a message code. Public relations messages shall be capable of being displayed alternately with the regular text and route messages or displayed separately.

An emergency message shall be activated by a push button or toggle switch in a location to be approved by the Procuring Agency. The emergency message shall be displayed on signs facing outside the vehicle while signs inside the vehicle, including the OCU display, shall remain unchanged. The emergency message shall be canceled by entering a new destination code or by power cycling (after removal of the emergency signal).

The programming software shall provide means of adjusting the length of time messages are displayed in 0.1 second increments up to twenty-five seconds.

Power to the sign system shall be controlled by the “Master Coach Run Switch”. The signs shall operate in all positions of this switch except “Off”, wherein the sign will only operate for 30 minutes after the master switch is turned off. The signs shall internally protect against voltage transients and Radio Frequency Interference (RFI) to ensure proper operation in the local environment.

2.2.17.4.2 Display and Display Illumination

All sign displays shall consist of pixels utilizing High Intensity Light Emitting Diodes (LED) for superior outdoor environmental performance, with White illumination appearance and light wavelength of 590nm. LED lighting should be made using Aluminum Indium Gallium Phosphide (AlInGaP) II material and superior UV-resistant Epoxy lens, with superior resistance to the effects of moisture. Each pixel shall have a dedicated LED for illumination of that pixel in all lighting conditions. The sign system shall have multi-level intensity changes, which adjust automatically as a function of ambient lighting conditions. There shall be no requirement for any fan or any specialized cooling or air circulation.

LEDs shall be mounted such as to be visible directly to the observer positioned in the viewing cone, allowing for full readability 65 degrees to either side of the destination sign centerline. LEDs shall be the only means of illumination of the sign system. The LED illumination source shall have an operating life mean time between failures (MTBF) of not less than 100,000 hours. Each LED shall not consume more than 0.02 Watts.

The characters formed by the system shall meet the requirements of the Americans with Disabilities Act (ADA) of 1990 Reference 49 CFR Section 38.39.

2.2.17.4.3 Sign Enclosures

All Signs shall be enclosed in a manner such as to inhibit entry of dirt, dust, water and other contaminants during normal operation or cleaning. Access shall be provided to clean the inside of the bus window(s) associated with the sign and to remove or replace the sign components. Access panels and display boards shall be mounted for ease of maintenance and replacement. Rear sign enclosure shall be made of Polycarbonate material containing fiberglass reinforcement. The vehicle manufacturer shall comply with the sign manufacturer's recommended mounting, mounting configuration, and installation procedures to assure optimum visibility and service accessibility of the sign system and system components.

2.2.17.4.4 Electronic System Requirements

All electronic circuit boards used in the sign system shall be conformal coated to meet the requirements of military specification MIL-I-46058C. All sign system components shall be certified to have been subjected to a "burn-in" test of a minimum of twelve (12) hours operation in a temperature of 150 °F prior to final inspection.

2.2.17.4.5 Front Destination Sign

The Front Destination Sign message shall be readable by a person with 20/20 vision from a distance not less than 350 feet for signs with display heights greater than 8

inches, and from a distance not less than 275 feet for display heights less than 8 inches. The Front Destination Sign shall have a viewing cone of equal readability of 65° to either side of a line perpendicular to the center of the mean plane of the display. The intensity of the illumination of the display pixels shall appear (to the naked eye) to be approximately uniform throughout the full viewing cone.

Provide electric defroster grid (automotive type) for the Front Destination Sign glass to help defrost the front glass.

2.2.17.4.6 Side Destination Sign

The Side Destination Sign message shall be readable by a person with 20/20 vision from a distance of not less than 110 feet. The Side Destination Sign shall have a viewing cone of equal readability of 65°to either side of a line perpendicular to the center of the mean plane of the display. The intensity of the illumination of the display pixels shall appear (to the naked eye) to be approximately uniform throughout the full viewing cone.

2.2.17.4.7 Operator Control Unit (OCU)

The OCU shall be used to view and update display messages. It shall be recess-mounted on the vehicle front sign compartment access cover or door. The OCU shall utilize a multi-key conductive rubber pad keyboard and be designed for transit operating conditions.

The OCU shall contain a display of at least two-lines of 20-character capability. The OCU shall contain an audio annunciator that beeps indicating that a key is depressed. The OCU shall continuously display the message associated with the selected destination readings (except the emergency message feature as noted above).

If the Input/Output Buffer Information Specification (IBIS) interface is required in the destination sign system, an auxiliary RS232 (DB9) port shall be made optionally available on the OCU under frame for inputs from any wireless technology that might be envisioned in the future. This auxiliary RS232 port shall operate at 9600 baud, accept commands from a wireless source (such as Spread Spectrum receivers), and set destination sign addresses as if manually operated by the OCU operator.

If the J1708 interface is selected for the destination sign system, an auxiliary J1708 port shall be made available on the J1708 OCU so that auxiliary J1708 commands may be provided to the destination sign system from a wireless source that conforms to the J1708 command structure. Twin Vision does not provide a wireless apparatus, but the Twin Vision destination sign system has the capability of interfacing via the J1708 link

with any such inputs, providing that the apparatus conforms with the appropriate signaling specifications.

2.2.17.4.8 Programming

Manufacturer's basic programming software package shall be submitted as part of the proposal.

On-board programming shall be configured with agency-specific programming installed on all buses prior to release for delivery. Manufacturer shall contact Procuring Agency prior to programming so that the most suitable software version is installed to ensure maximum commonality with software in use by Procuring Agency at time of delivery.

Agency-specific programming software package shall also be provided to Procuring Agency at time of delivery with the USB memory drive according to Agency's program list.

2.2.17.4.9 Message Memory Transfer and Update

The sign system shall be re-programmable on the vehicle with the use of a USB drive. A USB drive shall be provided on the OCU face for this purpose. The maximum reprogramming time for a 10,000-line listing shall be one minute. USB drives, with appropriate memory capacity based on the requirements of the message listing noted below shall be supplied at the rate of two drives per Procuring Agency for this contract.

2.2.17.4.10 Message Listing

Within 14 days of receipt of the first purchase order from Procuring Agency, the vehicle manufacturer shall supply to the sign manufacturer a list of the message readings or listings to allow the sign system to be pre-programmed with the correct readings.

2.2.17.5 Lift System

2.2.17.5.1 General

The design and construction of the bus shall be in accordance with all requirements defined in 49 CFR Part 38, Subpart B: "ADA Accessibility Specifications for Transportation Vehicles – Buses, Vans and Systems" as well as 36 CFR Part 1192. Space and body structural provisions shall be provided at the front of the bus to accommodate the wheelchair loading system.

The wheelchair loading system shall be an automatically controlled, power-operated ramp system, compliant with the requirements defined in 49 CFR Part 38.23(c). Loading system shall provide ingress and egress quickly, safely, and comfortably, both in

forward and rearward directions, for a passenger in a wheelchair from a level street or curb. All exposed surfaces shall be fabricated from stainless steel.

Space and body structural provisions shall be provided at the front door of the coach to accommodate the mobility aid, loading ramp. The ramp and mechanism shall be protected from collision damage; damage from curbing the coach; corrosion; and the entrance of water, sand, and salt. The mobility aid ramp shall provide safe, comfortable, and rapid ingress and egress for passengers using mobility aid devices either from street level or curb. The system shall be designed to operate in a service area environment where curb heights may reach 14 inches and with varying degrees of road crowns. The ramp shall be designed to protect the device from damage and persons on the sidewalk from injury during the extension and lowering phase of operation. The mobility aid ramp system shall not present a hazard or inconvenience to any passenger. In the stored position of the ramp, no tripping hazards shall be present, and any resulting gaps shall be minimized.

2.2.17.5.2 Design Requirements

The ramp shall be located at the front door, with the ramp being of a simple hinged, flip-out type design. The ramp shall be a Ricon FR2 4:1 or approved equal. Ramp shall support a load of 600 pounds, placed at the center of the ramp distributed over an area of 26 inches by 26 inches, with a safety factor of at least 3 based on the ultimate strength of material. The wheelchair lift control system must be capable of receiving multiplex command from vehicle interlocks.

Ramps shall have the least slope practicable and shall not exceed 1:6 slope when deployed to roadways or curb-height boarding and alighting areas when the vehicle is resting on a flat surface. When deployed to a boarding platform with the vehicle resting on a flat surface, slope shall be 1:8 maximum.

The loading platform shall be covered with a replaceable or renewable, non-skid material and shall be fitted with barriers at least 2 inches high to prevent the mobility aid devices from rolling off the ends or sides during loading or unloading. The ramp shall be firmly attached to the vehicle and no gap between the ramp, including its sections, and the vehicle shall exceed 5/8 inch. The ramp shall be furnished with anti-skid tape which has an adhesive backed laminate. The ramp shall not have protrusions from the surface greater than ¼-inch high and shall have a clear width of 30 inches.

2.2.17.5.3 Ramp Operation

The loading operation shall be under the surveillance and complete control of the operator. Stowing or deploying the ramp shall require two separate and distinct actions by the operator. A guarded master switch in the operator's console shall disable ramp

operation. The controls shall be simple to operate with no complex phasing operation required and should be integrated with the coach kneeling system to minimize slope from ramp to street level. The four-way hazard warning lights shall be automatically activated when the ramp master switch is in the enabled or on position at the operator's console. The ramp shall be incapable of stowing when a passenger is on the ramp. The safeguards incorporated into the ramp's operation to prevent accidental stowing of the ramp with a passenger on the ramp shall not cause damage to the ramp or mechanism. The coach shall be prevented from moving during ramp system operation by a throttle and brake interlock. The device shall function without failure or adjustment other than normal maintenance for 500 cycles or 30,000 miles in all weather conditions encountered in Vermont climate. In the event of a ramp malfunction, the ramp shall be able to be manually deployed or stowed by the operator without the need for tools or equipment.

2.2.17.5.4 Securement System

Flip-seats in wheelchair locations shall match the model and material of the rest of the passenger seating. All components used in the securement system shall conform to the requirements of the Americans with Disabilities Act and the Federal Motor Vehicle Safety Standards.

Securement areas shall be a minimum 30 inches x 48 inches as required by ADA. All buses shall be equipped with Q-Straint wheelchair securement system or approved equal. The "H Sliding Arm" restraint system shall be installed with Q-Straint retractable belts and remote pull handles with 2 rear belts and 2 retractors. Accommodations for two (2) wheelchair passengers shall be provided, including passenger seat belts, lap belts, wheelchair securement straps, and fold down seats. Passenger's personal restraint seat belts shall be of sufficient length to accommodate passengers in electric powered wheelchairs. All belt assemblies must stow up and out of the way to prevent a passenger safety hazard and the system shall comply with the ADA requirements outlined in 49 CFR Parts 27,37, and 38. All hardware parts which contact, under normal usage, a person, clothing, or webbing shall be free from burrs and sharp edges.

2.2.17.6 Pleasure Radio

Vehicle shall be equipped with a REI FM radio with built in PA function, without removable face plate. Radio shall be mounted above driver barrier storage box area. It shall be equipped with auto PA override. Antenna shall be a Metra 44-US01R.
8 rear ceiling mounted passenger speakers (four per side) and 1 driver overhead speaker. A separated driver volume (rheostat) switch shall be mounted on driver left side switch panel.

2.2.17.7 P.A. System R.E.I

A driver select toggle switch (Inside/Both/Outside) located on the left side driver switch panel shall be included with the Pleasure radio system with 1 outside speaker and a driver boom microphone located above driver, a foot control P.A. on/off switch shall be provided.

2.2.17.8 Two Way Radio/AVL

A Kenwood NX800N two way radio and a Fleetwave VP390 AVL shall be used along with a roof mounted antennas. A radio provided mount pad on dash within close proximity of driver controls. All wiring and antenna cables shall be preinstalled, a 20 amp fuse, 12-volt battery supply; 12-volt ignition supply, and negative ground circuits shall be provided. Vendor Burlington Communications shall install and program radio and AVL units, contact: todd.goad@burlingtoncommunications.com
phone (802) 862-7092

2.2.17.9 Auxiliary Power Supply

A 12 volt battery supply recessed connection at or near right side of dash shall be provided

2.3 Chassis/Power Plant

2.3.1 POWER PLANT OPERATING REQUIREMENTS

2.3.1.1 Power Requirements

The propulsion system components shall be sized to provide sufficient power to enable the bus to meet the defined acceleration, top speed, and gradeability requirements, and operate all accessories using actual road test results and computerized vehicle performance data.

The loss of power to the bus shall not cause the driver to lose control of the bus or to lose steering or braking. The bus shall be able to be safely brought to a controlled stop. The bidder should provide propulsion system specifications along with drive train/gear specifications (if any).

2.3.1.2 Top Speed

Top bus speeds will be set independently by Procuring Agency following award. The expectation is that the bus shall be capable of achieving a top speed of 65 mph on a straight, level road at GVWR with all accessories operating. The bus shall be capable of safely maintaining the vehicle speed according to the recommendations by the tire manufacturer.

2.3.1.3 Gradeability

Gradeability requirements shall be met on grades with a dry commercial asphalt or concrete pavement at GVWR with all accessories operating. The propulsion system shall be required to enable the bus to achieve a speed of 40 mph on a 2.5% ascending grade and 15mph on a 10% ascending grade.

2.3.1.4 Acceleration

The acceleration shall meet the requirements below and shall be sufficiently gradual and smooth to prevent throwing standing passengers off-balance. Acceleration measurement shall commence when the accelerator is depressed.

Maximum Start Acceleration Times on a Level Surface (assumes GVWR)[1]

Speed (mph)	Maximum time (seconds)
10	5
20	10
30	20
40	30
50	60
Top Speed = 65 mph	

2.3.1.5 Operating Range

The operating range of the bus shall be designed to meet the Design Operating Profile.

The operating range of the bus with full state of charge shall be at least 160 miles. Bidder shall include a calculation of operating range by identifying the bus's Usable Battery Capacity divided by its Overall Average Consumption fuel efficiency recorded at Altoona.

2.3.1.6 Fuel Economy

Test results from the Altoona fuel economy tests or other applicable test procedures shall be provided to the Procuring Agency. Results shall include vehicle configuration and test environment information. Fuel economy data shall be provided for each design operating profile and should be provided in miles per kWh. The design operating profile for this test is assumed to be defined by the Altoona fuel duty cycle.

Fuel economy tests shall be run on these three duty cycles: CBD, Arterial, and Commuter.

2.3.2 PROPULSION SYSTEM REQUIREMENTS

2.3.2.1 General

The bus shall be powered by a battery electric propulsion system. The propulsion system shall be specifically adapted for transit bus duty cycle that includes start and stop operation. In addition to power required for propulsion, sufficient excess power shall be available to operate all accessories at their normal operating condition throughout the transit bus duty cycle.

The Contractor shall assure that the bus structure can successfully accept the installation of the propulsion system and be operated on the stated duty-cycle for a period of 12-years without a structural failure. The propulsion system shall be designed to require no major overhaul to achieve this lifetime. A major overhaul consists of the concurrent replacement, due to wear, of major components.

The propulsion system shall comply with applicable local, state, and/or federal emissions and useful life requirements, as a zero emission bus. The propulsion system shall be rated for the GVWR or greater of the bus.

2.3.2.2 Propulsion System Components

The propulsion system includes an electrical energy storage system (ESS), propulsion control system (PCS), power-conditioning components, an appropriately sized permanent magnet (PM) traction motor, and the drive train to the driving wheels.

2.3.2.3 Propulsion Control System (PCS)

The Propulsion Control System (PCS) regulates energy flow throughout the system components in order to provide motive performance and accessory loads, as applicable, while maintaining critical system parameters (e.g., voltages, currents, temperature, etc.) within specified operating ranges. The controller shall monitor and process inputs and execute outputs as appropriate to control the operation of all propulsion system components.

The Traction Motor shall be equipped with an electronically controlled management system, compatible with 12-volt power distribution. The motor control system shall be capable of transmitting and receiving electronic inputs and data from other drivetrain components and broadcasting that data to other vehicle systems. Communication between electronic drivetrain components and other vehicle systems shall be made using the communications networks.

The battery electric drive system shall have onboard diagnostic capabilities able to monitor vital motor functions, store and time stamp parameter conditions in memory, and communicate faults and vital conditions to service personnel. Diagnostic reader device connector ports, suitably protected against dirt and moisture, shall be provided in the operator’s area. The onboard diagnostic system shall inform the operator via visual and/or audible alarms when out of parameter conditions exist for vital electric drive train functions. The on-board diagnostic system shall have capabilities for storing hard and soft codes and processing data and provide detailed information/reports on various aspects of fleet usage. The information shall be retrievable via cabling or wireless transmission to a laptop.

The motor drive shall protect the drive system against progressive damage. The system shall monitor conditions critical for safe operation and automatically de-rate power and/or speed and initiate motor shutdown as needed. The on-board diagnostic system shall trigger a visual and audible alarm to the operator when the motor control unit detects a malfunction and the electric drive train protection system is activated. Automatic shutdown shall only occur when parameters established for the functions below are exceeded:

- Over Temp
- Inverter Fault
- Over Voltage
- Broken Wire
- Loss of Electrical Communications
- Communications Safety
- No redundant bus manufacturer and/or component manufacturer "detection and shutdown" circuits. By default, the component manufacturer's software shall be used to record fault codes.

A control shall be available to the operator to allow a 30-second override, which, when depressed, will allow the operator to delay the drive system shutdown but not the activation and alarm system.

2.3.2.4 Regenerative Braking

The bus shall have a regenerative braking system to aid in the reduction of wear on the brakes and to help extend the range of the vehicle through energy recapture. The vehicle will employ regenerative braking as the accelerator pedal is completely released. Regenerative braking shall be additionally increased as the brake pedal is applied which shall also increase service brake application.

Actuation of Anti-Lock Braking System (ABS) and / or Automatic Traction Control (ATC) shall override the operation of regenerative brake. Disengaging regenerative braking should be at the discretion of the bus operator.

The ABS shall include a means of maintaining dynamic braking (braking retardation) as the ESS approaches 100% SOC, i.e., designed to prevent overcharging of the batteries.

2.3.2.5 Transmission

Buses may be proposed with or without a transmission. Demonstration of the benefits to the inclusion or absence of a transmission in the bus build must be definitively established in the Proposal.

2.3.2.6 Propulsion System Service

The Traction Motor shall be designed to operate for not less than 300,000 miles without major failure or significant deterioration. Components of the control system shall be designed to operate for not less than 150,000 miles without replacement or major service.

The propulsion system shall be arranged so that accessibility for all routine maintenance is assured. No special tools, other than dollies and hoists, shall be required to remove the propulsion system or any subsystems. However, Procuring Agency shall recognize that properly rated test equipment and safe electrical work practices are essential when servicing high voltage components. Contractor shall provide all specialty tools and diagnostic equipment required for maintaining the Propulsion System.

2.3.3 ENERGY STORAGE / BATTERY SYSTEM (ESS)

2.3.3.1 General

An overview of the design and performance of the Energy Storage System (ESS) shall be provided to Procuring Agency. The ESS shall be capable of operating in the Procuring Agency's transit environment. The ESS shall be designed, sized, and selected to ensure that the vehicle performance specifications, compatibility with charging, and other related requirements are met or exceeded, bearing in mind cost benefit and reliability variables as they relate to the characteristics of the different battery types. The power source for the vehicle shall be derived from established battery technology that has a field-proven track record of safe, reliable, and durable operation in similar applications.

The ESS design, including containers, module bracing systems, thermal-management systems, battery management systems, watering/venting systems, interconnections, fusing, and traction-controller should be completely described in the proposal.

The proposal shall include a detailed analysis of expected battery performance in the Design Operating Profile. The proposal should also include a comprehensive statement of the warranty terms relating to the battery, including explanation of all disclaimers within the warranty. The charge cycle and cycle life should be stated in the proposal and a life cycle cost analysis of the proposed battery system in the specified application should be provided.

The battery system shall be capable of withstanding the high current and voltage profiles necessary to accomplish daily recharge events without reducing the life of the battery.

2.3.3.2 Charging Requirements

The primary charging of the energy storage system shall be accomplished by conductive charging as needed to meet the required duty cycle. The energy storage system shall also make use of regenerative braking. The Energy Storage System shall comply with UN/DOT 38.3 requirements for lithium batteries or similar standards for non-lithium batteries.

The Contractor shall deliver the buses with an installed, fully-charged, functioning ESS. The ESS shall be fully formed, installed and tested in accordance with the battery manufacturer's recommended practices.

Contractor shall deliver any proprietary EVSE needed to charge the buses to a location of the Procuring Agency's choice.

2.3.3.3 Energy Storage System Safety

The ESS battery packs shall be located outside the passenger compartment and in a position outside of a direct side or rear impact zone. Additionally, the ESS batteries shall be load distributed within the bus to equalize weight between the wheels on the same axles and to achieve appropriate weight distribution between axles so as not to adversely affect handling of the bus.

The bus body shall be purpose-designed and constructed to ensure passengers and the operator will not be exposed to electrical current either in normal operation or in the event of a vehicle accident. Analysis and test data shall be provided to the Procuring Agency. The ESS shall be designed and constructed to prevent gassing or fumes from the ESS from entering the interior of the bus.

Proposals shall include complete descriptions of all safety standards followed in the design and manufacture of the battery system, safety testing procedures used to validate the safety of battery operation in this application, and documented results of safety testing to confirm that standards have been met.

All contactors in the system shall have feedback to allow the system to know if there is a potential for high voltage to be present when it shouldn't be.

2.3.3.4 Battery Thermal Management

Battery thermal management must be powered from an onboard source at all times. Thermal management must be continuously monitored at all times with appropriate safety interlocks installed to react to adverse conditions.

Battery temperatures must never exceed the manufacturer's recommended range during operation in the design operating profile and specified ambient conditions. Battery cooling must be sufficient to prevent the temperature from exceeding the battery manufacturer's recommended maximum temperature when the ambient temperature is above 105 degrees F for a period of 16 hours.

Proposer shall provide detail on cold-weather battery thermal management. Specifically, what heat source will warm the battery, and by what means (e.g. direct heating, water loop, forced air)? What will be the capacity of that heat source? Will the battery be in an insulated compartment, or have integrated thermal insulation? What measures have been taken to prevent battery thermal energy use from reducing vehicle range in cold weather?

2.3.3.5 Battery Management System (BMS)

The BMS shall communicate on the main vehicle Controller Area Network (CAN) bus to interface with the cooling, powertrain, charge and other systems.

The BMS must be capable of monitoring the voltage level of cells within each battery pack. The BMS must be able to read and store individual battery or block voltages at a frequency of 1 data point per block every 15 seconds.

The BMS must monitor battery pack temperatures using no fewer than 2 thermocouples placed in and around each battery pack sampled at intervals no greater than 15 seconds.

The BMS must monitor current imbalance between cells and packs.

The BMS must be capable of communicating when a battery fault (as defined by the battery manufacturer) has occurred and must be able to identify and communicate the faulty battery in order to perform maintenance.

The BMS must be capable of engaging prudent safety interlocks when an unsafe battery condition has been detected.

The BMS must be able to monitor the battery state-of charge and update a gauge viewed by the operator at least once every 15 seconds.

The BMS must be able to communicate all data to the bus level information system for storage and communication.

The BMS must manage traction battery charging to conform to traction battery manufacturer recommendations to maximize life and performance.

The actual charge profiles delivered under control of the BMS while charging, commissioning, equalizing, and conditioning the traction battery shall be recorded by the Contractor and shall be submitted to the battery manufacturer for review and approval. Written confirmation from the battery manufacturer attesting to the appropriateness of the delivered charge profile shall be submitted to Procuring Agency concurrent with or prior to delivery of the first bus.

2.3.3.6 Two-way power flow

As an option, buses should be equipped for two-way power flow. Vehicles should be capable of exporting power to the AC grid. Power exported to the grid should be 3-phase, AC 480 volt and with less than 5% harmonic distortion. Equipment should be UL certified. Bidder should provide example and contact information for transit property that has exported power from vehicle.

Additionally, buses may be equipped with the ability to transfer energy from the traction battery to another vehicle. Bidder should specify whether vehicle-to-vehicle energy transfer is standard, included in a two-way power flow option, or not available.

The price to include this feature shall be shown in the Optional Equipment table.

2.3.4 COOLING SYSTEMS

2.3.4.1 General Requirements

The cooling systems shall be of sufficient size to maintain all motor, drive train systems (if applicable), controller and battery systems at safe, continuous operating temperatures during the most severe operations possible (protected to -40° Fahrenheit) and in accordance with the manufacturers' cooling system requirements. The cooling system fan/fans control should sense the temperatures of the components or operating fluids and the intake air and if either is above safe operating conditions the cooling fan should be engaged. The fan control system shall be designed with a fail-safe mode of "fan on." The cooling system in new condition shall have an ambient capacity of at least 115° F with water as coolant and sea level operation.

2.3.4.2 Drive Train Component Cooling

The Traction Motor shall be cooled by a liquid-based cooling system that does not permit boiling or coolant loss during operation. Cooling fan(s) shall be temperature controlled, preventing the Traction Motor from exceeding manufacturer's recommended operating temperatures. Air vent valves shall be fitted at high points in the cooling system unless it can be demonstrated that the system is self-purging.

A low-level coolant sensor shall be provided and shall be accessible by an exterior access door at ground level. The sensor shall activate a warning light on the dash. The water filler shall be no more than 60 inches above the ground and both shall be accessible through the same access door.

2.3.4.3 Radiators

All radiators shall be of durable corrosion-resistant construction with integral tanks. Plastic tanks are not permitted. All radiators shall be designed so a 2M mechanic can gain access to a substantial portion for the purpose of cleaning the radiators in five minutes or less.

Radiators with a fin density greater than 12 fins per inch, and louvered/slit designs shall not be used.

All hose clamps shall be constant tension type clamps.
The radiators shall be designed to withstand thermal fatigue and vibration associated with the installed configuration.

2.3.5 PROPULSION SYSTEM SERVICE & ACCESSORIES

2.3.5.1 Service

The propulsion system components shall be arranged so that accessibility for all routine maintenance is assured. No special tools, other than dollies and hoists, shall be required to remove the Traction Motor. Two 3M mechanics shall be able to remove and replace the Traction Motor and gearbox in 8 hours or less.

Radiator fillers shall be arranged so as to ensure simple, efficient filling while tethering the cap and ensuring the filler is closed when filling is completed. All fluid fill locations shall be properly labeled to help ensure correct fluid is added and all fillers shall be easily accessible with standard funnels, pour spouts, and automatic dispensing equipment. All lubricant sumps shall be fitted with magnetic-type, drain plugs.

2.3.5.2 Hydraulic Systems

Hydraulic system service tasks shall be minimized and scheduled no more frequently than those of other major coach systems. All elements of the hydraulic system shall be easily accessible for service or unit replacement. Sensors in the hydraulic system shall indicate on the driver's diagnostic panel conditions of low hydraulic fluid level and low system operation pressure. Critical points in the hydraulic system shall be fitted with service ports so that portable diagnostic equipment may be connected, or sensors may

be permanently attached for an off-board diagnostic system to monitor system operation.

The hydraulic system shall operate within the allowable temperature range as specified by the lubricant manufacturer.

The hydraulic system shall be of a modular design which can be removed with no more than four bolts.

All hydraulic systems shall be listed in the Proposal.

2.3.5.2.1 Hydraulic Fluid Lines

All lines shall be compatible with the hydraulic fluid and be rated at a working pressure limit that is safely above the maximum pressures encountered by the system. Lines should be stainless steel in all locations where stainless steel is compatible with the substance carried. The lines must be designed and intended for use in the environment where they are installed, i.e., high temperatures, road salts, oils, etc. Lines shall be capable of withstanding maximum system pressures.

All hydraulic line routings shall be supported by click-bond supported fittings and clamps designed for this application. Lines passing through a panel, frame, or bulkhead shall be protected by grommets (or similar device) that fit snugly to both the line and the perimeter of the hole that the line passes through to prevent chafing and/or wear.

All flexible lines shall be as short as practicable, no greater than 6 feet in length, unless demonstrated inappropriate for a given application. Hydraulic lines shall be individually and rigidly supported to prevent chafing damage, fatigue failures, and tension strain on the lines and fittings. The hydraulic system shall be configured and/or shielded so that failure of any flexible line shall not allow hydraulic fluid to spray or drain onto any component operable above the auto-ignition temperature of the fluid. Flexible hoses and fluid lines shall not touch one another, or any part of the bus.

A priority system shall prevent the loss of power steering during operation of the coach if other devices are also powered by the hydraulic system.

Flexible lines shall be compatible with the fluids they are intended to carry, at all expected temperatures and pressures and shall have standard SAE, JIC or ORS stainless steel, swivel, end fittings. Flexible hoses over 1 inch in diameter shall be in conformance with SAE J100R5. Flexible hoses and fluid lines shall not abrade one another, or any part of the bus.

Hydraulic lines of the same size and with the same fittings as those on other piping systems of the bus, but not interchangeable, are tagged or marked for use on the hydraulic system only.

2.3.5.2.2 Fittings and Clamps

Compression fittings shall be standardized as much as practicable to prevent the intermixing of components. Compression fitting components from more than one manufacturer shall not be mixed even if the components are known to be interchangeable.

2.3.5.3 Radiator

Radiator piping shall be stainless steel and, if practicable, rubber hoses shall be eliminated. Necessary hoses shall be EPDM coolant hoses or silicone rubber type with 4-ply polyester fabric reinforcement. Hoses shall meet SAE J20R3 for heavy vehicle applications and shall be used in limited spaces.

All hoses shall be as short as practicable. All hoses shall be secured with constant tension spring clamps made from high tensile spring steel (51CrV4) and treated for 1000-hour ASTM B-117 corrosion resistance. The clamps shall maintain a constant tension at all times, expanding and contracting with the hose in response to temperature changes and aging of the hose material.

2.3.5.4 Oil Lines

Oil lines shall be compatible with the substances they carry. Lines should be stainless steel in all locations where stainless steel is compatible with the substance carried. The lines must be designed and intended for use in the environment where they are installed, i.e., high temperatures, road salts, oils, etc. Lines shall be capable of withstanding maximum system pressures.

Flexible oil lines, where necessary, shall be Teflon hoses with braided stainless steel jackets (except in applications where premium hoses are required) and shall have standard SAE or JIC stainless steel, swivel, end fittings. Hoses shall be individually supported and shall not touch one another, or any part of the coach.

2.3.6 FINAL DRIVE

2.3.6.1 Drive Axle

The bus shall be driven by a single, heavy-duty axle with rear-wheel drive and a load rating sufficient for the bus loaded to GVWR. The drive axle shall have a design life to

operate for not less than 300,000 miles on the design operating profile without replacement or major repairs. The lubricant drain plug shall be magnetic type, external hex head of a standard size. The oil level in the planetary gears shall be easily checked through the fill plug or sight gauge. The axle and driveshaft components shall be rated for both propulsion and retardation modes with respect to duty cycle.

The drive shaft (if applicable) shall be guarded to prevent hitting any critical systems, including brake lines, bus floor or the ground, in the event of a tube or universal joint failure.

2.3.6.2 Automatic Traction Control (ATC)

An Automatic Traction Control (ATC) system shall be installed on each drive axle wheel end to maximize torque to the wheel end having the best traction. The system shall be transparent to the bus operator.

2.3.7 SUSPENSION

2.3.7.1 General Requirements

The front and rear suspensions shall be pneumatic type. The basic suspension system shall last the service life of the bus without major overhaul or replacement. Normal replacement items, such as one suspension bushing, shock absorbers, or air spring shall be replaceable by a 3M mechanic in 30 minutes or less. Adjustment points shall be minimized and shall not be subject to a loss of adjustment in service. Necessary adjustments shall be easily accomplished without removing or disconnecting the components.

All axles shall be properly aligned so the vehicle tracks accurately within the size and geometry of the vehicle.

2.3.7.2 Springs and Shock Absorbers

2.3.7.2.1 Suspension Travel

The suspension system shall permit a minimum wheel travel of 2.75 in. jounce-upward travel of a wheel when the bus hits a bump (higher than street surface), and 2.75 in. rebound-downward travel when the bus comes off a bump and the wheels fall relative to the body. Elastomeric bumpers shall be provided at the limit of jounce travel. Rebound travel may be limited by elastomeric bumpers or hydraulically within the shock absorbers. Suspension shall incorporate appropriate devices for automatic height control so that regard-less of load the bus height relative to the centerline of the wheels does not change more than ½ in. at any point from the height required. The safe

operation of a bus will not be impacted by ride height up to 1 in. from design normal ride height.

2.3.7.2.2 Kneeling

A kneeling system shall lower the entrance(s) of the bus a minimum of 2.5 inches during loading or unloading operations regardless of load up to GVWR, measured at the longitudinal centerline of the entrance door(s), by the driver. The kneeling control shall use a three position, spring loaded to center switch, and provide the following functions:

- Downward control will lower the bus.
- Release of switch at any time shall completely stop the lowering motion and hold height of the bus at that position.
- Upward direction of the switch will allow the system to go to floor height without the driver having to hold the switch up.

Brake and Throttle interlock shall prevent movement when the bus is kneeled. The kneeling control shall be disabled when the bus is in motion. The bus shall kneel at a maximum rate of 1.25 inches per second at essentially a constant rate. After kneeling, the bus shall rise within 5 seconds to a height permitting the bus to resume service and shall rise to the correct operating height within 7 seconds regardless of load up to GVWR. During the lowering and raising operation, the maximum acceleration shall not exceed 0.2g and the jerk shall not exceed 0.3g/sec.

An indicator visible to the driver shall be illuminated until the bus is raised to a height adequate for safe street travel. An audible warning alarm will sound simultaneously with the operation of the kneeler to alert passengers and bystanders. A warning light mounted near the curbside of the front door, minimum 2" diameter, amber lens shall be provided that will blink when the kneel feature is activated. Kneeling shall be operational while the ramp is deployed.

2.3.7.2.3 Damping

Vertical damping of the suspension system is accomplished by hydraulic shock absorbers mounted to the suspension arms or axles and attached to an appropriate location on the chassis. Damping is sufficient to control bus motion to three cycles or less after hitting road perturbations. The shock absorber bushing is made of elastomeric material that will last the life of the shock absorber. The damper incorporates a secondary hydraulic rebound stop.

2.3.7.2.4 Lubrication

All elements of steering, suspension and drive systems requiring scheduled lubrication will be provided with grease fittings conforming to SAE Standard J534. These fittings shall be located for ease of inspection and shall be accessible with a standard grease gun from a pit or with the bus on a hoist. Each element requiring lubrication has its own grease fitting with a relief path. The lubricant specified shall be standard for all elements on the bus serviced by standard fittings and is required no less than every 6,000 miles.

2.3.8 STEERING

2.3.8.1 General

An electrically driven power steering hydraulic pump shall be provided. Hydraulic assisted steering shall be provided to reduce steering effort. The steering gear must be an integral type with the number and length of flexible lines minimized or eliminated.

No element of the steering system shall fail before suspension system components when one of the tires strikes a severe road hazard.

2.3.8.2 Steering Axle

The front axle shall be of an independent suspension design, non-driving with a load rating sufficient for the bus loaded to GVWR and shall be equipped with grease type front wheel bearings and seals.

All friction points on the front axle shall be equipped with replaceable bushings or inserts and lubrication fittings easily accessible from a pit or hoist.

2.3.8.3 Steering Wheel

The steering wheel diameter shall be approximately 18 to 20 in.; the rim diameter is ⅞ to 1¼ in. and shaped for firm grip with comfort for long periods of time.

Steering wheel spokes and wheel thickness ensures visibility of the dashboard so that vital instrumentation is clearly visible at center neutral position (within the range of a 95th-percentile male, as described in SAE 1050a, Sections 4.2.2 and 4.2.3). Placement of steering column is as far forward as possible, and in line with the instrument cluster.

2.3.8.3.1 Turning Effort

Steering effort is measured with the bus at GVWR, stopped with the brakes released on clean, dry, level, commercial asphalt pavement and the tires inflated to recommended pressure.

Under these conditions, the torque required to turn the steering wheel 10° shall be no less than 5 ft-lbs and no more than 10 ft-lbs. Steering torque may increase to 70 ft-lbs when the wheels are approaching the steering stops, as the relief valve activates. Power steering failure shall not result in loss of steering control. With the bus in operation, the steering effort will not exceed 55 lbs. at the steering wheel rim, and perceived free play in the steering system will not materially increase as a result of power assist failure. Gearing shall require no more than seven turns of the steering wheel lock-to-lock.

Caster angle shall be selected to provide a tendency for the return of the front wheels to the straight position with minimal assistance from the driver.

2.3.8.3.2 Steering Column Tilt

The steering wheel shall have a rearward tilt adjustment range of no less than 30 degrees as measured from the horizontal and upright position.

2.3.8.3.3 Steering Wheel Telescopic Adjustment

The steering wheel shall have full telescoping capability and have a minimum telescopic range of 2 in. and a minimum low-end adjustment of 29 in., measured from the top of the steering wheel rim in the horizontal position to the cab floor at the heel point.

TABLE 1

Steering Wheel Height[1] Relative to Angle of Slope

At Minimum Telescopic Height Adjustment (29in.)		**At Maximum Telescopic Height Adjustment (5 in.)**	
Angle of Slope	**Height**	**Angle of Slope**	**Height**
0 deg	29 in.	0 deg	34 in.
15 deg	26.2 in.	15 deg	31.2 in.
25 deg	24.6 in.	25 deg	29.6 in.
35 deg	22.5 in.	35 deg	27.5 in.

1. Measured from bottom portion closest to driver.

2.3.8.4 Turning Radius

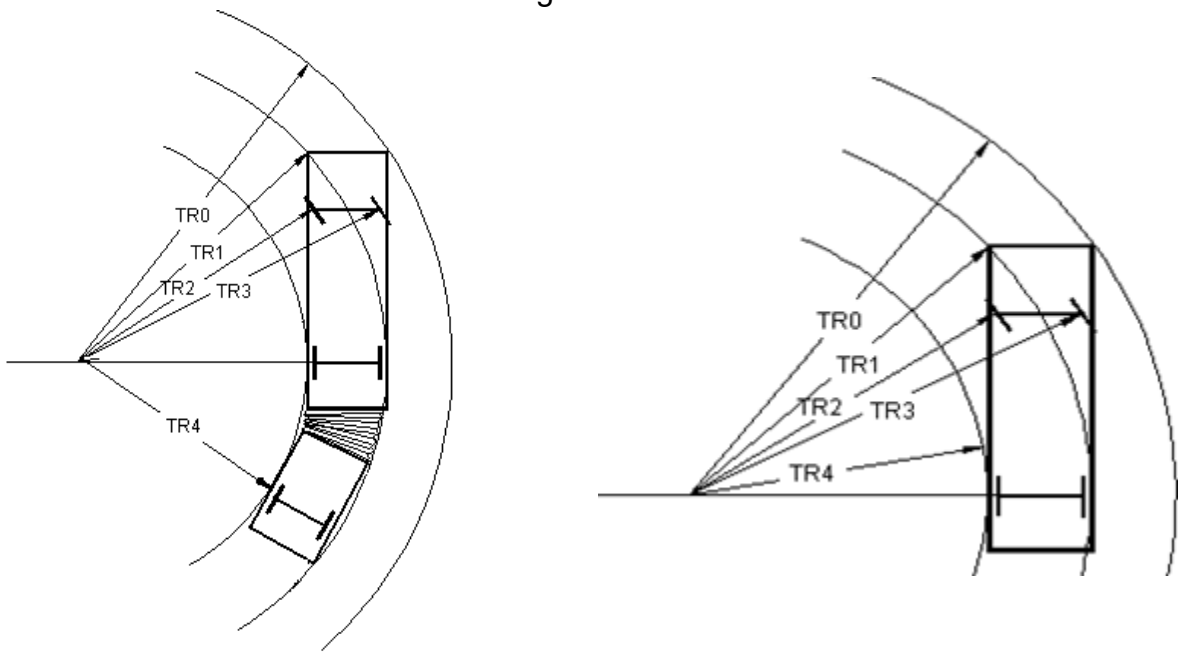
TABLE 2

Maximum Turning Radius

Bus Length (approximate)	Maximum Turning Radius (see Figure 4)	Procuring Agency Requirement
30 ft.	29.5 ft. (TR0)	Allow +1 inch
35 ft.	39 ft. (TR0)	Allow +1 inch
40 ft.	44 ft. (TR0)	Allow +0 inch

FIGURE 4

Turning Radius



2.3.9 BRAKES

2.3.9.1 Service Brake

The four-wheel disc brakes shall be self-adjusting. Brake wear indicators shall be provided on exposed push rods.

2.3.9.2 Actuation

Service brakes shall be controlled and actuated by a compressed air system. Force to activate the brake pedal control shall be an essentially linear function of the bus

deceleration rate and shall not exceed 70 pounds at a point 7 inches above the heel point of the pedal to achieve maximum braking. The heel point is the location of the driver's heel when foot is rested flat on the pedal and the heel is touching the floor or heel pad of the pedal. A microprocessor controlled Automatic Braking System (ABS) shall be provided. The microprocessor for the ABS system shall be protected yet in an accessible location to allow for ease of service. The total braking effort shall be distributed between all wheels in such a ratio as to ensure equal friction material wear rate at all wheel locations.

2.3.9.3 Friction Material

Friction materials shall have a replacement life of at least 25,000 miles with the regenerative brakes inoperative. Brakes shall be self-adjusting throughout this period. The brake linings shall be made of non-asbestos material. In order to aid maintenance personnel in determining extent of wear, a provision such as a scribe line or chamfer indicating the thickness at which replacement becomes necessary, shall be provided on each brake lining.

2.3.9.4 Hubs and Drums/Discs

Replaceable wheel bearing seals shall run on replaceable wear surfaces or be of an integral wear surface sealed design. Wheel bearing and hub seals shall not leak or weep lubricant for 100,000 miles when running on the design operating profile.
The bus shall be equipped with disc brakes on both the front and rear axles and the brake discs shall allow machining the surfaces up to ¼ inch each side to obtain smooth surfaces.

The brake system material and design shall be selected to absorb and dissipate heat quickly so the heat generated during braking operation does not glaze brake linings. The heat generated shall not increase the temperature of tire beads and wheel contact area to more than that allowed by the tire manufacturer.

2.3.9.5 Parking/Emergency Brake

The parking brake shall be a spring-operated system, actuated by a valve that exhausts compressed air to apply the brakes. The parking brake may be manually enabled when the air pressure is at the operating level per FMVSS 121.

An emergency brake release shall be provided to release the brakes in the event of automatic emergency brake application. The parking brake valve button will pop out when air pressure drops below requirements of FMVSS 121. The driver shall be able to manually depress and hold down the emergency brake release valve to release the brakes and maneuver the bus to safety. Once the operator releases the emergency brake release valve, the brakes shall engage to hold the bus in place.

2.3.10 PNEUMATIC SYSTEM

2.3.10.1 General

The bus air system shall operate the air-powered accessories and the braking system with reserve capacity in accordance with FMVSS 121. New buses shall not leak down more than 5 psi as indicated on the instrument panel mounted air gauges, within 15 minutes from the point of governor cut-off.

Provision shall be made to apply shop air to the bus air systems using a quick-disconnect fitting, Tru-Flate design 3/8" air coupler, or approved equal. A quick disconnect fitting specified herein shall be easily accessible and located in the Traction Motor system compartment and near the front bumper area for towing. Retained caps shall be installed to protect fitting against dirt and moisture when not in use. A quarter (¼) turn manual shutoff valve shall be added behind the fitting. Air for the compressor shall be filtered separately and specifically for the air compressor/intake. Location of fittings will be determined at time of award.

The air system shall be protected by a pressure relief valve set at 150 psi and shall be equipped with check valve and pressure protection valves to assure partial operation in case of line failures.

2.3.10.2 Air Compressor

The air compressor shall be electrically driven and shall be sized to charge the air system from 40 psi to the governor cut-off pressure in less than 4 minutes. A piston type air compressor is not acceptable. Air compressor shall have constant positive intake pressure or be unloaded through the air dryer system.

2.3.10.3 Air Lines and Fittings

Air lines, except necessary flexible lines, shall conform to the installation and material requirements of SAE Standard J1149 for stainless steel tubing with standard, brass, flared or ball sleeve fittings, or SAE Standard J844 for nylon tubing if not subject to temperatures over 200 °F. The air on the delivery side of the compressor where it enters nylon housing shall not be above the maximum limits as stated in SAE J844. Nylon tubing shall be installed in accordance with the following color-coding standards:

- **Green:** Indicates primary brakes and supply
- **Red:** Indicates secondary brakes
- **Brown:** Indicates parking brake
- **Yellow:** Indicates compressor governor signal

- **Black:** Indicates doors, hill hold, and accessories

Line supports shall prevent movement, flexing, tension, strain and vibration. Stainless steel lines shall be supported to prevent the lines from touching one another or any component of the bus. To the extent practicable and before installation, the lines shall be pre-bent on a fixture that prevents tube flattening or excessive local strain. Stainless steel lines shall be bent only once at any point, including pre-bending and installation. Rigid lines shall be supported at no more than 5 ft. intervals. Nylon lines may be grouped and are supported at 30 in. intervals or less.

The compressor discharge line shall be a flexible Teflon hose with a braided stainless steel jacket. Other lines necessary to maintain system reliability shall be flexible Teflon hose with a braided stainless steel jacketed fittings. They use standard SAE or JIC brass or steel, flanged, swivel-type fittings. Flexible hoses shall be as short as practicable and individually supported. They shall not touch one another or any part of the bus except for the supporting grommets. Flexible lines shall be supported at 2ft intervals or less.

Air lines shall be clean before installation and shall be installed to minimize air leaks. All air lines shall be routed to prevent water traps to the extent possible. Grommets or insulated clamps shall protect the air lines at all points where they pass through understructure components.

2.3.10.4 Air Reservoirs

All air reservoirs shall meet the requirements of FMVSS Standard 121 and SAE Standard J10 and shall be equipped with drain plugs and guarded or flush type drain valves. Major structural members shall protect these valves and any automatic moisture ejector valves from road hazards. Reservoirs shall be sloped toward the drain valve. All air reservoirs shall have drain valves that discharge below floor level with lines routed to eliminate the possibility of water traps and/or freezing in the drain line.

2.3.10.5 Air System Dryer

An air dryer shall prevent accumulation of moisture and oil in the air system. The air dryer system shall include a replaceable desiccant bed, electrically heated drain, and activation device. A 2M/3M mechanic shall replace the desiccant in less than 15 minutes.

2.3.11 WHEELS AND TIRES

2.3.11.1 Wheels

All wheels shall be interchangeable and shall be removable without a puller. Wheels shall be compatible with tires in size and load carrying capacity. Front wheels and tires shall be balanced as an assembly per SAE J1986.

Wheels shall be Hub-piloted, mounted Alcoa (or approved equal) aluminum wheels and shall resist rim flange wear. Wheels shall have a low maintenance special finish on both sides. Finish shall be Alcoa Dura-Bright, or approved equal.

2.3.11.2 Tires

Tires shall be suitable for the conditions of transit service and sustained operation at the maximum speed capability of the bus. Load on any tire at GVWR shall not exceed the tire supplier's rating.

The buses shall be equipped with low profile tires, Load range H as appropriate for the bus design. Expected tire sizes are 19.5 inches for 30-foot bus and 22.5 inches for 35-foot and 40-foot buses.

Bus manufacturer shall designate tire size in accordance with FMVSS requirements and manufacturer’s recommendations. If the buses must be equipped with low profile standard transit tires, with a specific load range, as appropriate for the bus design, the Proposer must advise with the technical proposal.

Delivery shall include one (1) set of four (4) mounted spare tires and rims supplied with each coach.

2.3.12 BUMPERS

2.3.12.1 Location

Bumpers shall provide impact protection for the front and rear of the bus with the top of the bumper being (26 +/- 2) inches above the ground. Bumper height shall be such that when one bus is parked behind another, a portion of the bumper faces will contact each other.

2.3.12.2 Front Bumper

No part of the bus, including the bumper, shall be damaged as a result of a 5mph impact of the bus at curb weight with a fixed, flat barrier perpendicular to the bus’s longitudinal centerline. The bumper shall return to its pre-impact shape within 10 minutes of the impact. The bumper shall protect the bus from damage as a result of 6.5 mph impacts at any point by the common carriage with contoured impact surface defined in Figure 2 of FMVSS 301 loaded to 4,000 lbs. parallel to the longitudinal

centerline of the bus. It shall protect the bus from damage as a result of 5.5mph impacts into the corners at a 30° angle to the longitudinal centerline of the bus. The energy absorption system of the bumper shall be independent of every power system of the bus and will not require service or maintenance in normal operation during the service life of the bus. The bumper may increase the overall bus length specified by no more than 7 inches.

The bumper shall provide mounting provisions for a bike rack.

2.3.12.3 Rear Bumper

No part of the bus, including the bumper, shall be damaged as a result of a 2 mph impact with a fixed, flat barrier perpendicular to the longitudinal centerline of the bus. The bumper shall return to its pre-impact shape within 10 minutes of the impact. When using a yard tug with a smooth, flat plate bumper 2 ft. wide contacting the horizontal centerline of the rear bumper, the bumper shall provide protection at speeds up to 5 mph, over pavement discontinuities up to 1 in. high, and at accelerations up to 2 mph/sec. The rear bumper shall protect the bus, when impacted anywhere along its width by the common carriage with contoured impact surface defined in Figure 2 of FMVSS 301 loaded to 4,000 lbs., at 4 mph parallel to or up to a 30-degree angle to, the longitudinal centerline of the bus. The rear bumper shall be shaped to preclude unauthorized riders standing on the bumper. The bumper shall not require service or maintenance in normal operation during the service life of the bus. The bumper may increase the overall bus length specified by no more than 7 inches.

2.3.12.4 Bumper Material

Bumpers shall be energy absorbing and black in color. Bumper material shall be corrosion-resistant and withstand repeated impacts of the specified loads without sustaining damage. Visible surfaces shall be black. These bumper qualities shall be sustained throughout the service life of the bus.

2.4 Electrical, Electronic, and Data Communication Systems

2.4.1 GENERAL REQUIREMENTS

2.4.1.1 Systems Overview

The Electrical System will consist of the vehicle battery systems and all other equipment that generate, distribute and use battery power throughout the vehicle (e.g., drive system batteries, inverters, motor drives, contactors, high voltage fuses, high voltage switches, wiring, relays, and connectors).

Electronics are those components of the electrical system made up of discrete solid-state devices such as transistors, resistors, capacitors and diodes that are part of individual vehicle systems. Electronics also include the integrated circuits that are part of microprocessors that allow individual vehicle systems to process and store data.

The data communication system consists of the bi-directional communications networks that electronic devices use to share data with other electronic devices and systems. Communication networks are essential to integrating electronic functions, both onboard the vehicle and off.

Data communications systems are divided into three levels to reflect the use of multiple data networks.

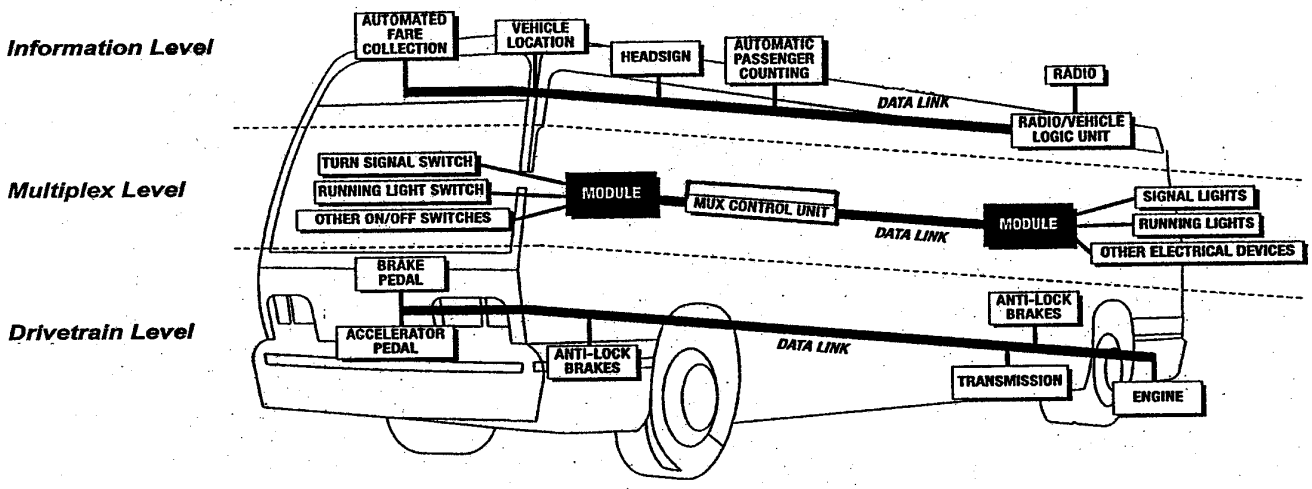
- **Drivetrain Level:** Components related to the drivetrain including the Traction Motor, transmission, and anti-lock braking system (ABS), which may include traction control.

- **Information Level:** Components whose primary function is the collection, control or display of data that is not necessary to the safe drivability of the vehicle (i.e., those functions, which when inoperable, will still allow the vehicle to operate). These components typically consist of those required for automatic vehicle location (AVL) systems, destination signs, fare boxes, passenger counters, radio systems, automated voice and signage systems, video surveillance, and similar components.

- **Multiplex Level:** Electrical devices controlled through input/output signals such as discrete, analog, and serial data information (i.e., on/off switch inputs, relay or relay control outputs). Multiplexing is used to control components not typically found on the Drivetrain or Information Levels such as lights, wheelchair lifts, doors, and heating, ventilation, air conditioning (HVAC) systems.

FIGURE 5

Data Communications Systems Levels



2.4.1.2 Modular Design

Design of the electrical, electronic and data communication systems shall be modular so that each major component, apparatus panel, or wiring bundle is easily separable with standard hand tools or by means of connectors. Each module, except the main body wiring harness, shall be removable and replaceable in less than 1 hour by a 3M mechanic.

Power Plant wiring shall be an independent wiring module. Replacement of the drive system compartment wiring module(s) shall not require pulling wires through any bulkhead or removing any terminals from the wires.

2.4.1.3 Environmental and Mounting Requirements

The electrical system and its electronic components shall be capable of operating in the area of the vehicle in which they will be installed, as recommended in SAE J1455.

Electrical and electronic equipment shall not be located in an environment that will reduce the performance or shorten the life of the component or electrical system when operating within the design operating profile. No vehicle component shall be able to generate or be affected by electromagnetic interference or radio-frequency interference (EMI/RFI) that can disturb the performance of electrical/electronic equipment as defined in SAE J1113 and UNECE Council Directive 95/54 (R10).

The mounting of the hardware shall not be used to provide the sole source ground, and all hardware is isolated from potential EMI/RFI, as referenced in SAE J1113.

All electrical/electronic hardware mounted in the interior of the vehicle shall be inaccessible to passengers and hidden from view unless intended to be viewed. The hardware shall be mounted in such a manner as to protect it from splash or spray. All electrical/electronic hardware mounted on the exterior of the vehicle that is not designed to be installed in an exposed environment shall be mounted in a sealed enclosure.

All electrical/electronic hardware and its mounting complies with the shock and vibration requirements of SAE J1455.

Contractor shall provide recommendations from bus manufacturer and subsystem suppliers regarding methods to prevent damage from voltage spikes generated from welding, jump-starts, shorts, etc. The Contractor will supply a checklist of connectors and connections to be opened when electric welding is performed on the bus.

2.4.2 ELECTRICAL SYSTEM REQUIREMENTS

2.4.2.1 Batteries

2.4.2.1.1 Low-Voltage Batteries

The system shall supply a nominal 12V and/or 24V of direct current (DC). Batteries, except those used for auxiliary power, shall be easily accessible for inspection and service from the outside of the vehicle only.

Group 31 Series deep cycling maintenance free battery units shall be provided with sufficient amperage capacity to continuously power 200% of the expected maximum low-voltage loads. Batteries shall provide sufficient amp-hours to power auxiliary loads for a duration of 2 hours in the event of a failure of the high-voltage battery system or DC/DC converter. Low-voltage batteries shall be capable of starting the coach after sitting idle for a minimum duration of one-week.

Each battery shall have a purchase date no more than one year from date of release for shipment to the customer.

2.4.2.1.2 Battery Cables

The positive and negative battery terminal ends and cables shall be color-coded with red for the primary positive, black for negative, and another color for any intermediate voltage cables. Heat shrink at the terminal ends of the aforementioned colors may be

used on battery cables with black insulation. Battery cables shall be flexible and sufficiently long to reach the batteries with tray in the extended position without stretching or pulling on any connection and shall not lie directly on top of the batteries. Except as interrupted by the master battery switch(s), battery wiring shall be continuous cables with connections secured by bolted terminals; and shall conform to specification requirements of SAE J1127 –Type SGT or SGX and SAE Recommended Practice J541.

2.4.2.1.3 Jump Start

A jump-start connector, red for 24V and blue for 12V, shall be provided in the electric drive train compartment, equipped with dust cap and adequately protected from moisture, dirt and debris.

2.4.2.1.4 Battery Compartments

The battery compartments shall prevent accumulation of snow, ice and debris on top of the batteries and shall be vented and self-draining. It shall be accessible only from the outside of the vehicle. All components within the battery compartments, and the compartments themselves, shall be protected from damage or corrosion from electrolyte and gases emitted from the batteries. The inside surface of the battery compartment's access door shall be electrically insulated, as required, to prevent the battery terminals from shorting on the door if the door is damaged in an accident or if a battery comes loose.

Provide and install 110/120-volt adapter/converter in the low-voltage battery compartment so as to operate all the interior lighting without draining the batteries while the bus is being cleaned. The plug location shall be installed on the dash door panel. The plug shall be stainless steel with stainless steel mounting screws.

2.4.2.1.5 Auxiliary Electronic Power Supply

If required, gel-pack, or any form of encased batteries used for auxiliary power, are allowed to be mounted on the interior of the vehicle if they are contained in an enclosed, non-airtight compartment and accessible only to maintenance personnel. This compartment shall contain a warning label prohibiting the use of lead-acid batteries.

2.4.2.1.6 Master Battery Switch

A single master switch shall be provided near the battery compartment for the disconnecting of all battery positives (12V & 24V) except for safety devices such as fire suppression system and other systems as specified. The location of the master battery switch shall be clearly identified on the exterior access panel, be accessible in less than

10 seconds for de-activation, and prevent corrosion from fumes and battery acid when the batteries are washed off or are in normal service.

Turning the master switch “OFF”, shall not damage any component of the electrical system. The master switch shall be capable of carrying and interrupting the total circuit load.

2.4.2.1.7 Low-Voltage Generation and Distribution

The Propulsion System Batteries shall maintain the charge on the low voltage batteries.

The vehicle shall be equipped with a 300-AMP minimum, 24 VDC DC-DC power converter, suitably rated to handle the electrical load requirements. The high output DC amps shall be achieved at the DC-DC power converter’s designed maximum output.

Power distribution shall be accomplished by means of conductive bus-bars, terminal strips, or stud-terminal blocks that are sized for the cumulative total current of connected branch circuits and for the physical securement of them. One such arrangement is to exist for each voltage potential level and ground. These points to all equipment requiring dedicated power and ground wiring to the batteries shall be accomplished by using power bus bars consisting of either a solid copper bar or heavy-duty terminal strip. One bus bar for each voltage potential, including ground, shall be located as close, electrically speaking, to the source of the potential (the battery source) as physically practical, based on recommendations of the vehicle manufacturer. Terminal stack-up is not to exceed a quantity of four (4) per each individual screw, post, or stud block. All cabling and wiring associated with an individual circuit will be sized to ensure a voltage drop figure of no more than 5% of the source voltage. This figure is to cover the total loop from source potential to source ground.

2.4.2.1.8 Circuit Protection

All branch circuits shall be protected by circuit breakers or fuses sized to the requirements of the load. The circuit breakers or fuses shall be easily accessible for authorized personnel. Fuses shall be used only where it can be demonstrated that circuit breakers are not practicable. Any manually re-settable circuit breakers shall provide visible indication of open circuits.

Fuses shall be located adjacent to power source, and in a fuse block except as specifically approved by the customer after contract award.

Circuit breakers or fuses shall be sized to a minimum of 15% larger than the total circuit load current. The current rating for the wire used for each circuit must exceed the size of the circuit protection being used.

2.4.2.2 Grounds

The batteries shall be grounded to the vehicle chassis/frame at one location only, as close to the batteries as possible. No more than four (4) ground connections shall be made per ground stud. Electronic equipment requiring an isolated ground to the battery (i.e., electronic ground) shall not be grounded to the chassis.

2.4.2.3 Low Voltage/Low Current Wiring and Terminals

All power and ground shall conform to specification requirements of SAE Recommended Practice J1127, J1128 and J1292 for type GXL and SXL wiring. Double insulation shall be maintained as close to the junction box, electrical compartment or terminals as possible.

Wiring shall be grouped, labeled, and color-coded. Wiring harnesses shall not contain wires of different voltage classes unless all wires within the harness are insulated for the highest voltage present in the harness. Kinking, grounding at multiple points, stretching, and exceeding minimum bend radius shall be prevented.

Strain-relief fittings shall be provided at all points where wiring enters electrical compartments. Grommets or other protective material shall be installed at points where wiring penetrates metal structures outside of electrical enclosures. Wiring supports shall be protective and non-conductive at areas of wire contact and will not be damaged by heat, water, solvents or chafing.

To the extent practicable, wiring shall not be located in environmentally exposed locations under the vehicle. Wiring and electrical equipment necessarily located under the vehicle shall be insulated from water, heat, corrosion and mechanical damage. Where feasible, front-to-rear electrical harnesses shall be installed above the window line of the vehicle.

All wiring harnesses over 5 ft. long and containing at least five wires shall include 10% (minimum one wire) excess wires for spares. This requirement for spare wires does not apply to data links and communication cables. Wiring harness length shall allow end terminals to be replaced twice without pulling, stretching or replacing the wire. Terminals shall be crimped to the wiring according to the connector or manufacturer’s recommendations for techniques and tools. All cable connectors shall be locking type, keyed and sealed, unless enclosed in watertight cabinets or the vehicle interior. Pins shall be removable, crimp contact type, of the correct size and rating for the wire being terminated. Unused pin positions are sealed with sealing plugs. Adjacent connectors shall either use different inserts or different insert orientations to prevent incorrect connections.

Terminals shall be crimped, corrosion-resistant and full ring type or interlocking lugs with insulating ferrules. When using pressure type screw terminal strips, only stranded wire shall be used. Insulation clearance shall ensure that wires have a minimum of "visible clearance" and a maximum of two times the conductor diameter or 1/16 inch, whichever is less. When using shielded or coaxial cable, upon stripping of the insulated, the metallic braid shall be free from frayed strands that can penetrate the insulation of the inner wires.

Ultra-sonic and T-splices may be used with 8 AWG or smaller wire. When a T-splice is used, it shall meet these additional requirements:

- It shall include a mechanical clamp.
- The wire shall support no mechanical load in the area of the splice.
- The wire shall be supported to prevent flexing.

All splicing shall be staggered in the harness. Wiring located in the electric motor compartment shall be routed away from high-heat sources or shielded and/or insulated from temperatures exceeding the wiring and connector operating requirements.

The instrument panel and wiring shall be easily accessible for service from the driver's seat or top of the panel. The instrument panel shall be separately removable and replaceable without damaging the instrument panel or gauges. Wiring shall have sufficient length and routed to permit service without stretching or chafing the wires.

2.4.2.4 Electrical Components

All electrical components, including switches, relays, flashers, and circuit breakers, shall be heavy-duty designs with either a successful history of application to heavy-duty vehicles, or design specifications for an equivalent environment. These components shall be replaceable in less than 5 minutes by a 3M mechanic.

All electric motors shall be either heavy-duty brushless type where practical, or have a constant duty rating of no less than 40,000 hours. All electric motors shall be easily accessible for servicing.

2.4.2.5 Electrical Compartments

All relays, controllers, flashers, circuit breakers, and other electrical components shall be mounted in easily accessible electrical compartments. All compartments exposed to the outside environment shall be corrosion resistant and sealed. The components and circuits in each electrical compartment shall be identified and their location permanently recorded on a drawing attached to the inside of the access panel or door. The drawing shall be protected from oil, grease, fuel, and abrasion.

Junction boxes shall have laminated schematics or the front compartment shall be completely serviceable from the operator's seat, vestibule, or from outside.

2.4.3 GENERAL ELECTRONIC REQUIREMENTS

If an electronic component has an internal real-time clock, it shall provide its own battery backup to monitor time when battery power is disconnected, and/or it may be updated by a network component. If an electronic component has an hour meter, it shall record accumulated service time without relying on battery backup.

The Contractor shall ensure that their electronic equipment is self-protecting in the event of shorts in the cabling, as well as in over-voltage and reverse polarity conditions. If an electronic component is required to interface with other components, it shall not require external pull-up and/or pull-down resistors. Where this is not possible, the use of pull-up or pull-down resistor must be limited as much as possible and if used, must be easily accessible and labeled appropriately.

2.4.3.1 Wiring and Terminals

Kinking, grounding at multiple points, stretching, and reducing the bend radius below the manufacturer’s recommended minimum shall not be permitted.

2.4.3.2 Discrete I/O (Inputs/Outputs)

All wiring to I/O devices, either at the harness level or individual wires, shall be labeled, stamped or color-coded in a fashion that allows unique identification at a spacing not exceeding 4 in. Wiring for each I/O device shall be bundled together. If the I/O terminals are the same voltages, then jumpers may be used to connect the common nodes of each I/O terminal.

2.4.3.3 Shielding

All wiring shall be shielded and shall meet the following minimum requirements. A shield shall be generated by connecting to a ground, which is sourced from a power distribution bus bar or chassis. A shield shall be connected at one location only, typically at one end of the cable. However certain standards or special requirements, such as SAE J1939 or RF applications, have separate shielding techniques that shall also be used as applicable.

> NOTE: A shield grounded at both ends forms a ground loop, which can cause intermittent control or faults.

When using shielded or coaxial cable, upon stripping of the insulation, the metallic braid shall be free from frayed strands, which can penetrate the insulation of the inner wires. To prevent the introduction of noise, the shield shall not be connected to the common side of a logic circuit.

2.4.3.4 Communications

The data network cabling shall be installed according to the selected protocol requirements. The physical layer of all network communication systems shall not be used for any purpose other than communication between the system components, unless provided for in the network specifications.

Communications networks that use power line carriers (e.g., data modulated on a 24V power line) shall meet the most stringent applicable wiring and terminal specifications.

2.4.3.5 Radio Frequency (RF)

RF components, such as radios, video devices, cameras, global positioning systems (GPS), etc., shall use coaxial cable to carry the signal. All RF systems require special design consideration for losses along the cable. Connectors shall be minimized, since each connector and crimp have a loss that will attribute to attenuation of the signal. Cabling should allow for the removal of antennas or attached electronics without removing the installed cable between them. If this cannot be done, then a conduit of sufficient size shall be provided for ease of attachment of antenna and cable assembly. The corresponding component vendors shall be consulted for proper application of equipment, including installation of cables.

2.4.3.6 Audio

Cabling used for microphone level and line level signals shall be 22 AWG minimum with shielded twisted pair. Cabling used for amplifier level signals shall be 18 AWG minimum.

2.4.4 DATA COMMUNICATION SYSTEM REQUIREMENTS

2.4.4.1 General Requirements

All data communication networks shall be in accordance with a nationally recognized interface standard such as those published by SAE, IEEE, or ISO.

Any electronic vehicle components used on a network shall be conformance tested to the corresponding network standard.

The vehicle shall be designed with a fully integrated diagnostic system were the master vehicle controller monitors and records the fault status from all systems on the main PCAN network as well as fault status from the multiplex devices. This shall include subsystems such as the powertrain controller, cooling system, ABS system, HVAC system, battery management system and other power devices. This diagnostic system shall also include the detection of loss of communication of all individual devises on the PCAN and MCAN network.

All faults shall be recorded, time stamped, odometer stamped and assigned a priority level based on the severity of the fault. A diagnostic tool shall also serve as a troubleshooting guide to aid in quick resolution of individual faults.

The following information shall be displayed when using the instrument cluster and diagnostic tool:

a) Fault status (active or previously recorded and inactive)
b) Identifying number (SPN and FMI according to J1939)
c) General description of part faulted (SPN description)
d) Type of fault (FMI description; i.e. value to high, to low, data erratic, loss of communication)
e) Multiplexer input or output pin where fault was detected or system where fault was originated
f) Time, date and odometer reading at time of fault

A vehicle data logger must be provided to monitor J1939 communications system. It shall provide:

a) Continuous monitoring and recording of the PCAN J1939 data bus.
b) Software that can generate structured reports using the gathered data.
c) Software to create tools for incident definition, data import/export, analysis and presentation.
d) Software for recording of user selected J1939 fault codes.

2.4.4.2 Bus Energy Monitoring

The vehicle’s onboard systems shall store data records representing the propulsion system activity at 1 second intervals, such as duty cycle information (time, location, altitude, speed), voltage and current input and output for major electrical components (ESS, power converters, HVAC, etc.), traction motor input voltage and current, traction motor output torque and rotational speed, system health, BMS information, and faults.

The system shall be capable of profiling DC and AC energy consumption, tractive energy, regenerative braking and hotel loads, such as, lighting, HVAC and support system loads, such as steering, fans, cooling, air, system faults, etc. Data shall be uploaded to a cloud-based central storage system in real time or upon returning to the depot. Data shall be viewable in the cloud-based system, and exportable in .csv format. The on-board system shall be capable of storing one week of all data and reports in memory that can be downloaded from the bus using a standard laptop computer.

2.4.4.3 Multiplexing Requirements

The primary purpose of the multiplexing system is control of components necessary to operate the vehicle. This is accomplished by processing information from input devices and controlling output devices through the use of an internal logic program.

Versatility and future expansion shall be provided for by an expandable system architecture. The multiplex system shall be capable of accepting new inputs and outputs through the addition of new modules and/or the utilization of existing spare inputs and outputs. All like components in the multiplex system shall be modular and interchangeable with self-diagnostic capabilities. The modules shall be easily accessible for troubleshooting electrical failures and performing system maintenance. Multiplex input/output modules shall use solid-state devices to provide extended service life and individual circuit protection.

Ten percent of the total number of inputs and outputs, or at least one each at each zone location shall be designated as spares.

2.4.4.3.1 System Configuration

Multiplexing must be centralized. A centralized system shall consist of several modules connected to form a control network. The system shall be managed by a master vehicle controller. It provides the configurability and the control required to integrate all systems on the bus. The vehicle shall be equipped with a I/O Controls DINEX G3 multiplexing system or approved equal.

The proposed multiplex network system shall provide the Intelligent Key™ feature.

Control system shall be equipped to accommodate a wireless diagnostic system if selected by Procuring Agency.

2.4.4.3.2 I/O Signals

The input/output for the multiplex system shall contain four types of electrical signals: discrete, analog, serial data, and modulating.

Discrete signals shall reflect the on/off status of switches, levers, limit switches, lights, etc. Analog signals reflect numerical data as represented by a voltage signal (for example 0–5V) or resistance signal (for example NTC thermistor). Both types of analog signals shall represent the status of variable devices such as rheostats, op-amps, potentiometers, temperature probes, etc.

2.4.4.4 Drivetrain Level

2.4.4.4.1 General Requirements

Drivetrain components, consisting of the traction motor inverters, regenerative braking system, anti-lock braking system, transmission (if used), and all other related components, shall be integrated and communicate fully with respect to vehicle operation with data using SAE Recommended Communications Protocols such as J1939. Drivetrain components shall be powered by a supply voltage to ensure data communication among components exists when the vehicle ignition is switched to the “on” position.

See fire protection requirements for wiring passing through the motor compartment bulkhead.

2.4.4.4.2 Diagnostics, Fault Detection and Data Access

Drivetrain performance, maintenance and diagnostic data, and other electronic messages shall be formatted and transmitted on the communications network.

The drivetrain level shall have the ability to record abnormal events in memory and provide diagnostic codes and other information to service personnel. These codes shall be available from the driver’s digital display or on the diagnostic tool. The communication ports shall be located at the front and rear interior of the vehicle.

2.4.4.4.3 Programmability (Software)

The drivetrain level components shall be programmable by Procuring Agency with limitations as specified by the sub system Supplier.

2.4.4.5 Multiplex Level

2.4.4.5.1 Data Access

At a minimum, information shall be made available via communication ports on the multiplex system at the front and rear interior of the vehicle. The location of the communication ports shall be easily accessible.

2.4.4.5.2 Diagnostics and Fault Detection

The multiplex system shall have a proven method of determining its status (system health and input/output status) and detecting either active (Online) or inactive (Offline) faults through the use of on-board visual/audible indicators.

In addition to the indicators, the system shall employ an advanced diagnostic and fault detection system, which shall be accessible via the diagnostic tool. The diagnostic tool shall have the ability to check logic function.

2.4.4.5.3 Programmability (Software)

The multiplex system shall have security provisions to protect its software from unwanted changes. This shall be achieved through any or all of the following procedures:

a) password protection,
b) limited distribution of the configuration software,
c) limited access to the programming tools required to change the software,
d) hardware protection that prevents undesired changes to the software.

Provisions for programming the multiplex system shall be possible through the diagnostic tool. The multiplex system shall have proper revision control to ensure that the hardware and software is identical on each vehicle equipped with the system. Revision control shall be provided by all of the following:

a) hardware component identification where labels are included on all multiplex hardware to identify components,
b) hardware series identification where all multiplex hardware displays the current hardware serial number and firmware revision employed by the module,
c) software revision identification where all copies of the software in service displays the most recent revision number, and a method of deter-mining which version of the software is currently in use in the multiplex system.

2.4.4.6 Electronic Noise Control

Electrical and electronic sub systems and components on all buses shall not emit electro-magnetic radiation that will interfere with on-board systems, components or equipment, telephone service, radio or TV reception, or violate regulations of the Federal Communications Commission.

Electrical and electronic sub systems on the buses shall not be affected by external sources of RFI/EMI. This includes, but is not limited to, radio and TV transmission,

portable electronic devices including computers in the vicinity of or onboard the buses, AC or DC power lines and RFI/EMI emissions from other vehicles.

2.4.5 COMMUNICATIONS ACCESSORIES

2.4.5.1 Mobile Radio System

A compartment shall be provided to accommodate a communication system enabling the driver to contact the dispatcher. It shall be located within 8 feet of the driver's seat and shall be connected to the driver's area by waterproof conduit. The compartment shall include a clear space 12 inches high, 18 inches wide, and 24 inches deep for location of the radio.

Procuring Agency shall have the option to add mounts and/or radio to the dash. A 20-amp fuse, 12-volt battery supply; 10-amp fuse, 12-volt ignition supply, and negative ground circuits shall be provided when dash mounts and/or radio are chosen.

Communication system shall be accessible from either inside or outside of the coach and shall be splash proof when the service door is secured. The radio compartment shall be supplied with a 30 amp, 12-volt, DC-protected service with positive and negative leads. A location convenient to the driver shall be provided for the radio control head, speaker, and handset. Provisions for attaching an antenna to the roof and routing an antenna lead to the radio compartment shall include a conduit with an interior diameter of ¾ inch and a pull wire. The antenna mounting and lead termination shall be accessible from the coach interior.

Unless specified otherwise, Procuring Agency will install their own radio system after delivery. The radio equipment is not part of the contract and the contractor shall not include radio equipment or the installation of a radio in this contract.

2.4.5.2 Public Address System

The contractor shall provide and install a public address system that enables the operator to address the passengers either inside or outside the bus. A total of eight (8) interior flush-mounted speakers shall broadcast in a clear tone, so that announcements are clearly perceived from all seat positions at approximately the same volume level. One (1) exterior speaker shall be provided outside the entrance door so that announcements can be clearly heard by passengers standing near the door. An operator-controlled switch shall select inside or outside announcements. The microphone shall be hands free operation.

Public address system shall be in compliance with the requirements of 49 CFR 38.35.

2.4.6 SECURITY CAMERA SYSTEM

The security camera system shall be a Seon Explorer TH8 Channel DVR with 2 TB HDD or approved equal, consisting of a minimum of 12 analog video and audio inputs, H.264 compression, and integrated locking enclosure, provided to monitor and record events onboard the buses at all times when the buses are powered on.

2.4.6.1 Recording Unit

The recording unit shall continually digitize video from all on-board cameras, provide compression of the video, and store the video on a removable hard drive. The recording unit shall have an internal clock, used to time and date stamp recorded video. The unit shall be designed for a mobile application and shall be protected against EMI and RFI. Each of the video inputs shall accept color, Nation Television System Committee (NTSC) format.

2.4.6.2 Resolution

Images shall be digitized with at least 720x480 pixel resolution.

2.4.6.3 Frame Rate

Video from each input shall be capable of recording at a rate of up to 30 frames per second (FPS) per camera, simultaneously.

2.4.6.4 Recording Capacity

Video compression shall be utilized such that the recorder shall have capacity to record images from all onboard cameras for at least seventy-two hours before overwriting the recorded information. This capacity shall include time and date stamp of the video. The oldest video stored shall be automatically overwritten so that video is recorded on a continuous basis.

2.4.6.5 Digital Format

The video storage format shall include secure, encrypted encoding such that alteration to the images can be detected. The system shall provide provisions to expand the recording media and provide the capability to upgrade to the latest digital media technology.

2.4.6.6 Diagnostics

The system shall be equipped with a fault log file which shall store fault and system information. The information to be stored shall include but is not limited to: ignition on/off

times, start and stop events, camera failures, and hard drive errors. All faults shall be time and date stamped and accessible via a laptop through a diagnostic port. Provisions shall be provided for wireless communications between a laptop, recording device, and fault log.

2.4.6.7 Removable Hard Drive

The hard drive used for video storage shall be a hot swappable, rugged, dual drive designed for a transit bus environment. It shall be housed in a ruggedized, locking enclosure which is integral to the recording unit. The hard drive shall be designed for rapid removal and installation, without the use of special tools and requiring no more than fifteen seconds. Connections shall provide positive feedback of correct insertion. When a hard drive is inserted, visual indication shall be provided on the front panel of the unit that the hard drive is inserted correctly and that it is functioning correctly. The hard drive shall automatically connect and synchronize to the onboard system. No additional formatting shall be required. A common key shall be used for all hard drives. One key will be provided with each bus.

2.4.6.8 Operating System and Processor

The recorder operating system shall be the most current and stable version of the operating system. The operating system shall detect a hang-up and shall automatically restart. Video that was previously recorded shall not be lost due to a processor restart. The processor shall be a commercially available Linux-based processor, designed for rugged application.

2.4.6.9 Decals

In accordance with State and Federal laws, interior and exterior decals shall be provided notifying passengers that this bus is equipped with a video security system. Decal location and text shall be approved by Procuring Agency.

2.4.6.10 Cameras

Eleven (11) Day/Night cameras shall be provided in the locations outlined here. Cameras shall be NTSC compatible with 1/3 inch or larger charge-coupled device (CCD) imager and fixed-length lens. Camera and lens combinations shall be selected to maximize image quality through the range of lighting conditions on buses in operation. Cameras shall accommodate normal and wide-angle lenses. Cameras shall meet or exceed the following specifications:

a) Minimum resolution shall be 720x480 pixels.
b) Scanning shall be interlaced.
c) Internal and external sync.
d) Minimum illumination shall be less than or equal to 0.95 lux.

e) Interior cameras shall have built-in microphone capable of recording audio

The system shall include one (1) IP camera with 720p / 1080p / 3MP (selectable) progressive scan resolution. Camera shall be located in the front of the bus facing forward through the windshield.

2.4.6.11 Lens

Camera lenses shall have an automatically adjusting iris. Focal length shall be selected to maximize viewable area for each camera location.

2.4.6.12 Enclosure

Each camera shall be provided within an enclosure suitable for the approved mounting location. Enclosures shall be vandal resistant and fastened with tamperproof screws. Camera enclosures shall be in neutral colors, suitable to the Procuring Agency's color scheme. Enclosure sizes shall be minimized. Enclosure shape shall be suitable for the mounting location, so as not to present sharp edges or corners.

2.4.6.13 Camera Location

Cameras on Transit buses shall be located to provide surveillance of the following areas:

1) Interior of the bus looking rearward from front vestibule.
2) Mounted beneath the front destination sign bulkhead, looking through windshield.
3) Exterior of bus, mounted above front door, looking rearward along curb side of bus.
4) Interior of bus looking forward from rear, ceiling-mounted at centerline of bus.
5) Passengers entering bus and fare box interaction, mounted above driver control area.
6) Exterior of street side of bus looking rearward, mounted above driver's window.
7) Interior of bus looking at rear balcony area, ceiling-mounted at centerline of bus.
8) Passengers exiting bus and fare box interaction, mounted on curb side of front vestibule.
9) Exterior of bus, mounted above rearmost passenger window, looking forward along curb side of bus.
10) Exterior of bus, mounted above rearmost passenger window, looking forward along street side of bus.

Contractor shall submit drawings detailing the proposed camera mounting locations for approval by Purchasing Agency.

Procuring Agency has option to add or delete any number of cameras and locations from base configuration.

2.4.6.14 Security Video Playback

Playback shall be made possible through the use of a laptop computer to download fault logs and the video/audio files stored on the system's hard drive. The unit shall also enable recordings of selected portions to a DVD and play back those portions for viewing.

Procuring Agency shall have the option to include, with the purchase, a laptop computer equipped with the necessary software, hardware, and cabling provisions for communication with security system.

2.4.6.15 Wiring Harness Conduit

All wiring for the Security Camera System shall be installed in appropriately sized conduit. Harness and conduit installation shall be approved by the Procuring Agency.

2.4.6.16 Wireless Download Capability

Security system shall include all necessary wireless LAN bus hardware to facilitate upload/download data to/from video system. The DVR shall support industrial Wi-Fi networking with Smart-Reach Mobile (wireless bridge) or equivalent with roaming capability. Consumer grade wireless bridge is not acceptable.

2.5 Vehicle Charging Requirements

2.5.1 GENERAL REQUIREMENTS

The vehicle must be immobilized during all charging operations. Upon successful engagement of the charging interface, the bus shall be interlocked such that propulsion is rendered non-tractive and the brakes applied.

Charging port shall be located at the rear of the bus, curb side. Charging port shall not be energized unless mated to EVSE plug.

Charging circuits shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 5 mA.

Vehicle loads shall be minimized while connected to the EVSE. Battery warmers and ancillary non-essential equipment shall operate for the minimum times and at minimum levels to preserve performance and ensure safety. Contractor shall list and provide estimated kW and hourly kWh of all ancillary loads that will operate while connected to the EVSE.

If the bus can accomplish depot charging from 20% SOC to 95% SOC in less than 4 hours only with the use of proprietary EVSE, the proprietary EVSE and control systems shall conform to the requirements here, and proposal shall include all details specified.

If the bus is able to charge from 20% SOC to 95% SOC in less than 6 hours <u>with non-proprietary EVSE</u> that use either SAE J1772 CCS Type 1 standard charging protocol or SAE J3068, <u>proposal need not include EVSE information</u>.

If proprietary EVSE is required for the bus to charge at full power, proposal shall include pricing for all required equipment to simultaneously charge all buses, including delivery as well as a description and/or design of the EVSE, showing dimensions and required free space. Port-sharing between buses will not be considered.

If proprietary EVSE is required as per above, Procuring Agency shall have the option of purchasing additional EVSE, and bidder shall provide the unit cost for additional EVSE.

2.5.2 PROPRIETARY CHARGING INFRASTRUCTURE

Proposals which require proprietary charging infrastructure shall include a complete description of the charging systems (including anticipated AC energy consumption for

buses operating on the specified operating profile, power factor, efficiency, total harmonic distortion, and harmonic spectrum). These parameters shall be defined over the entire charge profile that incorporates a complete charge from 20% SOC to 100% SOC.

2.5.2.1 Charging Infrastructure General Information

These general requirements apply to all EVSE to be delivered under the Contract. The Contractor shall provide EVSE and the control and data system needed to recharge the bus ESS.

Contractor shall provide EVSE to allow for simultaneous charging of all buses. EVSE must be vandal-resistant and weatherproof.

Procuring Agency will coordinate with engineering contractors as necessary to complete equipment installation at Procuring Agency's facility. Contractor shall provide close coordination with Procuring Agency and its engineering contractors during site design and installation of EVSE. The Contractor shall be responsible for equipment start-up and testing to ensure that the EVSE meets all stated specifications and functionality prior to site acceptance.

Delivery and configuration of the EVSE so that it is made fully functional upon delivery of buses shall be considered part of this contract.

2.5.2.2 Charging Infrastructure Requirements

The EVSE shall be capable of delivering the optimal battery charge profile as specified by the battery manufacturer and charging the installed traction battery to a fully charged state from the minimum recommended state of charge (SOC) including necessary cool-down time as specified by the battery manufacturer.

The EVSE shall be powered by a 480-volt, 3-phase, 60-Hz electrical supply.

EVSE shall not produce harmonic distortion in excess of 5% THD.

EVSE shall meet or exceed Energy Star key product criteria as outlined at: https://www.energystar.gov/products/evse_key_product_criteria

2.5.2.2.1 Data Requirements

- Measures and displays kWh consumed and real time AC load in KW within 1% accuracy;
- Is capable of RS-485 communications; and

- Records kWh and kVARh delivered, kWh and kVARh received Stores data in 15-minute intervals for up to 72 days or 5-minute intervals for up to 24 days. Maintains interval data storage in a first-in, first-out format.

Contractor may vary the capacity of the EVSE to allow for overnight charging and battery conditioning with a maximum charge time of six hours to reach 95% SOC Buses shall be charged to Maximum Standard Operating SOC at a rate that maximizes life of the batteries.

2.5.2.2.2 Control Requirements

EVSE shall be configured to automatically initiate charging if properly connected when so signaled by an external timing circuit or control input. The EVSE shall be configured to automatically terminate the connection in the event of hazardous or anomalous conditions.

The EVSE shall be configured to automatically restart charging after unintended interruption of a charging episode due to interruption or temporary degradation of electrical service. Provision shall be made to stagger the resumption of charging among vehicles to reduce spikes in current. The EVSE shall be configured to interface with on-board battery management and interlock systems.

2.5.2.2.3 EVSE Cable and Plug

Conductive cabling connecting depot chargers to the bus shall be a maximum of fifteen feet in length. The connectors shall of simple design and heavy-duty construction. Plug shall not be energized except when mated to vehicle.

2.5.2.3 Operating Environment

EVSE shall be capable of operating continuously without performance or safety degradations in environmental conditions typically found at the Procuring Agency's location. For the purposes of these Specifications such environmental conditions shall mean:

- Storage temperature when not in service: -40°F to +120°F
- Ambient service temperature: -20°F to +95°F
- Maximum service altitude: 1000m above sea level @ 100°F
- Relative humidity range: 5% to 95%, no condensation allowed.

2.5.3 MANAGEMENT, CONTROL AND DATA SYSTEMS

Two (2) data systems shall be provided by the Contractor:

1) **High Level Data System**: located in the cloud or at the central depot facility that serves as the data collection and control hub for all EVSE. The high-level data system shall be in communication with the individual EVSE.

2) **EVSE Data System**: located at each of the EVSE

All data system communications and license fees shall be pre-paid for ten years and included in the total price for Charging Infrastructure.

Information level systems that require vehicle information for their operations or provide information shall adhere to J1939 data standard.

2.5.3.1 High-Level Data System

The high-level system shall collect data from each component within the system and provide summary reports, such as utility cost, energy consumption, charging profiles, health checks, alarms, etc. The high-level controller shall also be the point of transferring instruction to the EVSE. The proposer shall provide a complete list of data elements reportable from EVSE and connected vehicles, respectively. The high-level system shall be capable of monitoring and limiting total charging system demand based on time of day and day of week at minimum intervals not greater than 15-minutes, configurable by procuring agency.

Proposals should include screenshots of the user interface for the High-Level System.

Contractor shall commission the high-level system when commissioning EVSE. High-level system commissioning shall include assistance with programming charging schedules and provision of up to three sets of login credentials as requested by Procuring Agency.

2.5.3.2 EVSE Data System

The EVSE level system shall be the control point for individual charging ports and provide vehicle- specific energy information including energy consumption by time of day and incident monitoring. The system shall manage and store records on each charge event, including, but not limited to bus ID, charger status, faults, beginning state of charge (SOC), ending SOC, AC energy consumption, max power, etc. The system shall be in communication with the high-level site controller in real time.

Procuring Agency shall have the ability to start and stop charging based on a signal from an outside source such as through Ethernet, Wi-Fi, or another communication protocol, or via the High-Level System.

2.5.4 TWO-WAY POWER FLOW (OPTIONAL)

If two-way power flow from vehicle batteries requires any additional EVSE equipment and/or cost, bidder shall provide details on equipment and pricing required to enable two-way-power flow.

2.6 Quality Assurance Provisions

2.6.1 CONTRACTOR'S IN-PLANT QUALITY ASSURANCE REQUIREMENTS

2.6.1.1 Quality Assurance Organization

The Contractor shall establish and maintain an effective in-plant, quality assurance organization. It shall be a specifically defined organization and should be directly responsible to the Contractor's top management.

2.6.1.1.1 Control

The quality assurance organization shall exercise quality control over all phases of production from initiation of design through manufacture and preparation for delivery. The organization shall also control the quality of supplied articles.

2.6.1.1.2 Authority and Responsibility

The quality assurance organization shall have the authority and responsibility for reliability, quality control, inspection planning, establishment of the quality control system, and acceptance/rejection of materials and manufactured articles in the production of the transit coaches.

2.6.1.2 Quality Assurance Organization Functions

The quality assurance organization shall include the following minimum functions.

2.6.1.2.1 Work Instructions

The quality assurance organization shall verify inspection operation instructions to ascertain that the manufactured product meets all prescribed requirements.

2.6.1.2.2 Records Maintenance

The quality assurance organization shall maintain and use records and data essential to the effective operation of its program. These records and data shall be available for review by the Resident Inspectors. Inspection and test records for this procurement shall be available for a minimum of three (3) years after inspections and tests are completed.

2.6.1.2.3 Corrective Action

The quality assurance organization shall detect and promptly assure correction of any conditions that may result in the production of a defective transit coach. These

conditions may occur in designs, purchases, manufacture, tests, or operations that culminate in defective supplies, services, facilities, technical data, or standards.

2.6.1.3 Standards and Facilities

The following standards and facilities shall be basic in the quality assurance process.

2.6.1.3.1 Configuration Control

The Contractor shall maintain drawings, assembly procedures, and other documentation that completely describe a qualified coach that meets all of the options and special requirements of this procurement. The quality assurance organization shall verify that each transit coach is manufactured in accordance with these controlled drawings, procedures, and documentation.

2.6.1.3.2 Measuring and Testing Facilities

The Contractor shall provide and maintain the necessary gauges and other measuring and testing devices for use by the quality assurance organization to verify that the coaches conform to all specification requirements. These devices shall be calibrated at established periods against certified measurement standards that have known valid relationships to national standards.

2.6.1.3.3 Production Tooling as Media of Inspection

When production jigs, fixtures, tooling masters, templates, patterns, and other devices are used as media of inspection, they shall be proved for accuracy at formally established intervals and adjusted, replaced, or repaired as required to maintain quality.

2.6.1.3.4 Equipment Use by Resident Inspectors

The Contractor’s gauges and other measuring and testing devices shall be made available for use by the Resident Inspectors to verify that the coaches conform to all specification requirements. If necessary, the Contractor's personnel shall be made available to operate the devices and to verify their condition and accuracy.

2.6.1.4 Control of Purchases

The Contractor shall maintain quality control of purchases.

2.6.1.4.1 Supplier Control

The Contractor shall require that each supplier maintains a quality control program for the services and supplies that it provides. The Contractor's quality assurance organization shall inspect and test materials provided by suppliers for conformance to

specification requirements. Materials that have been inspected, tested, and approved shall be identified as acceptable to the point of use in the manufacturing or assembly processes. Controls shall be established to prevent inadvertent use of nonconforming materials.

2.6.1.4.2 Purchasing Data

The Contractor shall verify that all applicable specification requirements are properly included or referenced in purchase orders of articles to be used on transit coaches.

2.6.1.5 Manufacturing Control

The Contractor shall ensure that all basic production operations, as well as all other processing and fabricating, are performed under controlled conditions. Establishment of these controlled conditions shall be based on the documented work instructions, adequate production equipment, and special working environments if necessary.

2.6.1.5.1 Completed Items

A system for final inspection and test of completed transit coaches shall be provided by the quality assurance organization. It shall measure the overall quality of each completed coach.

2.6.1.5.2 Nonconforming Materials

The quality assurance organization shall monitor the Contractor's system for controlling nonconforming materials. The system shall include procedures for identification, segregation, and disposition.

2.6.1.5.3 Statistical Techniques

Statistical analysis, tests, and other quality control procedures may be used when appropriate in the quality assurance processes.

2.6.1.5.4 Inspection Status

A system shall be maintained by the quality assurance organization for identifying the inspection status of components and completed transit coaches. Identification may include cards, tags, or other normal quality control devices.

2.6.1.6 Inspection System

The quality assurance organization shall establish, maintain, and periodically audit a fully-documented inspection system. The system shall prescribe inspection and test of materials, work in process, and completed articles. As a minimum, it shall include the

following controls.

2.6.1.6.1 Inspection Personnel

Sufficiently-trained inspectors shall be used to ensure that all materials, components, and assemblies are inspected for conformance with the qualified coach design.

2.6.1.6.2 Inspection Records

Acceptance, rework, or rejection identification shall be attached to inspected articles. Articles that have been accepted as a result of approved materials review actions shall be identified. Articles that have been reworked to specified drawing configurations shall not require special identification. Articles rejected as unsuitable or scrap shall be plainly marked and controlled to prevent installation on the coach. Articles that become obsolete as a result of engineering changes or other actions shall be controlled to prevent unauthorized assembly or installation. Unusable articles shall be isolated and then scrapped.

Discrepancies noted by the Contractor or Resident Inspector during assembly shall be entered by the inspection personnel on a record that accompanies the major component, subassembly, assembly, or coach from start of assembly through final inspection. Actions shall be taken to correct discrepancies or deficiencies in the manufacturing processes, procedures, or other conditions that cause articles to be in nonconformity with the requirements of the contract specifications. The inspection personnel shall verify the corrective actions and mark the discrepancy record. If discrepancies cannot be corrected by replacing the nonconforming materials, the Procuring Agency shall approve the modification, repair, or method of correction to the extent that the contract specifications are affected.

2.6.1.6.3 Quality Assurance Audits

The quality assurance organization shall establish and maintain a quality control audit program. Records of this program shall be subject to review by Procuring Agency.

2.6.1.7 Inspections

2.6.1.7.1 Inspection Stations

Inspection stations shall be at the best locations to provide for the work content and characteristics to be inspected. Stations shall provide the facilities and equipment to inspect structural, electrical, hydraulic, and other components and assemblies for compliance with the design requirements.

Stations shall also be at the best locations to inspect or test characteristics before they are concealed by subsequent fabrication or assembly operations. These locations shall

minimally include underbody structure completion, body framing completion, body prior to paint preparation, water test before interior trim and insulation installation, electric drive train installation completion, underbody dress-up and completion, coach prior to final paint touchup, coach prior to road test, and coach final road test completion.

2.6.1.7.2 Resident Inspector

Procuring Agency maintains the right to be represented at the Contractor's plant by Resident Inspectors and/or Procuring Agency personnel. They shall monitor, in the Contractor's plant, the manufacture of transit coaches built under the procurement. The Resident Inspectors shall be authorized to approve the pre-delivery acceptance tests and release the coach for delivery. The presence of these resident inspectors in the plant shall not relieve the Contractor of its responsibility to meet all of the requirements of this procurement. Upon request to the quality assurance supervisors, the Resident Inspectors shall have access to the Contractor's quality assurance files related to this procurement. These files shall include drawings, assembly procedures, material standards, parts list, inspection processing and reports, and records of defects.

Prior to the beginning of the coach manufacture and continuing throughout the scheduled production, the Contractor shall assist the Resident Inspector in verifying the Buy America domestic content requirement as specified in 49 CFR Part 661 and 49 USC Part 5323(j), as amended by Section 3011 of the FAST Act. Per the FAST ACT, domestic content shall be 65% for FFY2018 and FFY2019, and 70% for FFY2020 and after. At minimum, the Resident Inspector shall:

a) Review actual component content to ensure that the coach meets the Buy America domestic content requirement for the year of manufacture; and,
b) Check that the final assembly location is in the United States and the manufacturer’s final assembly activities meet the requirements as outlined in the FTA’s Pre-Award Buy America Certification, and as approved by Procuring Agency prior to award.
c) The Resident Inspector must verify that the actual manufacturing processes are consistent with the information provided by the manufacturer and approved by Procuring Agency.

The Contractor shall provide office space for the resident inspectors in close proximity to the final assembly area. This office space shall be equipped with desks, outside and inter-plant telephones, file cabinet, chairs, and clothing lockers sufficient to accommodate the resident staff.

2.6.2 ACCEPTANCE TESTS

2.6.2.1 Responsibility

Fully documented tests shall be conducted on each production coach following manufacture to determine its acceptance to Procuring Agency. These acceptance tests shall include pre-delivery inspections and testing by the Contractor and inspections and testing by Procuring Agency after the coaches have been delivered.

2.6.2.2 Pre-Delivery Tests

The Contractor shall conduct acceptance tests at its plant on each coach following completion of manufacture and before delivery to Procuring Agency. These pre-delivery tests shall include visual and measured inspections, as well as testing the total coach operation. Comprehensive testing of vehicle charging systems shall be performed as well, including interactions with Electric Vehicle Supply Equipment (EVSE), charging profile, and energy management during vehicle charge. The tests shall be conducted and documented in accordance with written test plans, approved by Procuring Agency. Additional tests may be conducted at the Contractor's discretion to ensure that the completed coaches have attained the desired quality and have met the requirements in these technical specifications.

The pre-delivery tests shall be scheduled and conducted with sufficient notice so that they may be witnessed by the Resident Inspectors, who may accept or reject the results of the tests. The results of pre-delivery tests, and any other tests, shall be filed with the assembly inspection records for each coach. The under-floor equipment shall be available for inspection by the resident inspectors, using a pit or coach hoist provided by the Contractor. A hoist, scaffold, or elevated platform shall be provided by the Contractor to easily and safely inspect coach roofs. Delivery of each coach shall require written authorization of the Resident Inspector. Authorization forms for the release of each coach for delivery shall be provided by the Contractor. An executed copy of the authorization shall accompany the delivery of each coach.

2.6.2.2.1 Inspection – Visual and Measured

Visual and measured inspections shall be conducted with the coach in a static condition. The purpose of the inspection testing is to verify overall dimensional and weight requirements, to verify that required components are included and are ready for operation, and to verify that components and subsystems that are designed to operate with the coach in a static condition function as designed.

2.6.2.2.2 Total Coach Operation

Total coach operation shall be evaluated during road tests. The purpose of the road test is to observe and verify the operation of the coach as a system and to verify the