Duluth Transit Authority
Attachment A

Electric Transit Buses

TECHNICAL SPECIFICATIONS

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TECHNICAL EQUIPMENT SPECIFICATIONS

1.00 INTRODUCTION

The Duluth Transit Authority ("DTA") is seeking Proposals from bus manufacturers for 2 battery electric 40-foot transit buses for use on bus rapid transit routes in the Duluth transit system.

The following technical specifications are meant as baseline requirements for the buses.

1.01 ABBREVIATIONS

Alternative: An alternative specification condition to the base bus configuration. The DTA may define alternatives to the base configuration to satisfy local operating requirements. Alternatives for the base configuration will be clearly identified.
Ambient Temperature: The temperature of the surrounding air. For testing purposes, ambient temperature must be between -20° F to 100°F.
Analog Signals: A continuously variable signal that is solely dependent upon magnitude to express information content.
Audible Discrete Frequency: An audible discrete frequency is determined to exist if the sound power level in any 1/3-octave band exceeds the average of the sound power levels of the two adjacent 1/3-octave bands by 4 decibels (dB) or more.
Automated charging Station: A Charging System that automates the charging process to allow for on-route Fast Charge of buses with little required input from the bus operator. The charging is accomplished through conductive connection to facilitate safe charging of the bis in a location out of reach of bus passengers and which can be operated during boarding and de-boarding of passengers. The operator input is limited to left/right steering, emergency braking and Charging System "on" and where departure occurs before completion of the charging process, Charging System "off" controls.
Base Bus Configuration: The bus described if no alternatives are selected. Signing, colors, the destination sign reading list and other information will be supplied by the DTA.
Battery Compartment: Designated area for placement of high-voltage or low-voltage energy storage, such as 12/24 VDC batteries. Battery Compartments shall be separately designated as "High Voltage Compartment" and "Low Voltage Compartment."
Battery Electric Bus ("BEB") A transit bus powered by high voltage batteries and associated systems.
Battery Management System ("BMS"): Monitors energy as well as temperature, cell or module voltages, and total battery pack voltage. The BMS adjusts the control strategy algorithms to maintain the batteries at uniform state of charge and optimal temperatures.
Braking Resister: Device that converts electrical energy into heat, typically used as a retarder to supplement or replace the regenerative braking.
Burst Pressure: The highest pressure reaching in a container during a burst test.
Capacity: The water volume of a container in gallons (liters).
Cell: Simplest discrete component of the battery storage system, such as a battery or a capacitor.
Charger: The equipment required to covert Alternating Current (AC) to Direct Current (DC), for the purpose of charging the battery and or vehicle operating electrical systems

while connected. The Charger may be on-board the vehicle or off-board the vehicle. Off-board Chargers may be built as part of the charging station.

Charging Interface: The equipment and/or coupler used to create a connection between the charging equipment and the vehicle for the purpose of recharging the vehicle's battery.

Charging Equipment: The equipment that encompasses all of the components needed to covert, control, and transfer electricity from the grid to the vehicle for the purpose of charging batteries. May include chargers, controllers, couplers, transformers, ventilation, backup generator, meters, etc.

Charging Station: A location that houses the charging equipment connected to a utility's electric service, to provide electricity to a vehicle's battery system through a charging interface.

Class 1 Failure (physical safety): A failure that could lead directly to passenger or operator injury and represents a severe crash situation.

Class 2 Failure (road call): A failure resulting in an enroute interruption of revenue service. Service is discontinued until the bus is replaced or repaired at the location of the failure.

Class 3, Bus Change: A failure that requires removal of the bus from service during its assignments. The bus is operated to a rendezvous point with a replacement bus.

Class 4, Bad Order: A failure that does not require removal of the bus from service during it assignments but does degrade bus operation. The failure shall be reported by driver or inspector.

Conductive Charging Interface: A charging interface that creates a physical connection between the EVSE and the vehicle's Energy Storage System to recharge the vehicle.

Code: A legal requirement.

Curb Weight: Weight of the vehicle, including maximum fuel, oil and coolant, and all equipment required for operation and required by their specification, but without passengers or driver.

dBA: Decibels with reference to 0.0002 microbar as measured on the "A" scale.

DC to DC Converter: A module that converts a source of direct currant from one voltage level to another.

Defect: A failure of a system or a component that makes the bus unable to operate. A defect can also be a safety defect, a failure of safety systems system such as airbags, tires, etc.

Design Operating Profile: The operating profile for design purposes shall consist of simulated transit type service consisting of three phases to be repeated in sequence: a central business district (CBD) phase of 2 miles with 7 stops per mile and a top speed of 20 mph, an arterial route phase of 2 miles with 2 stops per mile and a top speed of 40 mph, and a commuter phase of 4 miles with 1 stop and a maximum speed of 55 mph and a 5-minute idle phase.

Destroyed: Physically made permanently unusable.

Discrete Signal: A signal that can take only pre-defined values, usually a binary 0 or 1 nature, where 0 is battery ground potential and 1 is a defined battery positive potential.

Driver's Eye Range: The 95th percentile ellipse defined in SAE J941, except that the height of the ellipse shall be determined from the seat at its reference height.

Drive System Controller (DSC): Regulates energy flow throughout the system components in order to provide more performance and accessory loads, as applicable, while maintaining critical system parameters (voltage, currents, temperatures, etc.)

within specified operating ranges.
Electric Drive System (EDS): The mechanical and/or electromechanical components, including the motor and energy storage system.
Electric Vehicle Supply Equipment (EVSE): The conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings devices, power outlets, or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the battery electric Vehicle.
End of Life: A condition reached when an energy storage system fails to meet the specified capacity, power or function in specified use conditions.
Energy Density: The relationship between the weight of an energy storage device and its power output units of watt-hours per kilogram (Wh/kg).
Energy Storage Device (ESD): A component or system of components that stores energy and for which its supply of energy is rechargeable by the on-vehicle system (engine/regenerative braking/generator) or an off-vehicle energy source. (Also see ESS)
Energy Storage System (ESS): A component or system of components that stores energy and for which its supply of energy is rechargeable by the on-vehicle system (engine/regenerative braking/generator) or an off-vehicle energy source. (Also see ESD).
Energy System Controller (ESC): The ESC regulates energy flow throughout the electric system components in order to provide motive performance and accessory loads, as applicable, while maintaining critical system parameters (e.g., voltages, currents, temperatures, etc.) within specified operating ranges.
Fast Charge: A Charging System capable of charging the Energy Storage System during short in-route opportunity charging scenarios and simultaneously meeting the Operating Range requirements.
Fatigue Failure (Corrosion Fatigue): The mechanical degradation of material under the joint action of corrosion and cyclic loading.
Fireproof: Materials that will not burn or melt at temperatures less than 2,000° F.
Fire Resistant: Materials that have a flame spread index less than 150 as measured in a radiant panel flame test per ASME-E 162-90.
Fleet Defect: a failure of a component or system that affects multiple buses
Free Floor Space: Floor area available to standees, excluding ingress/egress areas, area under seats, area occupied by feet of seated passengers, and the vestibule area forward of the standee line, and any floor space indicated by manufacturer as non-standee areas, such as floor space swept by passenger doors during operation. Floor area of 1.5 sq. ft. shall be allocated for the feet of each seated passenger protruding into the standee area.
Fusible Material: A metal, alloy, or other material capable of being melted by heat.
GAWR (Gross Axle Weight Rated): The maximum total weight as determined by the axle manufacturer, at which the axle can safely and reliable operate for its intended purpose.
Generator (Electric): A device that converts mechanical energy into electrical energy.
GFD/GFI (Ground Fault Detector/Ground Fault Interrupter): A system capable of detecting, and if necessary, interrupting a measurable resistance below that required by SAEJ1766 between Isolated High Voltage and Low Voltage Systems.
Gross Battery Capacity: Gross capacity would be measured in kWh and would be the energy available from the entire battery pack.
Gross Load: One hundred fifty (150) pounds for every designated passenger seating

position, for the driver, and for each 1.5 square feet of free floor space.
GVW (Gross Vehicle Weight): Curb weight plus gross load.
GVWR (Gross Vehicle Weight Rated): The maximum total weight as determined by the vehicle manufacturer, at which the vehicle can be safely and reliably operated for its intended purpose.
High Voltage (HV): Greater than 50V (AC and DC).
Hose: Flexible Line.
Inverter: A module that converts DC to and from AC.
I/O: Input/Output for electrical systems.
kVA (Kilovolt-Amps): A unit of power generally associated with electrical devices.
kWh (Kilowatt Hour): A derived unit of energy consumption.
kWh/mi: A method of computing average energy consumption on a per mile basis.
Labeled: Equipment or materials that has a label, symbol or other identifying mark of an organization, which is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production, labeled equipment or materials, and by whose labelling the manufacturer indicates compliance with appropriate standards of performance in a specified manner. Labels on high-voltage devices to identify them as components conducting high voltage potential are required.
Leakage: Release of contents through a Defect or a crack.
Line: All tubes, flexible and hard, that carry fluids.
Local Regulations: Regulations below the state level.
Low Floor-Bus: A bus that, between at least the front entrance and rear exit door, has a floor sufficiently low and level so as to remove the need for steps in the aisle between the doors and in the vicinity of these doors.
Low Voltage (LV): 50V or less (AC and DC).
Maximum Service Temperature: The maximum temperature to which a container/cylinder will be subjected to normal service.
Maximum Standard Operating State of Charge: The maximum design operating state of charge as recommended by the propulsion system integrator and the battery manufacturer.
Metallic Hose: A hose whose strength depends primarily on the strength of its metallic parts, it can have metallic liners or covers or both.
Module: A collection of cells forming a physical and electrical sub-assembly contained within an enclosure.
Motor (Electric): A device that converts electrical energy into mechanical energy.
Motor (Traction): An electric motor used to power the driving wheels of the bus.
Pack: A collection of cells or modules described on the basis of electrical or physical attributes, to include *Electrical Pack* and *Physical Pack*.
Physical Layer: The first layer of a seven-layer International Standards Organization (ISO) reference model. This provides mechanical, electrical, functional, and procedural characteristics required to gain access to the transmission medium (e.g., cable) and is responsible for transporting binary information between computerized systems.
Physical Pack: An enclosure consisting of a collection of cells or modules at a location or multiple locations. Physical packs differ from electrical packs, as they are defined by layout rather than electrical equivalent.
Pipe: Nonflexible line.
Power: Work or energy divided by time.

Power Density: Power divided by mass, volume, or area.
Propulsion System: System that provides propulsion for the vehicle proportional to operator commands. Includes, traction motors, ESS, and system controllers, including all wiring and converter/inverter.
Propulsion Power Unit (PPU): System of components that provide traction power, such as traction motor.
Real time Clock (RTC): Computer clock that keeps track of the current time.
Regenerative Braking: Deceleration of the bus by switching motors to act as generators, which returns vehicle kinetic energy to the ESS.
Retarder: Device used to augment or replace some of the functions of primary friction based braking systems of the bus.
Rupture: Sudden and unstable damage propagation in the structural components of the container resulting in a loss of contents.
Seated Load: One hundred fifty (150) pounds for every designated passenger seating position and the driver.
SLW (Seated Load Weight): Curb weight plus seated load.
Special Tools: Tools not normally stocked by DTA.
Specific Energy: The amount of energy per unit of mass.
Specific Power: The amount of power per unit mass.
Standee Line: A yellow line marked across the bus aisle in line with the driver's barrier to designate the forward area which passengers may not occupy when the bus is moving.
State of Charge (SOC): Quantity of electric energy remaining in the battery relative to the maximum rated amp-hour (Ah) capacity of the battery expressed in a percentage. This is a dynamic measurement used for the ESS. A full SOC indicates that the ESS cannot accept further charging from the engine-driven generator or the regenerative braking system.
Stress Loops: The “pigtails” commonly used to absorb flexing in piping.
Structure: The basic body of the bus, including floor deck material and installation, load-bearing external panels, structural components, axle mounting provisions and suspension beams and attachment points.
Usable Battery Capacity: Usable battery capacity is measured in kW/hr and is the energy available for normal operations. Usable Battery Capacity would be the usable energy from the ESD as managed through the Battery Management System, usually less than the Gross capacity. It is calculated based on a useful range of something above 5% SOC and something less than 100% SOC. For example, if the range was between 10% and 90% SOC, the usable battery capacity would be 80% of gross capacity.

1.02 MAINTENANCE PERSONNEL SKILL LEVELS

(a) **"A"** - Journeyman or Class A Mechanic
(b) **"B"** - Service Mechanic or Class B Serviceman
(c) **"C”** - Mechanic
(d) **"Utility"** - Servicer, Cleaner, Fueler, Oiler, Miscellaneous

ASTM **A**merican **S**ociety For **T**esting and **M**aterials
SAE **S**ociety of **A**utomotive **E**ngineers
ANSI **A**merican **N**ational **S**tandards **I**nstitute
ASHRAE **A**merican **S**ociety of **H**eating, **R**efrigerating & **A**ir **C**onditioning **E**ngineers

SPI	**S**ociety For The **P**lastics **I**ndustry
USDHHS	**U**nited **S**tates **D**epartment of **H**ealth and **H**uman **S**ervices
JIC	**J**oint **I**ndustrial **C**ouncil
BMCS	**B**ureau of **M**otor **C**arrier **S**afety
FMVSS	**F**ederal **M**otor **V**ehicle **S**afety **S**tandards
ADA	**A**mericans With **D**isabilities **A**ct

The bus shall meet all applicable FMVSS and all applicable BMCS and ADA regulations in effect at the date of manufacture.

The Contractor shall comply with all applicable Federal, State and Local regulations. In the event of any conflict between the requirements of these specifications and any applicable legal requirement, then the legal requirement shall prevail.

1.03 GENERAL

1) General Dimensions

Length Overall	40 feet (between 38.5 and 43 feet)
Width Overall	up to 102 inches, ADA platform must move through the front entry of the bus.
Height Overall	up to 135 inches
Seating Capacity	Minimum of 36 with two wheelchair positions
Step Height From Ground - front	Maximum 12.5 inches kneeling. 15 inches normal
Step Height From Ground - rear	16.25 inches
Turning Radius - body corner	45.2 feet maximum

2) Service: All systems requiring routine maintenance shall be arranged for ease of access and maintenance. The Contractor shall list all special tools, fixtures or facility requirements recommended for servicing.

All fluid fill locations shall be properly labelled to help ensure that correct fluid is added. All fillers shall be easily readable with standard funnels, pour spouts, and automatic dispensing equipment. All lubricants sumps shall be fitted with magnetic type drain plugs or magnets in pan.

3) Service Life: The bus shall be designed to operate in transit service for at least 12 years or 500,000 miles. It shall be capable of operating at least 40,000 miles per year including the 12th year.

4) Mean Mileage Between Failures:
The following are design goals for mean mileage between failures by failure class, provided that specified preventative maintenance procedures are followed.

(a) Class 1 - Physical Safety: mileage shall be greater than 1,000,000 miles.

(b) Class 2 - Road Call: mileage shall be greater than 20,000 miles.

(c) *Class 3 - Bus Change*: mileage shall be greater than 16,000 miles.

(d) *Class 4 - Bad Order:* mileage shall be greater than 10,000 miles.

5) Accessibility: All systems or components serviced as part of periodic maintenance, or whose failure may result in Class 1 or Class 2 failures shall be readily accessible for service and inspection. To the extent practical, removal or physical movement or components unrelated to the specific maintenance and/or repair tasks involved shall be unnecessary. Relative accessibility of components, measured in time required to gain access, shall be inversely proportional to frequency of maintenance and repair of the components.

6) Interchangeability: Components with identical functions shall be interchangeable to the extent practical for each production run. These components shall include passenger window hardware, interior trim, lamps, lamp lenses and seat assemblies. Components with non-identical functions shall not be, or appear to be, interchangeable.

7) Conformity: All units or parts not specified shall be manufacturer's standard units. In all cases, material and dimensions must be furnished as specified unless an approved deviation is granted.

1.04 SHELL

1) Design: The design of the bus should be derived from bus performance requirements and passenger service criteria. The exterior and body features, including grilles and louvers, shall be shaped to allow complete and easy cleaning by automatic bus washers without snagging washer brushes. Water and dirt shall not be retained in or on any body feature to freeze or bleed out onto the bus after leaving the washer. Body and windows shall be sealed to prevent leaking of air, dust, or water under normal operating conditions and minimize leakage during cleaning in automatic bus washers for the service life of the bus. Accumulation on any window of spray and splash generated by the buses' wheels on a wet road shall be minimized.

2) Materials: Body materials shall be selected and the body fabricated to reduce maintenance, extend durability, and provide consistency of appearance throughout the life of the bus.

3) Finish and Color: All exterior surfaces shall be smooth and free of visible wrinkles and dents. Exterior surfaces to be painted shall be properly cleaned and primed as appropriate for the paint used, prior to application of paint to assure a proper bond between the basic surface and successive coats of original paint. Paint shall be applied smoothly and evenly with the finished surface free of dirt, runs, orange peel, and other imperfections. All exterior finished surfaces shall be impervious to diesel fuel and commercial cleaning agents. Finished surfaces shall not be damaged by controlled applications of commonly used graffiti-removing chemicals. Colors and paint schemes will be determined after the award of Contract.

4) Numbering and Signing: Monograms, numbers, and other special signing specified by the DTA shall be applied to the inside and outside of the bus as required. Signs shall

be durable and fade, chip, and peel resistant; they may be painted signs, decals, or pressure sensitive appliqués. At least one sign shall be provided on each side of the bus interior to indicate that seats at the front are priority seats for elderly and handicapped passengers.

Front bus numbers shall be control tack type reflective decals, 3-inch size, Black, in color, centered below the belt line. Side bus numbers shall be control tack type reflective decal's, 4-inch size, black in color, mounted at each side of the rear of the bus, centered on the belt line. 3M 680CR-10 reflective decals and 3M 180C-10 nonreflective decals are accepted as approved equals.

Bus numbers shall also be located on the roof; each number shall be at least 24-inches high, 30 inches wide and 4 inches wide.

Rear bus numbers shall be 4-inch, white in color control tack type reflective decals, placed near the left upper rear of the bus. Propulsion equipment compartment numbers shall be 3-inch, white in color, control tack type reflective decals mounted vertical on a black bracket on the left cradle hanger assembly or on power supports.

Bus manufacturer shall provide dimensional drawings showing the location, size, and orientation of the lettering and signage at the pre-production meeting.

5) ***Pedestrian Safety:*** Exterior protrusions greater than 1/2-inch and within approximately 58 to 60 inches of the ground shall have a radius no less than the amount of the protrusion. The left side rear-view mirror and required lights and reflectors are exempt from the protrusion requirement. Grilles, doors, bumpers and other features on the sides and rear of the bus shall be designed to minimize the ability of unauthorized riders to secure toeholds or handholds.

6) ***Passenger Windows:*** A minimum of 20,000 square inches of window area, including door windows, shall be required on the standard configuration 40-foot bus.

7) ***Passenger Doors:*** Two doors shall be provided in the right side of the bus for passenger ingress and egress. The front door shall be forward of the front wheels. The rear door shall be forward of the rear axle.

1.05 Body Structure

1) The OEM shall ensure that the bus structure is suitable for the electric propulsion system and can be operated safely for the transit service conditions in Duluth, MN. The electric vehicle structural frame shall be designed to operate with minimal maintenance throughout the 12-year operating useful life period of the vehicle.

2) The basic frame structure shall be a semi (or full)-monocoque design or approved equal. The DTA requires a stainless steel (304) chassis. The structure shall feature full length longitudinal members throughout, with cross-members, pillar, roof bows and bulkheads. The total girder type structure shall be designed for maximum strength, reliability and durability. All joints shall be welded.

The DTA shall inspect the vehicle at three years, six years and nine years in

accordance with Contractor's procedures provided prior to the inspection interval. Upon completion of the inspection, Contractor shall provide the DTA will all materials needed to maintain this warranty.

The body assembly shall be modular and comprised of lightweight and corrosion resistant aluminum and composite materials. The body frame assembly shall be of modular bolt-together industry proven aluminum construction. This type construction allows similar attachment of various body modules, as well as interior and exterior accessories and handrails, without the structural compromise or potential water leaks of drilled holes. Vertical and horizontal aluminum extrusion framing members shall be joined by a keyed aluminum casting with precision angles and using the bolted compression method. Drilled holes or welds shall not be used in joining these members.

The body attachment to the chassis shall be directly to the chassis, with the main attachments in the heavy steel side impact section of the chassis. In order to achieve maximum strength, maximum durability, and close-tolerance alignment, all body attachments shall be by high strength steel treated bolts, and/or shims as required. Special care shall be given to insulate the aluminum body from the stainless-steel chassis to discourage galvanic action.

3) Strength and the Fatigue Life: Under conditions of transit service throughout the service life of the bus, the basic structure shall withstand fatigue damage that is sufficient to cause Class 1 or Class 2 failure. The structure shall also withstand impact and inertial loads due to street travel throughout the bus's service life without permanent deformation or damage. Material: Reinforced glass fiber and plastic materials will be excluded from the structural body construction, except for replaceable panels, doors, coverings for the structural body, and except that steel reinforced glass fiber wheel-wells are permitted. Fiberglass caps in the front and rear are permissible; 0.18-inch-thick fiberglass exterior roof panels are acceptable.

Reinforced glass fiber and plastic materials will be excluded from the structural body construction, except for replaceable panels, doors, coverings for the structural body, and except that steel reinforced glass fiber wheel-wells are permitted. Fiberglass caps in the front and rear are permissible.

Ceiling trim panels shall be melamine or equal, 1/8-inch minimum thickness, in color specified by the purchaser.

4) Distortion: The bus at GVWR and under static conditions shall not exhibit deformation or deflection that impairs operation of doors, windows, or other mechanical elements. Static conditions include the vehicle at rest with any one wheel or dual set of wheels on a 6-inch curb or a 6-inch deep hole.

5) Resonance: All structure, body, and panel-bending mode frequencies, including vertical, lateral, and torsional modes, shall be sufficiently removed from all primary excitation frequencies to minimize audible, visible, or sensible resonant vibrations during normal service.

6) Corrosion: All Offerors should be aware of the harsh climate the DTA operates in

and therefore its extreme concern with the corrosion resistant properties of the bus. The bus must resist corrosion from atmospheric conditions and road salts and deicing materials. It will maintain structural integrity and nearly maintain original appearance throughout its service life or 12 years or 500,000 miles, whichever comes first, with the DTA's use of proper cleaning materials and neutralizing agents.

All materials that are not inherently corrosion resistant shall be protected with corrosion resistant coatings. All joints and connections of dissimilar metals will be corrosion resistant and will be protected from galvanic corrosion. The main welded structures (under - structure, roof, sides and, ends) are to be joined to make a complete welded structure. Threaded holes must be plugged to prevent damaging threads. All lap joints are to be sealed to prevent moisture creeping into areas where the primer will not reach.

The manufacturer shall be responsible for all damage caused by corrosion for the first seven years of use on the chassis. This includes all parts and labor.

Proposers may offer equals to the DTA's requirements under this Section. But all Proposers are required to meet **all** the DTA's requests for corrosion **or** to strongly support their Proposal by either providing themselves or paying the DTA to replace parts, and recoat as necessary at 3, 6, and 9 years of life for the vehicle. E coating radiators, hydraulic cooler.

Upon request, all Proposers shall submit test results using ASTM Procedure B-117 of a 336-hour (2-week) salt spray test of all structural components that shows no structural detrimental effects to visible surfaces, and no weight loss over 1 percent.

Radiators that are E-coated are acceptable, as is a hydraulic cooler core made of aluminum with an electrostatic epoxy plastic powder coated steel housing.

7) ***Jacking:*** Jacking from a single point shall permit raising the bus sufficiently high to remove and reinstall a wheel and tire assembly. Jacking pads or points located on the axle **or** suspension near the wheels shall permit easy and safe jacking with the flat tire or dual set on a 6-inch high run-up block not wider than a single tire. Jacking and changing any one tire shall be completed by a 2M serviceman in less than 30 minutes from the time the bus is approached. The bus shall withstand such jacking to a height sufficient to change a wheel **or** 18 inches whichever is less at any one or any combination of wheel locations without permanent deformation or damage.

8) ***Hoisting:*** The bus axles **or** jacking plates shall accommodate the lifting pads of a 2-post hoist system. Jacking plates, if used as hoisting pads, shall be approximately 5 inches square or round, with a turned-down flange not less than 1 inch deep on each side to prevent the bus from falling off the hoist. Other pads or the bus structure shall support the bus on jack stands independent of the hoist.

9) ***Firewall Protection:*** The passenger and propulsion compartments shall be separated by a bulkhead(s) which shall, by incorporation of fire-resistant materials in its construction, be a firewall. This firewall shall preclude or retard propagation of a propulsion compartment fire into the passenger compartment. Only necessary

openings shall be allowed in the firewall, and these shall be fire resistant. Any passageways for the climate control system air shall be separated from the propulsion compartment by fireproof materials. Piping through the bulkhead shall have copper, brass, or fire-resistant fittings sealed at the firewall with copper or steel piping on the forward side. Nelson's Fire Stop Putty in lieu of fire-resistant fittings is accepted as an approved equal.

Wiring may pass through the bulkhead only if connectors or other means are provided to prevent or retard fire propagation through the firewall. Aluminium bulkhead connectors are accepted. The conduit and bulkhead connectors shall be sealed with fireproof material at the firewall. Propulsion access panels in the firewall shall be fabricated of fireproof material and secured with fireproof fasteners. These panels, their fasteners, and the firewall shall be constructed and reinforced to minimize warping of the panels during a fire that will compromise the integrity of the firewall. Fire protection systems must meet or exceed FMVSS 302. Firewalls made of high tensile steel are approved.

10) ***Towing:*** Buses must have a provision for towing both on street and via flatbed or lowboy truck. Towing provisions must be included in Contractor's Proposal.

11) ***Crashworthiness:*** The bus body and roof structure shall withstand a static load equal to 150% of the curb weight evenly distributed on the roof with no more than a 6-inch reduction in any interior dimension. Windows shall remain in place and shall not open under such a load. The bus shall withstand a 25-mph impact by a 4,000-pound, post 1973, American automobile at any point, excluding doorways, along either side of the bus with no more than 3 inches of permanent structural deformation at seated passenger hip height. This impact shall not result in sharp edges or protrusions in the bus interior. Exterior panels shall withstand a static load of 2,000 pounds applied perpendicular to the bus by a pad no larger than 5 square inches. This load shall not result in deformation that prevents installation of new exterior panels to restore the original appearance of the bus.

12) ***Leakage Test:*** All buses covered by this specification shall, during the course of their manufacture, be subjected to a water test by the manufacturer to determine body leaks. Manufacturer shall take the necessary corrective action when body leaks are found to exist and conduct a second water test to recheck following corrective action.

13) ***Rain Gutters:*** Gutters shall be provided to prevent water flowing from the roof onto the side windows and passenger doors. When the bus is decelerated, the gutters shall not drain onto the windshield, or driver's side window, or into the door boarding area. Cross sections of the gutters shall be no less than 0.25 square inches.

14) ***License Plates:*** License plate provisions at the rear of the bus shall be recessed or surface mounted, there will be one rear position.

15) **Rubrails:** Rubrails are not preferred or required. If rubrails are included in the base design, they shall be composed of black, flexible, resilient rubber-like material will be provided to protect both sides of the coach body from damage caused by minor sideswipe accidents with automobiles. Rubrails will have vertical dimensions of no less

than 1 ½ inches with the centerline no higher than 33 inches above the ground. The rubrail will be capable of withstanding impacts as required in the FTA White Book crash test. The rubrail may be discontinued at doorways. A damaged portion of the rubrail will be replaceable without requiring removal or replacement of the entire rubrail.

1.06 INTERIOR

1) ***Headroom:*** Headroom above the aisle and at the centerline of the aisle seats shall be no less than 78 inches. At the centerline of the window seats, headroom shall be no lower than the required top of the side window. Headroom at the back of the rear bench seat may be reduced to a minimum of 50 inches at the rearmost sitting area of the rear bench, but it shall increase to the normal ceiling height at the front of the seat cushion. In any area of the bus directly over the head of a seated passenger and positioned where a passenger entering or leaving the seat is prone to strike his/her head, padding shall be provided on the overhead panelling.

2) ***Driver Barrier:*** A barrier or bulkhead of 1/4-inch thick double-faced melamine or equal, between the driver and the left front passenger seat shall be provided. The barrier shall eliminate glare and reflection in the windshield directly in front of the barrier from interior lighting during night operation. The barrier shall extend from the top of the interior left-hand wheelhouse cover, to within 1-inch of the ceiling and shall fit the bus side windows and wall to prevent passengers from reaching the driver or his personal effects.

A metal coat hook and securing straps for the operator's jacket will be provided on the driver's barrier. A Secure Diagnostic Station box located on the wheelhouse acting as the upper portion of the driver partition, and the wheelhouse acting as the lower portion of the driver partition is acceptable.

3) ***Driver Security Barrier*** A full-length Driver Security Barrier with “extended glass” to act as a barrier between the driver and passengers entering the bus shall be installed between the driver seat and the passenger entry. The barrier shall be constructed of scratch resistant anti-glare glass or plexiglass that permits unobstructed view of the curbside mirror. Door hinges must be stainless steel piano hinges or rotary hinges and the latch must be easily operated from the interior of the driver compartment. The door must include a non-motorized extended glass sliding window that can be easily operated with one hand and be lockable from the inside.

4) ***Modesty Panels:*** Sturdy divider panels throughout the bus shall be required. Modesty panels may be installed at the sides of longitudinal seats when the required armrests are integral. These dividers shall be mounted on the sidewall and shall project toward the aisle no further than passenger knee projection in longitudinal seats or the aisle side of the transverse seats. Modesty panels shall extend no higher than 6-inches higher than the lower daylight opening of the side windows and those forward of transverse seats shall extend to within 1¼ = ¼-inch of the floor. Panels forward of longitudinal seats shall extend to

below the level of the seat cushion. Dividers positioned at the exit doors shall provide no less than a 2¼-inch clearance between the modesty panel and the opened door to protect passengers from being pinched. The modesty panel and its mounting shall withstand normal kicking, pushing, and pulling loads of 200-pound passengers without permanent visible deformation.

Modesty panels shall at a minimum be located aft of the front door opening (full height above the curb side wheelhousing); ahead of the rear door opening, aft of the rear door opening, and across the front of the upper deck where necessary to provide modesty and safety to seated passengers.

1.07 FLOOR

1) ***Material:*** Composite Floor is required – wood products are not acceptable. Stainless steel screws shall be used to set flooring, along with adhesive. Silkaflex is an approved adhesive. The floor is secured to the structure using adhesive and tapping screws outside of the main rails (center aisle). Down the center aisle the fasteners in tapping plates are used on every 12-inch center every 24 inches longitudinally (every floor support).

Due to the amount of salt and other corrosive solvents that are carried on boots and shoes into the passenger area of the bus, zinc floor fasteners are not accepted as an approved equal.

3) ***Strength:*** The floor deck may be integral with the basic structure or mounted on the structure securely to prevent chafing or horizontal movement. Sheet metal screws shall not be used to retain the floor and all floor fasteners shall be serviceable from one side only. Tapping plates used for the floor fasteners shall be no less than the same thickness as a standard nut, and all floor fasteners shall be secured and protected from corrosion for the service life of the bus. The floor deck shall be reinforced as needed to support passenger loads at GVWR. The floor shall have an elastic deflection of no more than 0.60-inch from the normal place. The floor shall withstand the application of 2.5 times gross load weight without permanent detrimental deformation. Floor and step treads, with covering applied, shall withstand a static load of at least 150 pounds applied through the flat end of a 1/2-inch diameter rod, with 1/32-inch radius, without permanent visible deformation.

3) ***Slope:*** The floor shall be a continuous flat plane from the entrance at the front of the vehicle to the rear exit door, except at the wheel housings, but it shall not interfere with the passenger seating. The floor design shall consist of two levels (bi-level construction). Aft of the rear door position extending to the rear settee riser, the floor height may be raised to a height approximately 18 inches above the lower level. The slope may not exceed 3.5% for any distance greater than 14 inches.

An increase slope shall be allowed on the upper level not to exceed 3-1/2 degrees off the horizontal along the front-to-back axis of the bus. New Flyer's sloped floor transition at front entrance and exit doors to have lower step heights

is approved. Also the floor sloped at front axle about 2 degrees and at upper deck about 5 degrees to accommodate Voith transmission is approved.

4) ***Edges:*** Where the flooring meets the walls and the wheel wells of the bus, coved edging is required to prevent debris accumulation between the floor and wheel housings. Flooring that is butted tightly together between the floor and the wheel housing and then sealed is not permitted. All interior mouldings shall be smooth and free of sharp edges and designed to last the life of the vehicle.

The upper flooring may be a butted joint.

5) ***Floor Protection:*** The floor, as assembled, including any manufacturer's required sealant, attachments and covering shall be waterproof or made of non-absorbent materials, non-hygroscopic, resistant to wet or dry rot, resistant to mold growth and impervious to insects. Composite flooring is accepted as an approved equal.

6) ***Fastening:*** Interior panels shall be attached so that there are no exposed edges or rough surfaces. Panels and fasteners shall not be easily removable by passengers. Interior trim fasteners, where required, shall be rivets, cross-recessed head screws, or tamper proof screws.

7) ***Access Openings:*** These openings in the floor shall be sealed to prevent entry of fumes and water into the bus interior. Flooring materials shall be flush with the floor and shall be edge-bound with stainless steel to prevent the edges from coming loose. Access openings shall be non-symmetrical so that the ribs of reinstalled flooring shall be properly aligned. Fasteners shall tighten flush with the floor. Flooring materials to be edge-bounded with stainless steel or aluminum where necessary. Stainless steel is preferred to deter corrossion. Replacement parts must be available for hatch and latches.

1.08 WHEELHOUSING

1) ***Construction:*** Front wheelhousings shall be a matte finish, constructed of 14 gauge or 16-gauge 304 stainless steel. Rear wheelhousings shall be constructed of 14 or 16-gauge stainless steel. Wheelhousings as installed and trimmed, shall withstand impacts of a 2-inch steel ball with at least 200-foot pounds of energy without penetration. Lower portion trim shall be unpainted stainless steel only. If metal is used in construction of the wheelhousing, it shall be covered on the interior by the same material as the floor covering.

2) ***Splash Aprons:*** Splash aprons of 1/4-inch thick fabric reinforced rubber shall extend to within 3-inches of ground. The front aprons shall be installed either behind or in front of the front wheels. Rear splash aprons installed behind the rear wheels may be sectional but shall extend full width of the bus to protect all rear compartments from road splash. Splash aprons and their attachments will not be included in the road clearance measurements. Front wheelhousings shall also have a brush to minimize splashing.

4) ***Fender Skirts:*** Fender skirts may be applied to exterior contour of wheelhouses for finished appearance and to control wheel splash. They may extend beyond allowable vehicle width if they are flexible. Tires are removed without removal of skirts.

1.09 DOORS

1) ***Materials:*** Pnuematic doors are preferred. Structure of the doors, their attachments, inside and outside trim panels, and any mechanism exposed to the elements shall be durable and corrosion-resistant. Door construction shall be of extruded aluminium with bonded single skin construction. The doors, when fully opened, shall provide a firm support (grab-bar) and shall not be damaged if used as an assist by passengers during ingress or egress.

2) ***Front Door:*** Front entrance door on right-hand side ahead of front wheel shall be two section Vapor slide-glide type or approved equal. The clear opening inside grab rails shall be at least 34-inches wide and 76.1 inches high with the door open. Mating edges shall be of the overlapping type and provide a minimum of 4 inches between the metal door edges. Ameriview bolted door panels are approved equals.

   New Flyer's Ameriview bolted door panels are approved equals.

3) ***Rear Door:*** Rear exit door on right-hand side ahead of rear wheels shall be a two section Vapor Slide glide or swing type door or approved equal with clear opening of at least 30 inches wide. The doors shall have pneumatic sensitive edges for safety protection as well as touch bars for passenger operation. Door height shall be a minimum of 75.1 inches.

4) ***Glazing:*** Both rear and front doors shall have full length glazing in all door panels. The rear door may have split glazing. Glazing shall be 1/4-inch (6 mm) laminated safety glass.

5) ***Projection:*** Exterior projection of the doors shall be minimized and shall not exceed 19-inches during the opening or closing cycles or when doors are fully opened. Projection inside the bus shall not exceed 20 inches. The doors, when closed, shall be effectively sealed and the hard surfaces of the doors shall be at least 4 inches apart. Pantographic type rear doors are not acceptable. A brush-type gap filler shall be provided at the bottom edge of all doors to reduce the entry of wind, dirt, and water.

6) ***Control:*** Front and rear doors shall be fully air operated with pneumatic door engine, with a five-position door control valve with single lever handle operating in a horizontal plane.

   Operation of, and power to, the passenger doors shall be completely controlled by the driver. Rear doors shall open via the Vapor Class System or approved equal or via passenger-controlled touch bars. Doors shall open or close completely in 1.5 to 3.0 seconds from the time of control actuation and shall be

subject to adjustment requirements of Subsection (8). A control or valve in the driver's compartment shall shut off the power to, and/or dump the power from, the front door mechanism to permit manual operation of the front door with the bus shut down. A master door switch which is not within reach of the seated driver shall when set in the "Off" position, close the doors, deactivate the door control system, release the interlocks and permit only manual operation of the doors. There will be a rear door override that will allow the opening of the door and allowing it to stay open when the bus is not in operation.

7) ***Door Interlocks:*** To preclude movement of the bus, an accelerator interlock shall lock the accelerator in the closed position and a brake interlock shall engage the service brake system to stop movement of the bus when the driver's door control is moved to the rear door enable or open position, or rear door panel is opened more than three inches from the fully closed position (as measured fat the leading edge of the door panel.) The interlock engagement shall bring the bus to a smooth stop and shall be capable of holding a fully loaded bus on a 6 percent grade with the transmission (if provided) in gear until the interlocks are released. These interlock functions shall be active whenever the vehicle master switch is in any run position.

The braking effort shall be adjustable with hand tools only, from zero effort to the maximum capability of the rear axle brakes. The adjustment device shall be enclosed in a tamper-proof housing, if located inside the bus. A non-adjustable braking effort set to 45 PSI is approved as an equivalent to service brake application.

All door systems employing brake and accelerator interlocks shall be supplied with supporting failure mode effect analysis documention that demonstrates that failure modes are of a failsafe type, thereby never allowing the possibility of release of the interlock while an interlocked door is in an unsecured condition, unless the door master switch has been intentionally actuated to release the interlocks. Respondents are not required to submit the documentation with their Proposal, but will be required submit the documentation within 5-days of a written request from the DTA, or at the pre-production meeting, whichever is sooner.

8) The door interlocks should be disabled above 3 miles per hour.

9) ***Closing Force:*** No more than a 10-pound force shall be imposed on a 1 square-inch area of any passenger struck by a closing rear door. A maximum force of 35 pounds shall be required for a passenger to free himself after having either door close upon him, even if the sensitive edge or safety device on the rear door is inoperative.

10) ***Actuators:*** Each door shall be powered by a single actuator and motor (such as those manufactured by Vapor) which shall be both rebuildable and adjustable in such a manner so that the door opening and closing speeds can be independently adjusted from one second up to three seconds. Door actuators shall be adjustable so that the door opening and closing speeds can

be independently adjusted from one second up to three seconds. Actuators and the complex door mechanism shall be concealed from passengers but shall be easily accessible for servicing. All elements of the door and actuator system shall operate without a Class 3 failure for 50,000 miles on the design operating profile.

11) Emergency Operation: In the event of an emergency, it shall be possible to open the doors manually from inside the bus using a force of no more than 25 pounds after actuating an unlocking device at each door. The unlocking devices shall be clearly marked as an emergency only device and shall require two distinct actions to actuate. The door emergency unlocking device shall be accessible at the door areas. When this emergency device is actuated, the door interlock brake system shall apply to stop the bus.

Locked doors shall require a force of more than 100-pounds to open manually. When the locked doors are manually forced to open, damage shall be limited to the bending of minor door linkage with no resulting damage to the doors, engines, and complex mechanism.

1.10 SERVICE COMPARTMENTS AND ACCESS DOORS

1) Interior: Access for maintenance and replacement of equipment shall be provided by panels and doors that appear to be an integral part of the interior. Removal of fixtures or equipment unrelated to the repair task to gain access shall be minimized. Access doors shall be installed with spring hinges or gas filled props, as necessary to hold the doors out of the mechanic's way. Retention of all interior access panels, except on the door actuator compartments, shall be with tamper proof screws. Panel fasteners shall be standardized so that only one tool is required to service all special fasteners within the bus. All fasteners that retain access panels will be captive in the cover.

Access doors for the door actuator compartments shall be secured with hand screws or latches and shall prevent entry of mechanism lubricant into the bus interior. All fasteners that retain access panels shall be captive in the cover.

Access openings in the floor will be sealed to prevent entry of fumes, road noise, and water into the bus interior. Flooring material will be flush with the floor and will be edge-bound with stainless steel to prevent the edges from coming loose. Access openings will be non-symmetrical so that the ribs of reinstalled flooring will be properly aligned. Fasteners will be tightened flush with the floor.

2) Exterior: Conventional or pantograph hinged doors shall be used for the rear propulsion compartment and for all auxiliary equipment compartments including doors for checking liquid to the windshield washer reservoir and for access to the battery compartment master switch. Access to these compartments shall be from outside the bus. Access openings shall be sized for easy performance of tasks within the compartment including tool operating space. Access door shall be of rugged construction. They shall close flush with the body surface.

All doors shall be hinged at the top or on the forward edge and shall be prevented from coming loose or opening during transit service or in the washing operations. Large access doors with horizontal hinges and safety props are also acceptable. All access doors shall be retained in the open position by counterbalancing with over-center or shock supports or gas struts. Springs and hinges shall be corrosion-resistant. Latch handles shall be flush with, or recessed behind, the body contour and shall be sized to provide an adequate grip for opening. Large access doors shall hinge up and out of the way or flat against the bus body and shall be easily openable by one person. These doors, when opened, shall not restrict access for servicing other components or systems. Major access doors shall be equipped with locks requiring a nominal 5/16-inch, square end tool to open. The locks shall be standardized so that only one tool is required to open all major access doors on the bus. All exterior access doors have stainless steel hinges.

1.11 WINDSHIELD WIPERS AND WASHERS

1) ***Wipers:*** The bus shall be equipped with a variable speed (including intermittent) heavy duty windshield wiper for each half of the windshield. They will be electrically operated. No part of the windshield wiper mechanism shall be damaged by manual manipulation of the arms. At 60 mph, no more than 10% of the wiped area shall be lost due to windshield wiper lift. Both wipers shall park along the edges of the windshield glass. Windshield wiper motors and mechanisms shall be easily accessible for repairs or service from outside the bus.

2) ***Washers:*** The windshield washer system shall deposit washing fluid on the windshield and when used with the wipers, shall evenly and completely wet the entire wiped area.

   The windshield washer system shall have a minimum 2.5-gallon reservoir, located for easy access. Reservoir pumps lines and fittings shall be corrosion-resistant and the reservoir itself shall be translucent for easy determination of fluid level. An exterior access door for filling the tank shall be provided. The windshield washer system will be protected with an antifreeze washer solution to -20^0 F regardless of season of delivery. The protected solution will be tinted to provide easy visual indication that the washer solution is present.

1.12 LIGHTING, CONTROLS, INSTRUMENTS

1) ***Exterior Lighting:*** **All exterior lights, including headlights, shall be LED**. All exterior lights shall be sealed to prevent entry and accumulation of moisture or dust, and each lamp shall be replaceable in less than 5 minutes by a 2M mechanic. All exterior lamps will be designed to operate on 12 VDC. Lights mounted on the propulsion compartment doors shall be protected from the impact shock of door opening and closing. Lamps, lenses and fixtures shall be interchangeable to the extent practical. Lamps at the rear of the bus shall be visible from behind when the propulsion service doors are opened.

   Visible and audible warning shall inform following vehicles or pedestrians of

reverse operation. Visible reverse operation warning shall conform to SAE Standard J593. Audible reverse operation warning shall conform to SAE. Recommended Practice J994-Type C or D.

Lamps at the front and rear doors shall activate only when the doors open and shall illuminate the street surface to a level that meets or exceeds ADA requirements. The lights may be to be positioned below the lower daylight opening of the windows and shall be shielded to protect passengers' eyes from glare. One light shall be located above the rear door for this purpose. The lights may be positioned above or below the lower daylight opening of the windows and will be shielded to protect passengers' eyes from glare. These lighting systems must at a minimum provide a minimum of 3-foot candle of light, 5-foot candle of light three feet from the bus is preferred.

2) ***Headlights:*** Front headlights are to be r LED lights, LED/halogen sealed beam type, four (4) in total and located horizontally or approved equal. The outboard headlight shall be dual type with low beam and high beam capacity are desired, but single headlamps are also acceptable. The adjacent or inboard headlight shall be capable of high beam only. High beam, low beam functions shall be controlled by a driver's foot switch, sealed and protected from moisture. Sealed beam units shall be latest type and low beam rating of 320-hour rack life, at 12 volts. Low voltage daytime running lights are required. Dialight LED low beam outer and GE Halogen High Beam inner lights are approved.

A combination of LED for low beam and high intensity halogens for the high beams, and front LED round turn signal lights are approved.

3) ***Directional Signals:*** Directional signals shall be 2-inch x 6-inch rectangular 4-inch round, or oval at the front 4-inch diameter and 4-inches in diameter at the rear and shall meet FMVSS standards. All shall be LED. Front lights shall have a sealed amber/reflective lens; rear lights shall have a sealed amber lens. Directional signals shall be controlled by two (2) foot switches on the floor.

4) ***Stop, Taillights, and accident prevention system:*** There shall be eight (8) 4-inch diameter round lamp assemblies to give indication of direction, stop/tail and back-up operation. Three (3) lights shall be vertically mounted on each side. The lamps shall be mounted on the corner pillars so that they are visible even when the door is open, to provide warning to oncoming vehicles if the vehicle is disabled along the road and to maximize service access when rear and side closure doors are opened. The top light shall be amber, the middle two red, and the lower clear or white. The rear stop, turning, taillights, and accident prevention lights shall be LED lights.

The bus will be equipped with a rear accident prevention system mounted above the propulsion equipment compartment door (all LED lights). These lamps will be electrically connected to the rear brake lights. The lights will stay lit whenever the rear brake lights are activated.

The accident prevention lights will be amber and flash when any of the doors of the bus open. There will be four amber lamps centered above the engine door. **Wiring**

for the accident prevention system as per spec will be provided along with a hole in the bus surface. DTA will separately purchase and attach these lights.

THE DESIGN, MOUNTING, AND LOCATION OF THE REAR ACCIDENT PREVENTION LAMPS WILL BE SUBJECT TO DTA'S REVIEW AND APPROVAL.

5) ***Marker Lights:*** Individual roof marker lights shall be provided at each corner of bus, with amber front and red rear lens, or reflective decals at intermediate locations and intermediate maker lights at the roof line are acceptable. Intermediate marker lights with amber lens shall be provided at normal height (there is no requirement for a rubrail) at center of each side of the bus. LED Required. Dialight is acceptable.

6) ***Identification Lights:*** Identification lights (Michigan marker lights, individual type) to be mounted at front and rear center of roof crown panels, front to be circular or rectangular amber lens, rear to have rectangular red lenses. LED Required. Dialight marker lights are accepted as an approved equal.

7) ***Side Directional Lights:*** Two (2) side directional light with an amber lens, to function with front and rear directional signals, shall be mounted just rearward of the front wheel well on each side of the bus. LED Required. Directional lights located at forward of the rear wheel well and forward of the street side front wheel well is approved.

8) ***Hazard Lights:*** A circuit shall be provided for the directional signals which, when on, will cause them to function as traffic hazard warning signals. LED Required.

9) ***License Light:*** A recessed rear license plate with a two (2) candlepower license plate light shall be provided in the license plate well. LED Required.

10) ***Service Area Lighting:*** Lights shall be provided in the propulsion compartment to generally illuminate the area for night emergency repairs or adjustments. The lights shall be controlled by a switch located near the rear start controls (if provided) in the propulsion equipment compartment.

11) ***Passenger Interior Lighting:*** Proposers are encouraged to consider novel interior lighting applications to meet the aesthetic goals of the buses as well as the needs of people with low vision and light sensitivity. The lighting will have the ability to be programmed for a minimum ambient light level while the bus is in motion and be adjustable to a brighter setting during loading and offloading. Individual passenger lights at each seat may be an option. An overhead LED lighting system will provide general illumination in the passenger compartment and will be controlled independent of the run switch. The system will provide no less than 15-foot candles of illumination on a one-square-foot plane at an angle of 45 degrees centered 33 inches above the floor and 24 inches in front of the seat back at each seating position except at the rear cross seat where the illumination may be decreased to seven-foot candles. All fixture covers will attach with screws or filler strips that snap into the light panel extrusion. The overhead interior lighting system shall be LEDs. Pretoria LED interior lighting with programming capability, and Pretoria Gen4 LED lighting are approved. I/O Controls Corp interior lighting system is

accepted as an approved equal. New Flyer of America Genuine interior LED lighting is accepted as an approved equal.

The floor surface in the aisle will be illuminated at no less than ten-foot candles. Novel floor lighting may be considered to define different areas of bus, such as wheelchair locations, bike racks, special storage provisions, etc.

The floor surface in the vestibule will be illuminated to no less than four-foot candles with the front door open and to no less than two-foot candles when the front door is closed. ADA standards may again be substituted, the new generation Luminator system is acceptable. LED light fixtures will be located above the side windows at or near the juncture of the bus ceiling and the side wall and may be provided over the rear door. LED lighting will not be installed above the driver's side window and the front door.

Lamp fixtures and lenses will be fire resistant and will not drip flaming material onto seats or interior trim if burned. Advertising media located in this area will be illuminated by back or direct lighting, although the interior lighting requirements will be attained without advertising media installed. The fixtures will be sealed to prevent accumulation of dust and insects but will be easily operable on hinges for cleaning and service. The lenses will be retained in a closed position and if threaded fasteners are used, they must be captive in the lens with cross-recessed type heads. Power supplies will be enclosed with fireproof material and will be located at the individual light fixtures. Power supplies will be inaudible with an operating frequency above 18,000 Hz. Interchangeability of LED lamps, lenses, fixtures, and power supplies will be maintained.

The forward left and right hand interior light fixtures will be so designed as to automatically extinguish when the front passenger door is closed. When the front passenger door is opened and the interior lights are on the forward left and right hand, interior light fixture will come on. A toggle switch on the driver's instrument panel will allow the driver the option of keeping the forward interior lights on constantly.

A stepwell lighting system will be illuminated when the master switch is in RUN and NIGHT/RUN, except the front stepwell lamps which will be extinguished when the doors are closed. The system will provide no less than five-foot candles of illumination on the entry and exit step treads with the doors open. These lights will be shielded to protect passengers' eyes from glare. Light fixtures will be totally enclosed, splashproof, designed to provide east of cleaning as well as lamp and housing removal, and will not be easily removable by passengers. Stepwell lights will be protected from damage caused by passengers kicking lenses or fixtures and will not be a hazard to passengers.

Lighting (in floor or by the steps) by interior steps shall be LED with a service life of at least five years. Wiring for this system shall be corrosion resistant and protected from moisture.

12) Driver's Lighting: The driver's area shall have a light to provide general

illumination and it shall illuminate the half of the steering wheel nearest the driver to a level of 5' candles. This light shall be controlled by a switch that is convenient to the driver.

13) ***Driver Control:*** All switches and controls necessary for the operation of the bus shall be conveniently located in the driver's area and shall provide for ease of operation. Switches and controls shall be essentially within reach. In general, it is recommended that Contractor should use SAE J833, "Human Physical Dimensions" when designing the driver control area. Controls shall be located so that boarding passengers may not easily tamper with control settings. All switches shall be illuminated for night vision. Rocker switches are acceptable.

14) ***Accelerator/Brake Pedals:*** Accelerator and brake pedals shall be designed for ankle motion. Foot surfaces of the pedals shall be faced with wear-resistant, non-skid, replaceable material. Pedal travel shall be limited by stops under the pedals. Non-adjustable foot pedals are acceptable. Controls for bus operation shall be closely grouped within the driver's compartment. These controls include separate master run switch and start or button switch.

15) ***Run Switch:*** The run switch shall be a four-position switch with the following functions:

PROPULSION STOP - All electrical systems off, except when the I/O is active for power available for the interior lighting, stop lights, turn lights, hazard lights, silent alarm, horn, propulsion compartment lights and run box, auxiliary heater, fire detection/suppression system, and fare box wiring for a period of 15 minutes. When the I/O switches off, all electrical systems shall be off except fire detection system and farebox wiring.

NITE/PARK - All electrical systems off, except those listed in OFF and power to radio and marker lights.

DAY/RUN - All electrical systems and propulsion system on, except the headlights, parking lights, and marker lights.

NITE/RUN - NITE/PARK- All electrical systems and propulsion system on. The door control, kneel control, windshield wiper/washer controls and run switch shall be in the most convenient driver locations. They shall be identifiable by shape, touch, and markings. Doors shall be operated by a single control, conveniently located and operable in a horizontal plane by the driver's left hand. The setting of this control shall be easily determined by position and touch. Turn signal controls shall be floor-mounted, foot-controlled, waterproof/water resistant, heavy-duty, momentary contact switches. A master run switch with the following decals and controls: Stop Engine; Day Run; Night Run; Night Park is approved.

All switches and controls shall be marked with easily read identifiers. All panel-mounted switches and controls shall be replaceable, and the wiring at these controls shall be serviceable from the vestibule or the driver's seat. Switches, controls, and instruments shall be dust and water resistant. All required switches and controls are included in Table II.

16) ***Instrumentation:*** The speedometer, air pressure gauge(s), and certain indicator lights shall be located on the front cowl immediately ahead of the steering wheel. The steering wheel or rim shall not obstruct the driver's vision of the instruments when the steering wheel is in the straight-ahead position. Illumination of the instruments shall be simultaneous with the marker lamps. Glare or reflection in the windshield, side window, or front door windows from the instruments, indicators, or other controls shall be minimized; instruments and indicators shall be easily readable in direct sunlight.

Indicator lights immediately in front or in the side console of the driver shall include:

TABLE II

Warning Lights

- High headlamp beam
- Right turn
- Left turn
- Hazard Warning (may be common with turn signal indicators)
- Exit door open or unlocked
- Parking brake applied
- Service brakes applied (may be common with parking brake indicator)
- Stop request
- Wheelchair stop request
- Backup
- Daytime running lights (if equipped)

Switches

- Master run switch
- Start button or switch
- Kneel switch
- Turn signal switch(es)
- Interior lighting switch
- Instrument panel lighting intensity control
- Passenger chime switch
- Driver’s area light switch
- Hazard warning switch
- Horn button in steering wheel hub, protected to prevent accumulation of transfer punches in steering wheel hub (no identifier required)
- Foot-controlled headlight dimmer switch, waterproof/water resistant
- Diagnostic light panel test switch

Controls

- Accelerator pedal
- Brake pedal

- Door control
- Windshield wipers
- Windshield washers
- Interior climate control
- Defroster control
- Driver's heater control
- Parking/emergency brake control (actuation of brake, not control, shall be indicated to the driver)
- Transmission control (if transmission is included)
- Front door dump valve
- Public address system controls
- Destination sign controls (easily accessible without opening a compartment)

The instrument panel shall include a speedometer indicating readings in mph and kph. The speedometer shall be a rotating pointer type, with a dial deflection of 220° to 270° and 40 mph near the top of the dial. An integral odometer can be supplied as an option. A Vansco Intrument LCD display for additional indicators is accepted as an approved equal.

A multifunctional display dash is accepted as an approved equal.

The speedometer shall be sized and accurate in accordance with SAE recommended practice J678. The instrument panel shall also include air brake reservoir pressure gauge(s) with indicators for primary and secondary air tanks. The instrument panel and wiring shall be easily accessible for service from the driver's seat or top of the panel. Wiring shall have sufficient length and be routed to permit service without stretching or chafing the wires.

Fuel gauge for the auxiliary heater fuel on dash may be considered if available as an option.

An LED screen on the instrument panel to show gauge functions is approved.
A back up signal as part of the shift selector unit is approved.
A speedometer with an odometer or an electronic speedometer is also approved.

17) Onboard Operating System Diagnostics:

Critical systems or components shall be monitored with a built-in diagnostic system. This diagnostic system shall have visual and audible indicators. The diagnostic indicator lamp panel shall be located in clear sight of the driver but need not be immediately in front of him. The intensity of indicator lamps shall permit easy determination of on/off status in bright sunlight but shall not cause a distraction or visibility problem at night. All indicators shall have a method of momentarily testing the operation of the lamp. Wherever possible, sensors shall be of the closed-circuit type, so that failure of the circuit and/or sensor shall activate the malfunction indicator. An audible alarm shall sound when certain malfunctions are detected by the diagnostic system. The audible alarm shall be 80 to 83 dBA at the ear of a 5th to 95th percentile driver. Malfunction and other indicators listed in Table III shall be supplied on all buses.

Space shall be provided on the panel for future additions of not less than 3 indicators as the capability of on-board diagnostic systems improves. In lieu of space for future LED indicators for onboard diagnostics, additional visual indicators through an Instrument Panel's Touchscreen LCD is accepted as an approved equal.

Table III - Onboard Diagnostic Indicators

Visible Indicator	Audible Alarm	Function
Low state of charge	Yes	Per manufacturer's recommendations
Low air	Yes	Air system pressure low in primary or secondary reservoirs
Low coolant*	Yes	Radiator fluid level low
Generator stop	Yes or No	Generator not charging
Kneel activated	Yes	Kneeling system activated
A/C stop	No	Compressor off at high/low switch.
Fire	Yes	Over temperature in battery compartment.
ABS Fail	No	Failure of antilock braking
Check Transmission (if provided)	No	Transmission code sent
Check Propulsion System	Yes	Propulsion System code sent

*Visual indicators may be common; however, both functions shall be provided.

1.13 INTERIOR TRIM

1) General Requirements: The interior shall be generally pleasing, modern, and have no sharp depressions or inaccessible areas and shall be easy to clean and maintain. To the extent practical, all interior surfaces more than 10 inches below the lower edge of the side windows, or windshield shall be shaped so that objects placed on them fall to the floor when the bus is parked on a level surface. Handholds, lights, air vents, armrests, and other interior fittings shall appear to be integral with the bus interior. There shall be no sharp, abrasive edges and surfaces and no unnecessary hazardous protuberances. All plastic and synthetic materials used inside the bus shall be fire-resistant, except vinyl seat coverings which shall meet the requirements of FMVSS 302 for smoke/flammability on transit vehicles.

Materials shall be selected on the basis of maintenance, durability, appearance, safety, flameproof, and textile qualities. Trim and attachment details shall be kept simple and unobtrusive. Materials shall be strong enough to resist every day and vandalism; they shall be resistant to scratches and markings. Interior trim shall be secured to avoid resonant vibrations under normal operational conditions. Melamine, thermoplastics, kydex, polyethylene plastics, and transmagic GRP are all acceptable materials to be used in this area. Final color and patterns will be chosen by the DTA after the award.

2) ***Trim Panels:*** Side wall panels below the windows are to be constructed of 1/10-inch melamine**,** retained by anodized aluminium moldings or approved equal. Adhesive cushion strips are applied to frame before panels are applied.

The side window post cap mullions are to be constructed of 1/10-inch material. Painted material is not acceptable.

3) ***Headlining:*** Ceiling trim panels shall be melamine, or equal, 1/8-inch minimum thickness**.** Headlining shall be supported to prevent buckling, drumming, or flexing and shall be secured without loose edges. Adhesive cushion strips are applied to frame before panels are applied. Headlining materials shall be treated or insulated to prevent marks due to condensation where panels are in contact with metal members. Moldings and trip strips, as required to make the edges tamper proof, shall be stainless steel snap track. The outer edges of the panels are retained at the top of the side air duct/lighting fixture housing. Headlining panels covering operational equipment that is mounted above the ceiling shall be on hinges for ease of service but retained to prevent inadvertent opening. Ceiling insulation shall have an R value greater than or equal to 5 and with low water absorption and meet all Federal requirements. Polystyrene EPS is an acceptable material. Anodized aluminium trim J-moldings is accepted as an approved equal. Antique white ceiling panels made of ABS plastic is accepted as an approved equal.

4) ***Front End:*** The entire front end of the bus shall be sealed to prevent debris accumulation behind the dash and to prevent the driver from kicking or fouling wiring and other equipment with his feet. The front end shall be free of protrusions that are hazardous to passengers standing or walking in the front of the bus during rapid deceleration. Panelling across the front and any trim around the driver's compartment shall be formed metal, plastic or fiberglass material. Formed metal dash panels shall be painted and finished to exterior quality. Plastic dash panels shall be reinforced, as necessary, vandal-resistant, and replaceable. All colored, painted, and plated parts forward from the driver's barrier shall be finished with a dull matte black finished surface.

5) ***Rear End:*** The interior rear wall shall be carpeted and the riser below the rear seat will be ½-inch plywood, or stainless steel covered with matching rubber transit flooring. The rear bulkhead will be panelled with reinforced moulded fiberglass (gelcoated) or melamine. The ledge between the rear lounge seat and the propulsion equipment compartment will then be covered with carpet to dampen the sound. Access to rear electrical console is provided via a hinged panel.

6) ***Passenger Information and Advertising:*** Advertising media 11-inches high and 0.09-inch thick shall be retained near the juncture of the ceiling and side wall. The retainers may be concave and shall support the media without adhesives. The media shall be illuminated by the interior fluorescent lighting system or indirect LED lighting.

1.14 PASSENGER SEATS

1) ***Arrangements:*** Seating and interior trim shall have features to improve safety, comfort,

and capacity. The passenger seats shall be arranged in a transverse, forward facing configuration, except over the rear wheelhousings, wheelchair areas where seats may be arranged as appropriate with due regard for passenger access and comfort. As many seats as possible shall be forward facing and none shall be rear-facing. Seating capacity shall be 38 passengers or greater, including two wheelchair positions. Hip-to-knee room at all seating positions shall be no less than 26 inches using a fiberglass molded shell seat. Foot room, measured at the floor forward from a point vertically below the front of the seat cushion, shall be no less than 12 inches. Seats immediately behind the wheelhousings may have foot reduced, provided the wheelhouse is shaped so that it may be used as a footrest. Please provide a seating layout with Proposal materials. Seating layouts to be submitted with Proposal materials. Hip-to-knee room for cushioned seating option shall be minimum 26.5 inches at all seating positions in paired transverse seats immediately behind other paired transverse seating positions.

Each transverse, forward facing seat, except the rear seats, shall accommodate two passengers. Thickness of the transverse seat backs shall be minimized to increase passenger knee room. The area between the longitudinal seat backs and the attachment to the side walls shall be designed to prevent debris accumulation.

The aisle between the seats shall be no less than 24 inches wide at seated passenger hip height and 20 inches at standing passenger hip height. Minimum width of transverse seats shall be 34-inches. Final seating arrangements will be designed by the successful Proposer.

2) Structure and Design: The passenger seat and its supporting structure shall be cantilevered between entrance and exit doors and constructed and mounted so that space under the seat is maximized to increase wheelchair manoeuvring room and is completely free of obstructions to facilitate cleaning. The structure shall be fully cantilevered from the side wall with sufficient strength for the intended service. The lowest part of the seat assembly that is within 12 inches of the aisle shall be at least 10 inches above the floor. The underside of the seat and the side wall shall be configured to prevent debris accumulation and the transition from the seat underside to the side wall to the floor cover radius shall be smooth. Structural failure of any part of the seat or side wall shall not introduce a laceration hazard. Pedestal seating shall be installed in the raised rear section (if included in the configuration.) Cantilevered and T-Pedestal may also be used in combination.

The back of each transverse seat shall incorporate a handhold no less than 7/8-inch in diameter for standees and seat access/egress. The handhold shall not be a safety hazard during severe decelerations. The handhold shall extend above the seat back near the aisle so that standees shall have a convenient vertical assist, no less than 4 inches long that may be grasped with the full hand. This handhold shall not cause a standee using this assist to interfere with a seated 50th-percentile male passenger. The handhold shall also be useable by a 5th-percentile female, as well as by larger passengers, to assist with seat access/egress for either transverse seating position. The seat back handhold may be deleted from seats that do not have another transverse seat directly behind and where vertical assist is provided in accordance with Section 1.23. The handhold shall extend above the seat back near the aisle.

The handhold shall be thermoplastic. Armrests shall not be included in the design of transverse seats.

Composite resin handholds may be accepted as an approved equal.

Longitudinal seats shall be the same general design as transverse seats but without seat back handholds. Longitudinal seats may be mounted on the wheelhouses. When folded up, will make way for one wheelchair per unit of three each longitudinal seats. Armrests shall be included on the ends of each set of longitudinal seats except on the forward end of a seat set that is immediately to the rear of a transverse seat, the driver's barrier or a modesty panel and these fixtures perform the function of restraining passengers from sliding forward off the seat. Armrests are not required on longitudinal seats located in the wheelchair parking area that fold up when the armrest on the adjacent fixed longitudinal seat is within 1½-inches to 3½-inches of the end of the seat cushion. Armrests shall be located from 7-9 inches above the seat cushion surface.

The area between the armrest and the seat cushion shall be closed by a barrier or panel and still be constructed and trimmed to complement the modesty panels. The top and sides of the armrests shall have a minimum width of 2 inches and shall be free from sharp protrusions that form a safety hazard.

3) Construction and Materials: Seat material of the standard configuration seat shall be moulded fiberglass or approved equal. Any visually exposed metal of the standard seat structure including mounting brackets and other components shall be stainless steel. The seat shall be contoured for individuality, lateral support, and maximum comfort and shall fit the framework to reduce exposed edges. The seat back thickness shall not exceed 1/4-inches in the knee room area. Complete seat assemblies shall be interchangeable to the extent practical. The shell shall be recessed in seat and back areas to accept padded or fiberglass inserts.

Materials used shall minimize damage from vandalism and shall reduce cleaning time. The seat shall be contoured for lateral support, individuality, and comfort to each individual passenger, and constructed of energy absorbing materials. The upper rear portion of the seat back, seat back handhold, and upper rear surface of the modesty panels located immediately forward of transverse seats shall be constructed of energy absorbing materials.

All passenger seats will be either Transportation Seating (TSI) cantilevered design, American Seating InSight with the vandal resistant fabric seat inserts, USSC Gemini Passenger Seats, or an approved equal. **COLORS WILL BE CHOSEN AFTER THE BID AWARD WITH STANDARD COLORS APPROXIMATING THOSE PREVIOUSLY PURCHASED BY THE DTA.**

The minimum radius of any part of the seat back, handhold, or modesty panel in the head or chest impact zone shall be a nominal 1/4-inch. Seats, back cushions, and other pads shall be securely attached and shall be detachable by means of a simple release mechanism employing a special tool so that they are easily removed by the maintenance staff but not by the passengers. All seat cushions and backs shall be interchangeable throughout. All materials and workmanship shall conform to SPI standards and specifications in tests for plastic foam. Materials shall have high resistance to tearing,

flexing, wetting and shall comply with safety standards of White Book Docket 90A.

4) Wheelchair Position: Colors of these seats and inserts or cushions shall match rest of the seats on the bus. Flip-up seat (sets of two or three), shall be installed to accommodate parking space and secure tiedown for passengers in wheelchairs. These seat assemblies shall have the capabilities of folding up to make way for two wheelchairs. The tie-down positions shall be on either side of the bus, not both on the same side. Manoeuvring room inside the bus shall accommodate easy travel for two passengers in wheelchairs from the loading devise through the bus to the designated parking area and back out. Maneuvering must meet ADA standards.

Engineering diagrams should be included to confirm this. No portion of the wheelchair or its occupant shall protrude into the normal aisle of the bus when parked in the designated parking space. As a guide no width dimension should be less than 34 inches, areas requiring 90^0 turns of wheelchairs should have a clearance arc dimension no less than 45 inches and in the parking area where 180º turns are expected, space should be clear in a full 48-inch diameter circle. A vertical clearance of 12 inches above the floor surface should be provided on the outside of turning areas for wheelchair footrest clearance.

Lights shall be provided above doorways or adjacent to the stepwell to floodlight the loading area. The lamps shall illuminate when the bridge plate is in operation and shall illuminate the street surface as per previous specification. This seat assembly shall be equipped with fold-down seats for use when no wheelchair is parked. Wheelchair position, chair restraints and passenger tiedown shall meet all ADA laws and Federal safety requirements.

1.15 DRIVERS SEAT

Driver's Seat: The driver's seat shall be an air suspension type with headrest, pneumatic side bolsters in the seat back for lateral support and pneumatic lumbar support in the lower part of the seat back cushion. The driver's seat will be an air ride Recaro Ergo Metro with 3-cell air lumbar, manual lumbar support, and vent, Highback Vinyl Black Leather with cloth insert required (HBCLVBLK) or approved equal. The seat must be equipped with a retractable seat belt that does not interfere with the movement and adjustability of the seat. Upholstery will be ventilated. The driver's seat shall be ergonomically designed so it will adjust to compensate for different driver sizes. All controls must be conveniently accessible by the operator from the seated positions. The driver must be able to operate the manual back recline and seat cushion tilt controls from both sides of the seat.

Seat support shall have sufficient dampening capability to preclude "bouncing" while travelling upon rough roadway surfaces. Fore and aft seat travel must be at least nine (9) inches, adjustment accomplished by an air actuated fore and aft slide release. Seat stops shall be supplied to prevent the seat hitting the driver's barrier. An ABS plastic protective backshell shall be installed onto the seat back to protect the upholstery. Seat back frame shall be constructed of tubular steel and shall be equipped with a solid steel back that prevents breakthrough. The back pan shall be curved to support the cervical, thoracic, lumbar, and sacral regions of

the back.

Seat belts shall be retractable, mounted to the seat with an internal safety strap that allows the seat to meet the FMVSS 207/210 pull test. **The seat and shoulder belt shall be orange in color.** Vertical adjustment travel of the seat must not be more than five (5) inches. The seat shall accommodate drivers from the 5th percentile female the 95th percentile male.

The DTA requires a heated seat for driver comfort as part of the winter weather package provisions.

1.16 FLOOR COVERING

1) ***Vestibule:*** The floor in the vestibule shall be covered with 3/16 of an inch, non-skid, rubber composition material that remains effective in all weather conditions. floor covering, as well as transitions of flooring material to the main floor and to the stepwell area, shall be smooth and present no tripping hazards. Floor covering ribs shall run transversely in line with the entrance, longitudinally in line with the aisle. The standee line shall be at least 2-inches wide and shall extend across the bus aisle in line with the driver's barrier. This line shall be the same color as the edge of the steps, bright yellow.

2) ***Driver's Compartment:*** The driver's platform shall be of such height that in a seated position, the driver can see an object located at an elevation of 42 inches above the road surface, 24 inches from the leading edge of the bumper. Notwithstanding this requirement, the platform height shall not position the driver so the driver's vertical upward view is less than 15 degrees.

   The floor in the driver's compartment shall be easily cleaned and shall be arranged to prevent debris accumulation. Any floor coverings shall be 3/16 of an inch thick, smooth surface, heavy-duty, rubber composition material. Color of the driver's floor shall be coordinated with the vestibule.

3) ***Passenger Area:*** The floor in the passenger area shall be covered with non-skid material that remains effective in all weather conditions. A one-piece center strip shall extend from the rear seat between the aisle sides of transverse seats to the standee line. The covering between the center strip and the wheel housings may be separate pieces. The material shall be 3/16 of an inch thick in the aisle section and as wide as the door shall extend from the center strip to the top step.

   At the rear door, however, a separate strip as wide as the door will extend from the center strip to the top step.

   The floor under the seats shall be covered with 1/8 of an inch thick, smooth surface flooring material. The floor covering shall closely fit the sidewall cover or extend to the top of the cover.

   Altro Radial TFM 2706 (2.7 mm/0.11" thick) is accepted as an approved equal for aisle and under seat floor covering.

The floor covering will be attached continuously to the subfloor by waterproof adhesives without voids. All seams and interfaces with the wall, wheel wells, etc., will be covered with trim or butt joints that will provide a floor that is free of tripping hazards and easy to clean by dry and wet wash with cleaning solutions. Clear or matching silicone caulking will be used at any point such as seams where moisture may enter into the flooring material. Caulking will not be required if the plywood used is marine grade and the adhesive used is St. Claire #45136. Other approved adhesives include Aquastik 2900 and Scotch-Grip 847.

1.17 WINDOWS

1) ***Windshield:*** The windshields are laminated, formed safety glass ASI, .270-inch-thick laced in a reinforced fiberglass aperture or 1/4 -inch tinted safety or laminated glass is acceptable. The windshield shall permit a driver's field of view as referenced in SAE Recommended Practice J1050. The vertically upward view shall be a minimum of 15° measured above the horizontal and including any shaded band. The vertically downward view shall permit detection of an object 3½ feet high no more than 2 feet in front of the bus. The horizontal view shall be a minimum of 90° above the line of sight. Any binocular obstruction due to a center divider may be ignored when determining the 90° requirement provided that the divider does not exceed a 3°angle in the driver's field of view. Windshield pillars shall not exceed 10°of binocular obstruction.

   The windshield shall be designed and installed to minimize external glare as well as reflections from inside the bus. When the bus is operated at night with the passenger interior lighting on, essentially no reflections shall be visible in the windshield immediately forward of the driver's barrier. Reflections in the remainder of the windshield shall be minimized, and no reflection of any part of the bus interior behind the driver's barrier shall be visible in the windshield. The windshield shall be easily replaceable by removing zip-locks from the windshield retaining moldings. Bonded-in-place windshield shall not be used. The glazing material shall have single density tint. The upper portion of the windshield above the driver's field of view shall have a dark, shaded band with a minimum luminous transmittance of 6% when tested in accordance with ASTM D-1003. Windshield, driver's window and side windows must not fog at the edges during their useful life. The useful life of this glass is six (6) years.

2) ***Driver's Window:*** The driver's window shall be sliding and open sufficiently to permit the seated driver to easily adjust the left outside rear-view mirror. This window section shall slide rearward in tracks or channels or utilizes fore and aft sliding sashes with an interior and exterior handle. The driver's side window shall not be bonded in place and shall be easily replaceable. The glazing material shall be a 1/4-inch or 7/32-inch single density tint, laminated safety glass. Window tint shall be green and a minimum of 23% light transmittance or match the windshield.

3) ***Side Windows:*** Side windows shall extend from the shoulder height of 5th-percentile, seated, female passenger to the eye level of a 95th-percentile, standing male passenger. Vertical mullions between windows including the trim shall not exceed 10 inches in width. All side windows shall be fixed windows and shall comply with FMVSS-217. The windows will be non-openable by the customer except in an emergency. They shall be easily replaceable without disturbing adjacent windows.

The frames shall be black anodized aluminium, or aluminium frames with black powder coat finish, or approved equal. Windows are fitted with emergency latches as per FMVSS- 217 in the lower portion of the coach.

Options shall be provided for top tip-in transom, flush mount fixed windows, and flush mount top tip-in windows. Exception to top tip-in shall be allowed for narrower window panels. Up to 4 windows may be required to have paint applied to a portion of the glazing (Ricon, Dura Ceramic Ink Jet Printing, or equivalent process).

DTA may select from a top tip in window with a frame, a top tip in window without a frame, or a flush mount, frameless window.

Side window glazing material shall be 1/4-inch nominal thickness laminate glass or approved equal. The material shall conform with the requirements of ANSI Z26.1-1977 Standard for Type AS-5 Safety Glazing Materials except for Test Number 17 which shall subject the specimens to 1000 cycles and the arithmetic mean of the percentages of light scattered shall not exceed 5%. Windows on the sides and in the rear door shall be tinted a neutral color, complementary to the exterior. The maximum solar energy transmittance shall not exceed 44%, as measured by ASTM E-424, and the luminous transmittance shall be no less than 16% as measured by ASTM D-1003. The destination sign glass shall be clear. Side window sashes will be made of black anodized aluminium.

4) ***Rear Window:*** No rear window will be required unless required by the Contractor. If it is required, it will be a fixed, one-piece ¼-inch single density laminated glass clamped to rear panel or “zipped in”.

1.18 INSULATION

1) ***Properties:*** 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 bus. The insulation material shall be non-hygroscopic and resistant to fungus and breeding of insects. Any insulation material used inside the propulsion equipment compartment shall be fire-resistant and shall not absorb or retain oils or water.

2) ***Thermal Insulation:*** The combination of inner and outer panels on the sides, roof, and ends of the bus, and any material used between these panels shall provide a thermal insulation to meet the interior temperature requirements. The body shall be adequately sealed so that drafts cannot be felt by the driver or passengers during normal operations with the passenger doors closed. Styrofoam SM brand thermal insulation is used between panels, or 1-inch polystyrene foam insulation manufactured by an extrusion process on the roof and side wall panels with R-value of 5.0. Dupont AE64 square edge Styrofoam is accepted as an approved equal. The products must comply with burn rate criteria of FMVSS 302. **The steering column must be sealed and insulated where it exits the bus.**

3) ***Sound Insulation:*** The combination of inner and outer panels and any materials 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 bus shall have a sound level of 65 Dba or less at any point inside. These conditions shall prevail with all openings, including doors and windows, closed and with the propulsion motor and accessories switched off.

The bus-generated noise level experienced by a passenger in any seat location in the bus shall not exceed 83 Dba and the driver shall not experience a noise level of more than 77 Dba under the following test conditions.

The bus shall be empty, except for test personnel, not to exceed four persons, and the test equipment. All openings shall be closed and all accessories shall be operating during the test. The bus 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 path. During the test, the ambient noise level in the test area shall be at least 10 dB lower than the bus 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.

1.19 ANCILLARY FEATURES

1) ***Visors:*** Adjustable sun visor(s) will be provided for the driver's side of the windshield and the driver's side window. Pull down sunscreens are acceptable. Visor(s) will be shaped to minimize light leakage between the visor and windshield pillars, there must not be a gap of greater than 1 inch. Pull down visors are requested. **If one visor will not cover sufficiently then two are required.** Visors will store out of the way and will not obstruct air flow from the climate control system or foul other equipment such as the radio handset or the destination control. Deployment of the visors will not restrict vision of the rearview mirrors. Visor adjustments will be made easily by hand. Sun visor construction and materials will be strong enough to resist breakage during adjustments. Visors, when deployed, will be effective in the driver's field of view at angles more than five degrees above the horizontal. The sun visor for the operator’s window shall be the roller shade type of visor. In addition to visors, a coat hook and strap shall be installed in the driver’s area.

2) ***Exit Signal:*** A passenger chime signal audible to the driver and to passengers anywhere inside the bus will be provided. The chime will have pull cords that are convenient to seated passengers, standees, and passengers standing at the rear door. Standees will be able to easily reach the chime signal located near the passenger interior lighting fixtures. Separate controls shall be provided at each wheelchair securement location which shall be no more than 48 inches nor less than 15 inches above the floor these will be tape switch or touch pad at the DTA’s option. It shall be operable by one hand and shall not require tight grasping, pinching, or twisting of the wrist. Force required shall not exceed 5-foot pounds. A selection switch shall be provided to select either be on or to set a single chime. A stop request feature is to be incorporated into the exit signal system, this will feature an electric sign in the front center of the bus noting a stop has been requested and a colored light on the operator dash plainly visible to the driver. A separate light signal is required for wheelchair patrons. DTA will approve a

system that meets ADA requirements. Such a system is made by Transsign and the ADA light is on the end of the stop requested sign. DTA also requires a light on the dash.

3*)* ***Outside Mirrors:*** The Proposal shall include remote control and heated mirrors. The bus will be equipped with remote controlled, corrosion resistant, outside rearview mirror on each side of the bus. The mirrors will permit the driver to view the highway along both sides of the bus including the rear wheels. Each rear-view mirror will measure at least ten inches (height) by eight inches (width) and have a minimum surface area of 80 square inches. Additionally, a 5-inch diameter convex mirror will be mounted to the rectangular mirror, it will be above the rectangular mirror on both sides of the bus. Additionally, a 4-inch by 6-inch convex mirror will be mounted to the rectangular mirror on the passenger side of the bus. Mirrors will be firmly attached to the bus to prevent vibration and loss of adjustment, but not so firmly attached that the bus or its structure is damaged when the mirror is struck in an accident. Mirrors will be mounted so that its lower edge is no less than 56 inches above the street surface. Mirrors will retract or fold sufficiently to allow automatic washing operations.

SafeFleet adjustable heated exterior mirrors are accepted as an approve equal.

4) ***Inside Mirrors:*** Mirrors shall be provided for the driver to observe passengers throughout the bus without leaving his seat and with shoulder movement, with a full standee-load, (including standees in the vestibule) he shall be able to observe passengers in the front and rear stepwells, anywhere in the aisle, and in the rear seats. Inside mirrors shall not be in the line of sight to the right outside mirror.

A center rear view mirror will be located above the windshield. A right windshield header mirror, 6-inch round, will be located so as not to interfere with passenger traffic and be mounted on an adjustable bracket. A 12-inch parabolic mirror will be mounted at the exit door area to an adjustable bracket and allow the operator to view the exit door and stepwell area.

5) ***Safety Equipment:***

a) 5 lb Fire extinguisher (ABC type). The safety equipment shall be mounted where it is easily accessible to the Driver.

b) Safety Triangles - three bi-directional emergency reflective triangles conforming to the FMVSS 125 in a case and mounted.

c) First Aid Kit - one First Aid Kit meeting or exceeding the requirements of Manufacturers Code 81.16. It shall contain at a minimum - 2 units of 1-inch adhesive tape at least 7.5 feet long - 2 units of sterile gauze pads that are 3-inch by 3-inch and a minimum of 12 per unit - one box of 100 bandages that are 3/4 inch by 3-inch disposable CPR mouth piece. In addition, a standard Body Fluid Clean-Up Kit shall be provided. This is the minimum requirement.

d) Biohazard Kit

e) Seat Belt Cutter.

6) Driver's Security Box: A security box shall be provided in the general driver's area to allow the driver to secure his valuables. The box cover shall be retained with a 1/4 turn thumb latch.

1.20 PASSENGER ASSISTS

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 4th-percentile female standee. **They will all be covered with yellow powder coat.** Starting from the entrance door and moving anywhere in the bus and out the exit door, a vertical assist shall be provided either as the vertical portion of seat back assist or as a separate item so that a 5th-percentile female passenger may easily move from one assist to another using one hand and the other without losing support. Excluding those mounted on the seats and doors, the assists shall be 11/4-inch in diameter or width with radii no less than1/4-inch. All passenger assists shall permit a full hand grip with no less than 1 ½-inch of knuckle clearance around the assist. One hanging strap is required between each vertical pole with a minimum of ten per bus in the passenger seating area behind the wheelchair section. Two hanging straps must be provided in the wheelchair seating section.

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. All 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 16-gauge stainless steel with 180 grid finish. 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. Brackets, clamps, screw heads, and other fasteners used on the passenger assists shall be free of rough edges.

2) Vestibule: The aisle side of the driver's barrier and the modesty panels shall be fitted with vertical passenger assists. These assists 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 bus and shall prevent passengers from sustaining injuries of a fare collection device or windshield in the event of a sudden deceleration. Without restricting the vestibule space, the assist shall provide support for a boarding passenger from the front door through the fare collection procedure.

Passengers shall be able to lean against the assist for security while paying fares. The assist shall be no less than 36-inches above the floor or the average step tread surface. The assists at the front shall be arranged to permit a 5th percentile female passenger to easily reach from the door assist to the front assist, to vertical assists on the driver's barrier or front modesty panel.

3) Overhead: Except forward of the standee line and at the rear door, a continuous, full-

grip overhead assist shall be provided. This assist shall be convenient to standees anywhere in the bus 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. Overhead assists shall simultaneously support 150 pounds on any 12-inch length. No more than 5% percent of the full grip feature shall be lost due to assist supports. In the area over the wheelchair position a plastic assist will hang from the overhead assist.

4) Longitudinal Seats: Longitudinal seats, excluding flip up seats, shall have vertical assists located between every other designated seating position. Assists shall extend from near the leading edge of the seat and shall be functionally continuous with the overhead assist. Assists shall be staggered across the aisle from each other where practical and shall be no more than 52- inches apart.

5) Rear Doorway: Vertical assists that are functionally continuous with the overhead assist shall be provided at the aisle side of the transverse seat immediately forward of the rear door and on the aisle side of the rear door modesty panel. Read doors, or the exit area, shall be fitted with assists no less than 3/4-inch in width and shall provide at least 1½ inch of knuckle clearance between the assists that are functionally continuous during the entire exiting process, and the assists shall be no more than 6 inches from the outside edge of the lower step tread.

1.21 ENTRY LOADING SYSTEM, WHEELCHAIR SECUREMENTS

1) Loading System: A fold-out electrically operated ramp (ADA compliant) with stainless steel tray shall be provided at the front door for deployment by the driver from the driver's seated position. The deployed ramp measuring 30.5 inches wide or widder and 44-inches long or longer shall fold out to the curb height and retract back into a recessed floor area. The recessed area shall be designed to prevent passengers from tripping or falling while entering and exiting the bus.

The driver's controls consist of an easy to operate three-position toggle switch on the instrument panel marked DEPLOY-STOW or DEPLOY - FLOAT - STOW. The ramp will be the flip out type, not a cassette style ramp. The ramp must also be able to be manually deployed by a pull strap or a mechanical latch. It shall also be sealed so that dirt and debris will not enter the mechanism.

Approved ramp for the DTA is Lift-U LU18 Dual Mode or approved equal.

2) Securements: for each wheelchair position, the wheelchair restraint devices shall be Q'pod by Q'Straint or approved equal. Wheelchair securements must be in compliance with all federal ADA guidelines, including the requirement that one securement must be front facing. Wheelchair accessible buses will have two tie downs (approved by the Minnesota Department of Transportation) and jump seats. An extra seat belt extension that is 24 inches in length will be provided with each bus. **Prior to release of vehicle for delivery, Contractor shall supply DTA a copy of the wheelchair securement manufacturer's certificate of approval from the State of Minnesota, Department of Public Safety, pursuant to Minnesota Rules 7450.0500.**

Passenger securement devices must have permanent part numbers affixed to each retractor as per MN DOT requirements.

The exit signal shall be easy to reach. All systems must meet current ADA rules and regulations.

1.22 ELECTRIC PROPULSION SYSTEM

1) ***Power Requirements:*** Propulsion system and drive train shall be all electric, conform to SAE J2910 and SAF J2344 to the greatest extent possible. The propulsion system shall not be supplemented by any onboard range extenders, including, but not limited to internal combustion engines, gas turbines, hydrogen fuel cells, etc. The electric propulsion system must be able to provide power to enable the bus to meet the defined acceleration, top speed, and gradability requirements. Enough excess power shall be available to operate all accessories.

   The electric propulsion system shall meet or exceed all applicable local, state and/or federal useful life requirements.

2) ***Detailed Description.*** The Proposer shall provide a detailed description of the Proposed Propulsion System, including:
   - -A written narrative of the system
   - -A block diagram of the major propulsion system components
   - -An illustration of the physical layout of the propulsion components and high-voltage wire routing within the electric vehicle
   - -A detailed wiring diagram or electrical schematic for the high voltage system
   - -A list of applicable industry standards and verification that the Proposed system meets said standards

   Top Speed: The bus shall be capable of a top speed of 60 mph (for emergency and passing maneuvers) on a straight, level road at SLW with all accessories operating.

3) ***Gradability:*** Gradability requirements shall be met on grades with a surface friction coefficient of 0.3 and above at SLW with all accessories operating. The standard configuration powerplant shall enable the bus to maintain a speed of 38 mph on a 5% grade and 22 mph on a 10% grade or 40 mph on a 4.47% grade and 22 mph on an 8.25% grade. Gradability is more important than top speed. Final gear ratios will be discussed with successful Proposer.

4) ***Acceleration:*** An average acceleration rate of at least 0.6g shall be achieved at SLW between 0 and 15 mph. Acceleration measurement shall commence when the accelerator is depressed.

5) ***Jerk:*** Jerk, the rate of change of acceleration, shall be minimized throughout the acceleration/deceleration range and shall average 0.3g/sec under normal driving conditions.

6) ***Operating Range:*** The operating range of the bus run on the design operating profile shall be provided by the Proposer at the time of Proposal submission, taking into account the operating conditions in Duluth, MN.

1.23 PROPULSION SYSTEM SERVICE

1) ***Service:*** The propulsion system shall be arranged so that accessibility for all routine maintenance is assured. The Contractor shall identify safe electrical work practices are essential when servicing high-voltage components. **Labels on high-voltage devices to identify them as components conducting high-voltage potential are required.**

2) Upon Proposal submission, the Contractor shall identify safe electrical work practices that are essential when servicing high-voltage components. The Contractor shall provide all specialty tools and diagnostic equipment required for maintaining the electric propulsion system in accordance with OEM requirements.

1.24 PRIMARY PROPULSION UNIT AND TRACTION MOTORS

1) The Contractor shall submit the optimal configurations of the propulsion system components to maximize the performance and efficiency of the system. Alternate configurations may be Proposed, but Contractor must include a description of the deviations and their anticipated impact on performance and efficiency.

2) The propulsion and braking systems shall meet the performance requirements of these Specifications. Braking application and performance shall remain consistent regardless of the System State of Charge ("SOC") or other variances related to regenerative braking.

3) The propulsion system shall be programmable to allow optimization of acceleration and deceleration rates.

4) In addition to power required for propulsion, sufficient excess power shall be available to operate all accessories at their normal operating condition throughout the useful life of the vehicle.

5) The propulsion system shall be designed so that no component operates at more than 80% if its maximum designed load, speed, voltage or amperage. A programmable system shall be provided to limit motor speed to a safe value. Propulsion system operation, including charging the energy storage system, shall be electronically controlled. It shall have programmable performance control system and the latest maintenance and diagnostic software system. DTA will be granted full reprogramming functionality to all components of the vehicle.

1.25 ENERGY STORAGE SYSTEM AND CONTROLLER

1) The Energy Storage System ("ESS") shall be of a design capable of operating in the DTA's transit environment throughout the useful life of the vehicle. The ESS shall use battery technology with field-proven track record of safe, reliable and durable operation in similar traction applications.

2) The ESS shall be designed, sized and selected to ensure that the vehicle performance specifications, forwards and backwards compatibility with charging

equipment and other related requirements are met or exceeded, with cost, benefits and reliability variables considered as they relate to the characteristics of different battery types of capacities.

3) The ESS shall fully comply with the most stringent U.S. DOT standards for lithium batteries or similar requirements for non-lithium batteries, including UN/DOT38.3 and/or SAEJ2464 requirements, as applicable.

4) The ESS shall be fully formed, installed, tested in accordance with battery manufacturer's recommended practices, and upon delivery of the vehicle, the ESS will be fully charged and functional.

5) The ESS design, including containers, module bracing systems, thermal-management systems, battery management systems, watering/venting systems, interconnections, fusing and traction controller and charger interfaces shall be adequately described in the Proposal for the DTA's evaluation.

6) The Proposal shall include a description of all battery maintenance requirements, including any periodic charge requirements necessary for cell balancing.

7) The Proposal shall include a detailed analysis of expected battery performance in the DTA operating profile.

8) The Proposal shall also include a comprehensive statement of the warranty terms of the battery, including an explanation of all disclaimers within the Warranty. The charge cycle and cycle life shall be stated in the Proposal, and a life-cycle cost analysis of the Proposed battery system in the specified application shall be provided.

9) The battery system shall be capable of withstanding the current and voltage profiles necessary to accomplish daily recharge events within the DTA operating profile.

10) Thermal management will be provided as needed to ensure the optimal life and performance of the ESS over the anticipated environmental operating range of the DTA transit system. The battery thermal management system shall be adequate to maintain the battery within the battery manufacturer's recommended temperature range during operation for the DTA transit system operating requirements.

11) If running the ESS with a low SOC will in any way damage the ESS and/or the propulsion system, the propulsion system manufacturer, together with the Contractor, shall provide sufficient warning to the operator. An approved system shutdown may be used, including a phased automatic shutdown system shall be provided. A complete description of this warning system is required at the time of Proposal.

12) Proposals shall include complete descriptions of all life-cycle procedures used to validate the life of the batteries used for this application at the proposed charging rates, charge durations, and expected ambient temperatures and operating profiles. Proposers shall include documented results of life cycle testing at the time of Proposal submission, including certification of testing by an independent testing agency.

13) ***Energy Storage System Capacity.*** The ESS shall have sufficient energy storage capacity to meet the intended duty cycle when new and up until the degradation has reached the warranted end of life as defined within the Warranty terms of this RFP as measured by percent of remaining capacity. For example, if the capacity when new is 300 kWh and the warranted end of life is at 80%, then the usable capacity shall be from 100 kWh to 240 kWh.

14) ***Energy Storage System Safety.*** The ESS shall be placed on the bus to optimize both interior space and vehicle weight distribution. The batteries shall be load distributed within the bus to equalize weight between the wheels on the same axles and to achieve appropriate wight distribution between axles so as to not adversely affect handling of the bus.

15) The bus body shall be designed and constructed to ensure that passengers and the operator will not be exposed to hazardous electrical current. This design will also minimize potential exposure to hazardous electrical current in the event of any accident. Analysis and test data shall be provided to the DTA at the time of Proposal submission demonstrating these safety requirements. The vehicle and ESS shall be designed and constructed to prevent gassing or fumes from the ESS from entering the interior of the bus, either through a vent path to the exterior above the roof, or an alternate path as designed by the Contractor that meets these specifications.

1.26 BATTERY SYSTEM REQUIREMENTS

1) Written confirmation from the battery manufacturer attesting to the safety of the Proposed battery system in the DTA use profile shall be submitted as part of the Proposal, and shall include full disclosure and discussion of any and all relevant issues with the safety of the batteries or the ESS or prior incidents relating to the safety of the Proposed bus.

2) 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.

3) Both automatic and manual battery disconnect devices must be included and documented. Contactors must be rated to interrupt the full load of the bus. Service and emergency manual disconnects must be included and their usage documented to the satisfaction of DTA maintenance personnel. Contractor shall provide a means to isolate the high-voltage battery during maintenance operations. Manual and automatic disconnects should open both poles of each physical battery pack.

4) The HV and ESS shall include isolation procedures between the HV and the bus chassis system, to include automatic detection of isolation faults, alerts to the operator, diagnostic system and appropriate action to prevent personnel from HV exposure.

5) The system described above may also be an integral part of the overall emergency shutdown system with functions to include the following:

a. Offers a quick, safe and organized means for the operator, maintenance personnel and/or first responders to shut down the HV system;
b. Shutting down the system shall include, at least:
    i. "Opening" all HV contactors;
    ii. Discharging capacitors (if used), and
    iii. Disconnecting any devices that could provide HV, during normal operation and including during charging.
c. Devices used to initiate shutdown shall be located within and outside the bus to satisfy ease of use by the operator, maintenance personnel, and/or first responders, and be clearly marked as to the location and use.
d. In addition to manual use, this same functionality shall extend to the charging operation in the event of a fault sensed by the GFI, to also include termination of charge.

6) ***Battery Containers.*** Battery containers shall be constructed to withstand the rigors of the DTA transit service for the design life of the buses. Construction shall be of materials compatible with the battery electrolyte. All electrical connections shall be fully shielded and hand-operable. Connector and cabling design shall prevent inappropriate or unsafe connections. Vent and fill systems components for individual packs or containers shall not require any disassembly on removal or installation of battery packs or containers. Pack design must comprehend the protection of battery cabling and vent/watering components during pack removal and installation. When installed, the batteries shall be secured to the chassis to prevent any movement that may cause damage or personal harm while the vehicle is in operation.

7) ***Battery Management System ("BMS").*** The BMS should be designed to ISO 26262 safety principles to control SOC, voltage, current and temperatures on a cell-to-cell level and provide diagnostic output at the lowest field-serviceable element. The diagnostic output must be made available to DTA maintenance personnel.

8) As a minimum, the BMS must perform the following functions:
a. The BMS must be capable of monitoring the voltage of the cells within each battery pack.
b. The BMS must be able to read individual battery or block voltages at a frequency of one data point per block every fifteen seconds.
c. The BMS must be capable of monitoring battery temperatures, mitigating damage to the battery and surroundings, and prevent thermal runaway.
d. 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 location of the faulty battery in order to perform maintenance.
e. The BMS must be able to engage prudent safety interlocks when an unsafe battery condition has been detected.
f. The BMS must be able to monitor the battery SOC and provide information to the rest of the vehicle.
g. The BMS must be able to communicate all data to the bus level information system for storage and communication.

9) ***Battery Thermal Management.*** Thermal management shall be provided to ensure optimal life and performance of the ESS over the DTA environmental use and

operating range. Battery temperatures must never exceed the manufacturer's recommended range during operation and under DTA ambient conditions. Battery cooling must be sufficient to prevent the temperature from exceeding the manufacturer's recommended maximum temperature.

10) ***Battery Charging.*** The bus shall support and SAE-approved charging standards (SAE J3068 AC and/or SAE J1772 DC). Manufacturer shall provide a detailed description of its charging system, including the onboard charge controller, and specify its compliance with one of the above listed standards. Proposers shall include a description of the charging infrastructure required to install and operate the charging equipment.

11) All charging systems provided for use with the bus and in conjunction with the BMS must comply with the manufacturer's electrical and thermal limits.

12) The buses must be immobilized during all charging operations. Upon successful engagement of the charging interface, the bus shall be interlocked such that the propulsion system is rendered inoperable.

13) ***Charging Port.*** The buses shall include charging ports located on the curbside rear (preferred) and either streetside front or streetside rear of the bus, if multiple charging port locations are available. The charging port(s) shall be at the manufacturers standard mounting locations. Proposer should indicate where their standard mountings are located. If the mounting location is customizable, meaning DTA has a choice, the Proposer should indicate in their Proposal response.

14) ***Charging.*** The bus shall support and SAE charging standard. Proposers shall include a detailed description of their charging system and specify its compliance with one of the above noted standards. Proposers shall include a description of the charging infrastructure required to charge the bus on route and at the bus depot.

1.27 PROPULSION SYSTEM CONTROLLER ("PSC")

1) The PSC shall regulate energy flow throughout the system components in order to provide motive performance and accessory loads, as applicable, while maintaining critical system parameters for voltages, currents, temperatures, etc. within specified operating ranges.

2) The PSC shall monitor and process inputs and execute outputs as appropriate to control the operation of all propulsion system components.

1.28 TEMPERATURE MANAGEMENT SYSTEMS

1) The capacity of the cooling systems, including the battery thermal temperature management system and the power electronics cooling system, shall be sufficient to maintain component temperatures under all operating conditions present in the Duluth, MN service area, for the design life of the vehicle. The Contractor shall provide evidence that the cooling systems have the capacity to handle normal and peak heat ejection from the traction motor, ESS, PCS and intermediate and low-voltage power supply with a partially clogged radiator at maximum ambient

temperature. The Contractor shall submit documentation verifying the cooling system capabilities.

2) The cooling system shall be sufficient to maintain all continuous operating temperatures during the most severe operations possible and in accordance with manufacturers' cooling system requirements. The cooling system fan controls must be capable of sensing the temperature of the operating fluids and the intake air, and if either is above safe operating conditions, the cooling fans will engage. The fan control system shall be designed with a fail-safe mode of "fan on."

3) Operation of required BTMS shall be automatically controlled under all normally encountered operating and charging conditions and shall be powered by an onboard source at all times. Thermal management shall be continuously monitored during all periods of charge and discharge with appropriate safety interlocks installed to react to adverse conditions.

4) All intakes shall be properly positioned and configured to minimize the intake of water, road dust, chlorides and other road salt chemicals, and debris and shall be filtered to minimize intrusion into bus systems and compartments.

5) Coolant fill systems will include at least one ground level accessible fill point. Systems must also have an accessible coolant drain valve and ground level coolant level indicators.

6) In the event of a failure of the BTMS while charging, the charge system shall be disabled and a visual and audible alert shall be activated on the dashboard. A reset button will be provided, and require a deliberate action from maintenance personnel to disable the alert.

7) In the event of BTMS failure while the bus is in operation, an audible and visual alert shall be activated on the dashboard. The reset button to silence the alert shall require the deliberate action from maintenance personnel.

8) In the event of an onboard fire, the BTMS fans shall be automatically turned off.

9) A complete description of the BTMS system shall be submitted with the Proposal. Written confirmation from the battery manufacturer attesting to the suitability and capacity of the BTMS shall be submitted to DTA concurrent with or prior to the delivery of the first bus.

1.29 COMPONENT THERMAL MANAGEMENT, RADIATOR(S)

1) Under the vehicle operating range, the thermal management system shall be designed so each component will remain within its optimal operating range. Component temperature sensors may be used for monitoring, control or component/system protection. If equipped and serviceable, component temperature sensors shall be easily accessible. Under typical failure modes or out of limit conditions, component temperature sensors shall not disable the bus unless there is an immediate risk of hazardous fault propagation, e.g., temperature levels in the

motor area known to start fires.

2) In the event that a component temperature sensor must disable the bus, the component or system must comply with the automatic propulsion system protection/shutdown override feature requirements herein.

3) Motor cooling fans shall be of durable, corrosion resistant construction and designed so a mechanic can gain access. The cooling fan and mounting bracket shall be designed to withstand the thermal fatigue and vibration associated with the installed configuration.

4) The radiator shall be of durable, corrosion resistant contraction with non-removable tanks. An EMP radiator cooler is accepted as an approved equal.

5) **Pressure Filler.** For roof-mounted radiators and surge tanks, a pressure filler will be provided at ground level and shall be electronically vented.

6) **Radiator Screen.** The radiator input shall be protected by an easily cleanable screen designed to collect large debris. The radiator core shall be easily cleaned with standard pressure washing equipment. A radiator screen is not required if the radiator is located on the roof of the bus.

7) **Coolant Filtration without Supplemental Additives.** The cooling system shall be equipped with a properly sized, spin on water filter. The filter shall not release or contain supplemental coolant additives.

8) **Radiator Fans.** Mounting and drive of the radiator fan(s) shall be the Contractor's standard design.

1.30 DRIVE UNIT COOLING

1) If required, the drive unit shall be cooled by a heat exchanger which is sized to maintain operating fluid within the drive unit's recommended parameters of flow, pressure and temperature.

1.31 POWER ELECTRONICS COOLING SYSTEM

1) The thermal management system shall maintain all power electronic system components within design operating temperature limits.

1.32 DRIVE UNIT

1) The drive unit shall be designed to operate for a minimum of 500,000 miles in the DTA transit system without requiring major service or replacement.

2) The electronic controls shall be capable of transmitting and receiving electronic inputs and data from other propulsion system components and of broadcasting the data to other vehicle systems. Communications between electronic propulsion system components and other vehicle systems shall be made using the communications

networks.

3) Electronic controls shall be compatible with either 12 or 24 volt power distribution, provide consistent shift quality and compensate for changing conditions, such as variations in vehicle weight and power. At a minimum, propulsion system components consisting of batteries, drive unit and anti-lock braking systems shall be powered by a dedicated and isolated supply voltage to ensure data communication among components exists when the vehicle ignition is switched to the “on” position.

4) A nominal brake pedal application of 6 to 10 psi shall be required by the driver to engage forward or reverse range from the neutral position to prevent sudden acceleration of the bus from a parked position.

5) The electronically controlled drive unit shall have on-board diagnostic capabilities, be able to monitor functions, store and time stamp out of parameter conditions in memory, and communicate faults and vital conditions to service personnel.

6) The drive system shall consist of built in protection software to guard against severe damage. The on-board diagnostic system shall trigger a visual alarm to the driver when the electronic control unit detects a malfunction.

1.33 REGENERATIVE BRAKING

1) The powertrain shall be equipped with regenerative braking designed to improve energy efficiency and extend brake lining service life. The application of regenerative braking shall cause a smooth blending of both regenerative and service brake function and shall activate the brake light.

2) Actuation of the ABS and/or automatic traction control (ATC) shall override the operation of the regenerative brake.

3) Brake lights shall illuminate when regenerative braking is activated.

4) The regenerative braking system shall be adjustable within the limits of the powertrain and activated when the accelerator pedal is depressed.

5) Regenerative braking shall be provided in order to maximize the life of wearing components in the service brake system. A dynamic resistor grid, or approved equal, shall be provided to seamlessly compensate for the lack of regenerative braking when the ESS is fully charged.

6) Electric braking shall be supplied by the traction motor, acting as a generator.

7) Power generated shall be utilized on the following sequence: on-board energy storage, dynamic brake resistor.

8) Deceleration should start at throttle off, be smooth and seamless throughout the full braking application until the bus comes to a complete stop.

9) The OEM/drive system manufacturer shall provide performance setting options to DTA for preferred performance of the bus.

1.34 MOUNTING

1) All electrical/electronic hardware shall be serviceable. All electrical/electronic hardware mounted in the interior of the bus shall be vandal resistant.

2) All electrical/electronic hardware mounted on the exterior of the bus that is not designed to be installed in an exposed environment shall be mounted in a protective enclosure. The hardware shall be mounted in such a manner as to protect it from the operating environment in the Duluth, MN service area.

3) All electrical connectors shall be sealed and resistant to water intrusions. No exposed terminals will be allowed.

4) All electrical/electronic hardware and its mounting shall comply with the shock and vibration requirements of SAE J1455.

5) All propulsion system mounting shall be mechanically isolated to minimize transfer of vibration to the body structure and to provide a minimum clearance of 0.75 inches. Mounts shall control the movement of the propulsion system so as not to affect the performance or cause strain in piping and wiring connections in the propulsion system.

6) All components requiring service or replacement shall be easily removable and independent of the propulsion system components and transmission removal.

7) Radiator filler caps shall be hinged or tethered to the filler neck and closed with spring pressure or positive locks. All fluid fill locations shall be properly labelled 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, external, hex head, drain plugs of a standard size excluding the transmission.

8) All filters shall be easily accessible and the filter bases shall be plumbed to assure correct re-installation. There will be shut off valves on either side of **all** removable filters so as to prevent loss of fluids when changing the filter. Shut off valves for internal cartridge type filters for the transmission are not required.

9) Flexible lines shall be FC300, FC355, GH195, or FC510/2807 PTFE, in applications where premium hoses are required, such as the Power Steering output line, 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 bus. Flexible hoses may be used but must meet all Federal safety regulations.

10) Transmission (if required): If the Contractor's propulsion system uses a multispeed transmission, it must be automatic shift. Gross input power, gross input torque and rated input speed shall be compatible with the propulsion system. The transmission

shall be designed to operate for not less than 400,000 miles in the Duluth, MN operating profile without replacement or major service. The transmission should be easily removable without disturbing the propulsion system and accessible for service. A 3M mechanic, with optional assistance, shall be able to remove, replace, and prepare the transmission assembly for service in less than sixteen total combined man-hours.

The electronic controls shall be capable of transmitting and receiving electronic inputs and data from other drivetrain components and broadcasting that data to other vehicle systems. Communications between electronic drivetrain components and other vehicle systems shall be made using the communications network. Electronic controls shall be compatible with either 12 or 24 volt power distribution, provide Long consistent shift quality and compensate for changing conditions such as variations in vehicle weight and power.

The electronically controlled transmission shall have on-board diagnostic capabilities, be able to monitor functions, store and communicate faults and vital conditions to service personnel. The transmission shall contain built-in protection software to guard against severe damage. The on-board diagnostic system shall trigger a visual alarm to the driver when the electronic control unit detects a malfunction.

All major repairs to the transmission during the warranty period will be the responsibility of the authorized dealer of the component. The Offeror will provide full details on the warranty center the Offeror is proposing to use.

1.35 EMISSIONS

1) Gas and Smoke: The bus shall meet all applicable emission standards required by the Federal government for a low or no emission vehicle as defined by the U.S. Department of Transportation.

2) ***Exhaust Location:*** Exhaust gases and waste heat from the auxiliary heater shall be discharged by an exhaust pipe on the streetside of the bus or above the top of the bus rear roof.

3) Exterior Noise: Airborne noise generated by the bus and measured from either side shall not exceed 83 Dba under full power acceleration when operated at or below 35 mph at curb weight, just prior to transmission up shift.

1.36 FINAL DRIVE

1) ***Axles:*** Load rating shall be sufficient for the bus loaded to GVWR. Ring gear must be **bolted** instead of riveted or welded. The driven axles shall operate for 300,000 miles on the DTA service area operating profile without repairs. Wheels bearing inner grease seal shall run on a replaceable wiper ring or the tube. The axle ratio shall be determined after contract signing with the intent of a maximum speed of 60 mph.

2) ***Rear Axle Drive Motor:*** Manufacturer shall provide details on the rear axle drive motor at the time of proposal submission.

1.37 SUSPENSION

1) General Requirements: The front axle shall be an Arvin-Meritor FH946 or approved equal, solid beam type axle with air suspension, non-driving with a load rating sufficient for the bus loaded to GVWR. Both the front and rear axle suspensions shall be pneumatic type. The basic suspension system shall last the life of the bus without major overhaul or replacement. Items such as bushings and air springs shall be easily and quickly replaceable by a 3M mechanic. 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 must be properly aligned so the vehicle tracks accurately within the size and geometry of the vehicle.

2) Regulation and Operation: The pneumatic system shall be regulated by levelling valves (warranties for 50,000 miles) located at front and rear wheel locations. The suspension system shall maintain a constant floor height in relation to the axles regardless of load. The source of air shall be the accessory air tank, and a pressure regulating valve shall protect against air loss from leaks in the suspension air springs. Warranty for consumable components one year or 50,000; structural members three years or 150,000; and structural (except where covered elsewhere in this specification) is seven years or 350,000.

The ride height monitoring shall not be magnetic type.

Front and rear suspension shall be equipped with Barksdale mechanical leveling valves or approved equal.

3) Travel: The suspension system shall permit a minimum wheel travel of 3.5-inch in jounce-upward travel of a wheel when the bus hits a bump (higher than the street surface) and 3-inches in rebound downward travel when the bus comes off a bump. 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.

4) Kneeling: A driver-actuated kneeling device shall lower the bus a minimum of 2 inches during loading or unloading operations regardless of load up to GVWR to a floor height of 12.5 inches to 15.5 inches measured at the longitudinal centerline of the front door. A kneeler is not required if the floor height is 11.5 inches or less off the pavement.

Brake and throttle interlock shall prevent movement when the bus is kneeled. The bus shall kneel and rise at an essentially a constant rate. After kneeling, the bus shall rise within two seconds to a height permitting the bus to resume service and shall rise to the correct operating height within five seconds. During the lowering and raising operation, the maximum acceleration shall not exceed 0.2g and the jerk shall not exceed 0.3g/sec. measured on the front doorstep tread. An indicator visible to the driver shall be illuminated until the bus is raised to a height adequate for safe street travel. Manufacturer to provide and install both audible and visual warning devices that operate together with the kneeling system. Devices are to be easily seen and heard by boarding passengers at the front door. Audible devices are to be an identical beeping or buzzing

tone on all buses. Both devices to be operated from a single control mechanism/switch.

5) ***Damping:*** Vertical damping of the suspension system shall be accomplished by hydraulic shock absorbers mounted to the suspension arms or axles and attached to an appropriate location on the chassis. Damping shall be sufficient to control bus motion to three cycles or less after hitting road perturbations. The shock absorber bushing shall be made of elastomeric material that will last the life of the shock absorber. The shock absorber shall incorporate a secondary rebound stop. Shock absorbers shall maintain their effectiveness for at least 50,000 miles in normal service, and each unit shall be replaceable by a 2M mechanic in less than one hour.

6) ***Lubrication:*** All elements of steering, suspension, and drive systems requiring scheduled lubrication shall 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 with or without flexible hose end from a pit or with the bus on a hoist. Each element requiring lubrication shall have its own grease fitting with a relief path. The lubricant specified shall be standard for all elements serviced by standard fittings and shall be required no fewer than 6,000 miles.

1.38 STEERING

1) ***Strength:*** Fatigue life of all steering components shall exceed 500,000 miles. No element of the steering system components shall fail before suspension system components when one of the tires strikes a severe road hazard.

2) ***Turning Radius:*** Outside body corner turning radius shall not exceed 45.5’ at SLW and 17 feet inside rearmost axle.

3) ***Design:*** Steering column is to be Douglas Model 909, Model 920, Model 9204, Model 929 or approved equal (including the TRW model with the same features), tilt-type design and telescoping, with four positions, for maximum adaptability to individual drivers. When steering column location is selected a positive lock shall engage to prevent inadvertent movement of column.

4) ***Grease Fittings:*** 45**-**degree grease fittings at the U-joints within the steering column and linkage are preferred.

5) ***Turning Effort:*** The steering wheel shall be no less than 20-inches in diameter and shall be shaped for firm grip with comfort for long periods of time. The steering wheel shall be removable with a standard or universal puller.

Steering stops and steering pressure relief shall coincide.

Hydraulically assisted power steering shall be provided. The steering gear shall be an integral type with flexible lines eliminated or the number and length minimized. Steering torque applied by the driver shall not exceed 10-foot pounds with the front wheels straight ahead to turned 10°. Steering torque may increase to 70-foot pounds when the wheels are approaching the steering stops. Steering effort shall be measured with the bus at SLW, stopped with the brakes released and the propulsion system at normal idling

speed on clean, dry, level, commercial asphalt pavement and the tires inflated to recommended pressure. Power steering failure shall not result in loss of steering control. With the bus in operation, the steering effort shall not exceed 55 pounds at the steering wheel rim and perceived free play in the steering system shall 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 shields to the straight position with minimal assistance from the driver.

1.39 BRAKES, WHEELS, and TIRES

1) ***Brakes:*** Disc brakes are acceptable but drum brakes are preferred.

2) ***Actuation:*** Service brakes shall be controlled and actuated by an air system. The system shall be balanced with no front/rear displacement. E10, Bendix E6, E8P, E15 (E10P, OR1, R14, & SR1 are also acceptable) brake valves are required. 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 emergency braking. Microprocessor controlled Antilock 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. The DTA understands that based on axle load tire from front to rear axle and single tire on front versus dual tire on rear, rear axle friction material wears faster than the front axle friction material.

   Microprocessor-controlled Automatic Traction Control (ATC) shall be available as an option.
   Four-wheel disc brakes shall be available as an option, including allowance for machining up to 1/4-inch on each side.

   Activation of the ABS and/or ATC shall override the operation of the brake retarder.

2) ***Friction Material:*** The entire service brake system, including friction material, shall have an overhaul or replacement life of at least 30,000 miles when running on the design operating profile. Brakes shall be self-adjusting throughout this period. Heavy duty Haldex automatically adjusted brake slack adjusters are preferred. The slack adjusters will have the proper rated inch point torque specification and be of the proper length to provide the necessary leverage and to avoid excessive travel of brake diaphragm. Levers will not have more than one hole and it will be properly bushed. The slack adjusters will not be repairable and a have a grease fitting for periodical lubrication and will have a normal replacement life of 100,000 miles. The S-cam (Quick-cam) brakes are preferred.

   Brake lining must be designed and approved for use on the vehicle being proposed. Brake lining must provide optimum performance with the brake system being used and will minimize brake noise under all weather conditions. Non asbestos material will be used in the brake lining. Front and rear brake material must be the same.

3) ***Hubs and Drums:*** Front hubs will be of the type that can be disassembled to remove bearings, races, and seals. Both front and rear axles shall have oil seals.

New Flyer's request to provide MAN axles with unitized non-serviceable, wheel bearings is accepted as an approved equal.

4) ***Anti-Lock Braking System (ABS) and Automatic Traction Control (ATC):*** Microprocessor-controlled ABS and ATC shall be available as a standard feature. The microprocessor for the ABS system shall be in a protected but accessible location to allow for ease of service.

5) ***Regenerative Braking:*** In addition to traditional mechanical friction service braking, the bus shall be equipped with regenerative braking designed to improve energy efficiency and extend brake lining service life. The application of regenerative braking shall cause a smooth blending of both regenerative and service brake function. Actuation of ABS and/or ATC shall override the operation of the regenerative brake.

6) ***Actuation:*** Service brakes shall be controlled and actuated by a compressed air system. Brakes shall be self-adjusting, with wear indicators (visible brake sensors) on exposed push rods. The system shall be balanced with no front/rear displacement. Force to activate the brake pedal control shall be an essentially linear function of the bus deceleration rate and shall not exceed 75 pounds at a point 7-inches above the heel point of the pedal to achieve maximum braking. 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. Braking shall be initiated simultaneously for stability control per FMVSS121, Section 5.3.6.

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

8) ***Hubs and Seals:*** Replaceable wheel bearing seals shall run on replaceable wear surfaces or be of an integral wear surface seal designed. Wheel bearing and hub seals and unitized hub assemblies shall not leak or week lubricant when operating in DTA's transit conditions for the duration of the initial manufacturer's warranty period.

9) ***Wheels and Tires:*** Painted or powder coated steel wheels provided. Wheels shall be sized to accommodate tubeless tires, are ten stud and be hub pilot mounted. Wheel hubs may be painted. Tires will be Goodyear leased tires.

10) Wheels shall be compatible with tires in size and load-carrying capacity. Front wheels and tires shall be hub-piloted with standard, non-locking nuts.

1.40 PNEUMATIC SYSTEM

1) ***Air System:*** The bus air system shall operate all accessories and the braking system with reserve capacity. New buses shall not leak down more than 5 psi over a 15-minute

period of time as indicated on the dash gauge. This system shall be equipped with a remote air hook-up, Schrader type located in the propulsion compartment that will allow hook-up for auxiliary air and behind front bumper.

2) The electrically-driven air compressor shall be sized to charge the air system from 40 psi to the governor cut-off pressure in less than three minutes while not exceeding the fast idle speed setting of the propulsion system. Contractor must provide a provision to separate the oil from the air. Baldor 5 H.P. capacity and Powerex 13.3 CFM capacity compressors are approved equals.

3) Air Reservoirs: Air reservoirs shall meet the requirements of FMVSS-121 and SAE J10 and shall supply air for the vehicle's air suspension system, door operating mechanism and brake system. These reservoirs shall be equipped with drain plugs or flush type drain valves. Major structural members shall protect the drain valves and any automatic moisture ejector valves from road hazards. Reservoirs shall be sloped toward the drain valve. All 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 lines.

Check valves shall be furnished between the first and all other air reservoirs and shall be located adjacent to the other tanks. First air reservoirs shall have 150 psi safety valve.

4) Air Lines: Air lines, except necessary flexible lines, shall conform to the installation and material requirements of SAE Standard J1149 for copper tubing with standard, brass, flared or ball sleeve fittings, or SAE Standard J1844. 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 accessories.
Blue - indicates suspension lines

5) Line supports shall prevent movement, flexing, tension strain, and vibration. Copper lines shall be supported to prevent the lines from touching one another or any component of the bus. To the extent practical and before installation, the lines shall be pre-bent on a fixture that prevents tube flattening or excessive local strain. Copper lines shall be bent only once at any point, including pre-bending and installation. Rigid lines shall be supported at 30-inch intervals or less.

6) The compressor discharge line between powerplant and body-mounted equipment shall be flexible convoluted copper or stainless-steel line or may be flexible Teflon hose with a braided stainless-steel jacket. Other lines necessary to maintain system reliability shall be FC 300 hose. End fittings shall be standard SAE or JIC brass or steel, flanged, reusable, swivel type fittings. Flexible hoses shall be as short as practical 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 24-inch intervals or less. Air lines shall be cleaned and blown out before installation and shall be installed to minimize air leaks. Air lines shall be routed to prevent water traps the extent possible. Grommet or insulated clamps shall protect the air lines at all points where they pass through understructure

components.

7) An air dryer shall prevent accumulation of moisture in the air system. It shall have a dual filter and be designed for buses. It shall be vertical-mount, desiccant type with replaceable desiccant cartridge and thermostatically controlled heater element. It shall have automatic purge and drain cycle and be cleanable through the bottom of the unit. Bendix AD-9 is an approved equal.

1.41 BUMPER SYSTEM

1) Location: Bumpers shall provide impact protection for the front and rear of the bus up to 27 inches (+/- 2 inches) above the ground. Bumpers that wrap around the bus are permitted **but may not exceed allowable width**. Bumper height shall be such that when one bus is parked behind another, a portion of the bumper faces will contact each other.

2) Front Bumper: No part of the bus, including the bumper, shall be damaged as a result of a 5-mph impact of the bus at curb weight with a fixed, flat barrier perpendicular to the bus's longitudinal centerline. The bus will return to its pre-impact shape within 10-minutes of impact. The bumper shall protect the bus from damage as a result of 6.5 mph impacts at any point by the striker defined in Figure 2 of FMVSS 301 loaded by 4,000 pounds parallel to the longitudinal centerline of the bus and 5.5 mph impacts into the corners at a 30-degree angle to the longitudinal centerline of the bus. The energy absorption system of the bumper shall be independent of every power system and shall not require service or maintenance in normal operation during the service life of the bus. The flexible portion of the bumper may increase the overall bus length specified by no more than 6 inches.

4) Rear Bumper: The rear bumper and its mounting shall provide impact protection to the bus at curb weight from a two-mph impact with a fixed, flat barrier perpendicular to the longitudinal centerline of the bus. When using yard tug with a smooth, flat plate bumper 2 feet wide contacting the horizontal centerline of the rear bumper, the bumper shall provide protection at speeds up to five mph, over pavement discontinuities up to 1-inch high, and at accelerations up to two mph/sec. The rear bumper shall protect the bus, when impacted anywhere along its width by the striker defined in FMVSS #301 loaded to 4,000 pounds, at four mph parallel to the longitudinal centerline of the bus or into the corners up to a 30-degree angle to the longitudinal centerline. The rear bumper or bumper extensions shall be shaped to preclude unauthorized riders standing on the bumper. The bumper shall be independent of all power systems and shall not require service or maintenance in normal operation during the service life of the bus. Any flexible portion of the bumper may increase the overall length specified by no more than 6- inches.

3) Bumper Material: Bumper material shall be corrosion resistant. These qualities shall be sustained throughout the service life of the bus.

1.42 ELECTRICAL SYSTEM

1) General Requirements: The electrical system will consist of vehicle battery systems and components that generate, distribute and store power throughout the vehicle (e.g., generator, voltage regulator, wiring, relays and connectors.) All electrical components, including switch, relays, flashers, and circuit breakers, shall be heavy-duty designs. To

the extent practical, these components shall be designed to last the service life of the bus and shall be replaceable in less than five minutes by a 3M mechanic. Sockets of plug-in components shall be polarized where required for proper function and the components shall be positively retained. All electric motors shall be heavy-duty brushless type. Electric motors shall be located for easy replacement.

Horns: Dual electric horns will be provided. Horns will be positioned to be protected from road hazards and the elements. The horn trumpets will be down turned to assure drainage of any moisture that may enter.

Electronic devices are individual systems and components that process and store data, integrate electronic information or perform other specific functions.

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

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

Data communication systems are divided into three levels for the use of multiple data networks:

i. Powertrain Level: Components related to the powertrain, including the propulsion system components, (electric energy storage, energy storage controller, motors, inverters, converters, etc.) and system components consisting of the batteries, drive unit, regenerative braking, and antilock braking systems shall be powered by a dedicated and isolated supply voltage to ensure data communication between components exists when the vehicle is switched to the “on” position.
ii. 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 (e.g., the vehicle will continue to operate when those functions are inoperable.) These components typically consist of those required for an automatic vehicle location systems (AVL), destination signs, fareboxes, passenger counters, radio systems, automated voice and signage systems, video surveillance and similar systems.
iii. Multiplex Level: Electrical or electronic devices controlled through input/output signals such as discrete, analog and serial data information (i.e., on/off switch input, relay and relay control outputs. Multiplexing is used to control components not typically found on the drivetrain or information levels, such as lights, wheelchair lifts, doors, heating, ventilation and air conditioning (HVAC) systems and gateway devices.

2) Modular Design: Design of the electrical system 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 60 minutes by a 3M mechanic. Powerplant wiring shall be an independent wiring module.

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 of the DTA.

4) Precautions shall be taken to minimize hazards to service personnel. The DTA will follow recommendations from the manufacturer and subsystem suppliers regarding methods to prevent damage from voltage spikes generated from welding, shorts, etc. All electrical/electronic hardware mounted on the interior and exterior of the bus that is not designed to be installed in an exposed environment shall be protected. All electrical/electronic hardware and its mounting shall comply with the shock and vibration requirements of published industry standards, SAE, ISO, etc.

5) 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.
All electronic component suppliers shall ensure their equipment is self-protecting in the event of shorts in the cabling, and also in over-voltage (over 32 VDC on a 24 VDC nominal voltage rating with a maximum of 50 VDC) 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 a pull up or pull-down resistor shall be limited as much as possible and easily accessible and labeled.

6) ***Low Voltage Batteries:*** The Proposer's battery system shall have adequate capacity to execute a start sequence after the bus has been parked and off for a minimum of 48 hours. Low voltage battery cables shall be color coded, black for negative, yellow for 12-volt and red for 24-volt, and the battery cables shall not cross each other, shall be flexible, shall be sufficiently long to reach the batteries with the tray in the extended position without stretching or pulling on any connection, and shall not lie directly on top of the batteries.

7) ***Battery compartment:*** The battery compartment 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 bus. All components within the battery compartment, and the battery compartment itself, shall be protected from damage and corrosion from the electrolyte.
The bus shall be bus shall be equipped with one or more quick disconnect switches. The non-locking access door shall be clearly marked.
The batteries will be securely mounted on a stainless-steel tray that can accommodate the size and weight of the batteries. The tray will easily extend and be properly supported to permit service. The same fire-resistant principles must apply to the battery compartment. No sparking devices should be located within the battery box.

8) ***Auxiliary Electronic Power Supply:*** If required, gel-pack or any form of sealed (non-

venting) batteries are allowed to be mounted on the interior of the bus, the compartment must contain a warning label prohibiting the use of lead-acid batteries.

9) ***Master Battery Switch:*** The location of the master battery switch must be clearly identified and be accessible in less than 10 seconds.

10) ***Low Voltage Generation and Distribution:*** The low-voltage generating systems shall maintain the charge on fully charged batteries. Voltage monitoring and over-voltage output protection (recommended at 12V) shall be provided. Charging profile shall be maintained within the battery manufacturer's guidelines.
Dedicated power and ground shall be provided as specified by the component or system manufacturer. Cabling to the equipment must be sized to supply the current requirements with no greater than a 5-percent volt drop across the cable.

11) ***Circuit Protection:*** All branch circuits except battery to starting motor and battery to generator/alternator circuits, shall be protected by current-limiting devices such as circuit breakers, fuses or solid state devices sized to the requirements of the circuit. The circuit breaker fuses shall be easily accessible for authorized personnel. This requirement applies to inline fuses supplied by either the Contractor or the supplier. Fuse holders shall be constructed to be in a location convenient to the DTA mechanic with visible indication of open circuits. The Contractor shall show all in-line fuses in the final harness drawings. Any manually resettable circuit breakers shall provide a visible indication of open circuits. All exterior fuse holders must be of weatherproof design.

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

13) ***Grounds:*** Redundant grounds shall be used for all electrical equipment, except where it can be demonstrated that redundant grounds are not feasible or practical. One ground may be the body and framing. Grounds shall not be carried through hinges, bolted joints (except those specifically designed as electrical connectors), or powerplant mountings. Electrical equipment shall not be located in an environment that will reduce the performance or shorten the life of the component or electrical system. Major wiring harnesses shall not be located under the floor, and under-floor wiring shall be eliminated to the extent practical. Wiring and electrical equipment necessarily located under the bus shall be insulated from water, heat, corrosion, and mechanical damage.

14) ***Low Voltage and High Voltage Wiring and Terminals:*** Kinking, grounding at multiple points, stretching and reducing the bend radius below the manufacturer's recommended minimum shall not be permitted. All power and ground wiring shall conform to specifications and requirements of SAE J1127, J1128, and J11292. All high voltage power and ground wiring shall conform to requirements of SAE J1763, J1654, and J2910. In the case of conflicts with the requirements below, SAE standards shall apply. Double insulation shall be maintained as close to the junction box, electrical compartment or terminals as possible. The requirement for double insulation shall be met by wrapping the harness with plastic electrical tape or by sheathing all wires and harnesses with nonconductive, rigid or flexible conduit.

Wirings located inside a junction box that are secured to prevent chaffing does not require double insulation.

The bus shall be manufactured so that high-voltage systems and cabling do not interfere with the operation of low-voltage control systems. To this end, high voltage cabling and low voltage wiring must be separated as far as possible. Additionally, parallel runs of high voltage cabling and low voltage control wiring shall be maintained.

Strain-relief fittings shall be provided at all points where wiring enters electrical compartments. Grommets of elastomeric material shall be provided at points where wiring penetrates metal structure. Wiring supports shall be non-conductive. Precautions shall be taken to avoid damage from heat, water, solvents, or chafing. Wiring length shall allow replacement of end terminals twice without pulling, stretching, or replacing the wire.

Except for those on large wires such as battery cables, terminals shall be crimped to the wiring and may be soldered only if the wire is not stiffened above the terminal and no flux residue remains on the terminal. Terminals shall be full ring type or interlocking and corrosion resistant. "T" Splices may be used when it is less than 25,000 circular mills of copper in cross-section: a mechanical clamp is used in addition to solder on the splice; the wire supports no mechanical load in the area of the splice; and the wire is supported to prevent flexing. All splicing shall be staggered in the harness so that no two splices are positioned in the same location within the harness. All wiring shall be color coded and/or numbered so as to be identical from one bus to the next.

To the extent possible, 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 should be installed above the window line of the bus.

All wiring harnesses over five feet long and containing at elase five wires shall include 10 percent (minimum one wire) excess wires for spares. This requirement for spare wires does not apply to datalinks and communications cables. Wiring harness length shall allow end terminals to be replaced twice without pulling, stretching or replacing the wire. Pins shall be removalbe, crimp contact type, of correct size and rating for the wire being terminated. Unused pin postions shall be sealed with sealing plugs. Adjacent connectors shall use either different inserts or diffenent insert orientations to prevent incorrect connections.

15) ***Junction Boxes:*** All relays, controller, flashers, automatic or manual resetting circuit breakers, and other electrical components should be mounted in easily accessible junction boxes. In areas with high moisture or areas exposed to the elements, the boxes shall be sealed to prevent moisture from normal sources, including propulsion equipment compartment cleaning, from reaching the electrical components and shall prevent fire that may occur inside the box from propagating outside the box. The components and circuits in each box shall be identified and their locations recorded on a schematic drawing permanently glued to or printed on the inside or outside of the box cover or door plastic coated schematics placed rather than glued are also acceptable. The drawing shall be protected from oil, grease, fuel, and abrasion. If the junction box is located along the left side wall, it shall be replaceable as a unit in less than 25 minutes by a 3M

mechanic. If provided, a rear start and run control box shall be mounted in an accessible location in the propulsion compartment. All wires entering junction boxes from above shall have a drip loop to prevent water from wicking into the box. Wires should be set to enter the box perpendicular as to not compromise the integrity of the weather seal.

16) ***High-Voltage Generation and Distribution:*** All high voltage wiring shall be clearly marked and isolated from low voltage wiring. High voltage wiring shall be loomed in a bright red or orange, watertight, anti-abrasive, flexible conduit. High voltage wiring shall utilize grommet less bulkhead fitting to pass through walls and bulkheads. The entire high voltage wiring circuit shall be watertight. Power cables shall be flexible multistranded copper with a Hypalon or neoprene jacket. The jacket insulation shall be rated at a minimum of 900 volts. The conductors for the traction battery and motor cable shall be sized for continuous operation at maximum controller current without exceed a 20 F degree rise above ambient temperature. The conductors for other power cables shall be sized for continuous operation at their maximum expected current without exceeding a 20 F degree rise above ambient temperature. Connections between battery blocks shall be fastened, providing a contact area at least as large as the circular area of the cell post. Other connectors shall be selected and sized to carry the maximum expected current.

17) ***High Voltage Disconnect System:*** The high-voltage wiring shall be fitted with automatic disconnecting contactors located as closely as possible to the positive and negative battery output terminals so as to minimize the external circuitry that is not de-energized when the devices open. These contactors shall be in addition to any such devices incorporated in the motor controller, and shall not require electrical power to operate (that is, they shall be normally open when unpowered.) The contactors shall be rated as capable of interrupting the maximum normally encountered charging or operating current at the highest voltage likely to be encountered (maximum charger output voltage or charger-input voltage, whichever is greater.) Contactors shall be controlled by the “High Voltage Disconnect” switch, and any safety-critical interlock loops, motor-controller overcurrent protection functions, and vehicle crash and/or fire sensors. Reset of the contactors shall require the deliberate action of the operator or maintenance personnel. Contactors should provide a visual or electrical indication of their status, (open or closed) or of a failure to function.
Lids in high voltage enclosures must be interlocked, such that opening an enclosure automatically disconnects the high voltage system. Any high voltage cable of 5 amps or greater must also have an interlock such that disconnecting any cable of this type will disconnect the high voltage system.
The feature could be part of the emergency shutdown system, providing a failsafe method for shutting the high voltage system down by manual activation of an emergency switch (red palm button), sensed isolation fault between high voltage and chassis, opening an interlocked panel or disconnecting a high voltage cable of 5 amps or greater.

18) ***High Voltage Wiring:*** High voltage wiring shall conform in all respects to SAE recommended practices, J1654 (High-voltage Primary Cable), J1673 (High-voltage Automotive Wiring) and J1742 (High-voltage On-Board Connectors). The outer layer of insulation the high-voltage wiring shall be bright orange or yellow in color.

High-voltage wiring shall be protected by major structural members from road hazards

and collision damage. Wiring shall be continuous cables with connections secured using suitable vibration resistant fasteners such as nylocks or lock washers on bolted terminals. Terminals shall be rated for the expected current, corrosion-resistant and crimped or secured with setscrews.
Wiring length shall allow replacement of end terminals without pulling, stretching or replacing the wire. Double insulation shall be maintained as close to the terminals as practicable. Terminal shanks and cable ends shall be protected by shrink tubing or vulcanized covers. Shrink tubing or vulcanized covers shall be color coded to indicate polarity; black to indicate terminals normally negative, red for terminals normally positive. Red or black shall not be used for protective covers of terminals on wiring normally carrying high-voltage alternating currents. All high-voltage wiring shall be labeled and numbered to be identical from bus to the next.
All high-voltage wiring that runs through areas where rotating or moving components might cause abrasion must be enclosed in orange or yellow non-conductive conduit. The conduit must be securely anchored at least at each end and must be located out of the way of possible snagging or damage. Wiring inside of battery enclosures is not required to be covered but must be adequately secured and protected from abrasion and mechanical stress.
All external heat sinks or metal housings for high-voltage components (i.e., motors, inverters, etc.) must be securely grounded. Within an enclosure, exposed (uninsulated) high voltage terminals or conductors of opposing polarities must be spaced with an adequate air gap to prevent arcing due to dielectric breakdown. It is strongly recommended that the spacing is significantly larger than this to reduce the risk of accidental short circuit during service.
High voltage wiring shall not be bundled with low volage wiring (except appropriately fused and distinctively marked high voltage instrumentation-signal wires may be routed with other instrumentation signal wires if the conduit or bundle is also distinctively marked as carrying high voltage.) Grommets or elastomeric material shall be provided at points where wiring penetrates metal or rigid structures. Wiring supports shall be non-conductive. Precautions shall be taken to avoid damage from heat, water, solvents, commonly encountered automotive fluids, and chafing. Wire shall support no mechanical loads in the area of terminals and the wires shall be supported to prevent flexing. All wiring shall be numbered identically from one bus to the next.

19) High Voltage Overcurrent Protection: All wiring and connected devices and equipment shall be protected against overcurrent by fuses or circuit breakers. Fuses and circuit breakers shall be rated to protect against prolonged overloads and short circuit conditions. The time-current characteristics of overcurrent protective devices and functions shall minimize hazard to personnel and equipment in the event of failure of any single protective device or function.

20) High Voltage Grounding: The bus chassis and all conductive structural elements of the vehicle shall be electrically interconnected by means of low-resistance mechanical connections, ground straps, wires, or welded connections. Buses with a nonconductive chassis shall be provided with a low-impedance grounding system suitably sized for the level and duration of possible faults currents. Gound paths shall not exhibit an electrical potential in excess of 0.1-volt relative to each other while the bus is off or in normal operating or charging configurations. The high-voltage electrical system shall not, in any normally encountered operational or charging configuration, make use of the vehicle

chassis or of the low voltage grounding system as a current path. The high-voltage electrical system shall not, in any normally encountered operation or charging configuration, induce any detectable electrical current as a design feature of instrumentation circuits.
High voltage and low voltage (chassis grounded) circuits must be physically segregated. If both high-voltage and grounded circuits are present within an enclosure, they must be separated by insulating barriers or other moisture resistant, UL recognized insulating materials, or well separated so that there is no risk of arcing due to dielectric break down or contact due to slight shifting of components during use.
If hazardous voltages are contained within a conductive exterior case or enclosure that may be exposed to human contact as installed in the vehicle, such case or enclosure shall be provided with a conductive connection to the vehicle.
Energy storage components (including batteries) and major power electronic components shall have their conductive external cases connected to the vehicle chassis or grounding system by a ground strap, wire, welded connection or other suitable low resistance mechanical connection. This grounding connection shall provide a low impedance path, sized appropriately for the level and duration of possible fault currents. Ground paths shall not be carried through hinges, bolted joints (except those specifically designed as electrical connectors), body or propulsion system mountings.
Other components that receive hazardous voltages from sources outside their enclosures may have their cases grounded either directly (as above) or indirectly through the wiring harness that carries the voltage(s) from the external source. Disconnecting the wiring harness used to provide indirect grounding shall also disconnect the source of hazardous voltages.
Low isolation of the high-voltage electrical system from the chassis grounding system shall cause a dashboard warning lamp to illuminate and automatic disconnect of the high voltage system.

20) ***DC-DC Converters and DC-AC Converters:*** The buses shall be fitted with a device or controller function to maintain the low voltage batteries at a full state of charge using energy drawn from the traction battery.
The high voltage inputs to individual DC to AC and DC to DC conversion devices shall be protected by circuit breakers or fuses. The output circuits of DC to AC and DC to DC conversion devices shall also be protected by appropriately rated circuit breakers or fuses.
The Contractor will assist the DTA with verification that the charger/charge function works throughout Acceptance Testing stages. Contractor will provide written verification that the fuses or circuit breakers are appropriately sized by consulting the conversion device maker's literature in the Contractor's engineering files, as well as an independent testing agency assessment if available.

21) ***Programmable Logic Control System:*** The bus shall be equipped with an IO Controls Corp. or Allen Bradley industrial or a Vansco programmable logic control system that will have the ability to talk to various modules located throughout the bus that can store and retrieve data for the mechanical and electrical functions of the bus. The system shall be so designed to significantly reduce the connectors, circuit breakers and wiring harnesses of a standard bus. It shall have the capability to quickly trouble-shoot electrical failures for the mechanic and notify maintenance when an electrical component has failed.
The system shall have the capability to download information to in-house computer system

per bus and automatically determine mechanical failures. A programmable controller shall be located in a sealed compartment in the rear of the interior of the bus.
The manufacturer shall provide training on the programming of components and the report formatting and usage of the system.

22) Radio Noise Suppression: Proper suppression equipment shall be provided in the electrical system to eliminate interference with radio and television transmission and reception. This equipment shall not cause interference with any electronic system on the bus.

23) **General Electronic Requirements**

a If an electronic component has an internal clock, it shall provide its own battery backup to monitor time when battery power is disconnected. Any component with its own real-time clock will be set to Central Standard Time.
All electronic component suppliers shall ensure that their equipment is self-protective in the event of shorts in the cabling, and also 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 without prior approval of the DTA.
Kinking, grounding at multiple points, stretching, and exceeding minimum bend radius shall be prevented.
The Contractor shall consult with the DTA Director of Maintenance on the configuration of accessory reserve power when the bus is shut off.

b. 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. Labels shall be resistant to rubbing (hot stamped tubing and protected printing are service-proven examples of acceptable labels). 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 of each I/O terminal.

c. Shielding

All wiring that requires shielding 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.

d. Communications

The data network cabling shall be selected and installed according to the selected protocol requirements. The physical layer of all network communication systems shall not be used for any other 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 24 V-power line) shall meet the most stringent applicable wiring and terminal specifications.

e. 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 has a loss, which will contribute to attenuation of the signal. Cabling should allow for the removal of antennas or attached electronics without removing the installed cable between them. The corresponding component vendors shall be consulted for proper application of equipment including installation of cables.

f. Audio

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

g. Multiplexing

i. All vehicles shall be equipped with a multiplexing system. 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. This system shall meet the network communications requirements of the DTA IT Specifications. DTA shall approve the multiplex system.

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 the spare inputs and outputs provided on each module. 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 (10%) of the total number of inputs and outputs (or at least one each) at each zone location shall be designated as spares.

ii. System Configuration

Multiplexing may either be distributed or centralized. A distributed system shall process information on multiple control modules within the network. A centralized system shall process the information on a single control module. Both systems shall consist of several modules connected to form a control network.

iii. I/O (Input/Output) Signals

The input/output for the multiplex system may contain three types of electrical signals: discrete, analog, or serial data.

Discrete signals shall reflect the on/off status of switches, levers, limit switches, lights, etc. Analog signals shall reflect numerical data as represented by a voltage signal (0-12 V, 10-24 V, etc.) or current signal (4-20 mA). Both types of analog signals shall represent the status of variable devices such as rheostats, potentiometers, temperature probes, etc. Serial data signals shall reflect ASCII or alphanumeric data used in the communication between other on-board components.

h. Data Communications Systems

i. General

All data communication networks shall be either in accordance with a nationally recognized interface standard such as those published by SAE, IEEE, or ISO, or shall be published to the DTA with the following minimum information:

1. Protocol requirements for all timing issues (bit, byte, packet, inter-packet timing, idle line timing, etc.) packet sizes, error checking, and transport (bulk transfer of data to/from the device).
2. Data definition requirements that ensure access to diagnostic information and performance characteristics.
3. The capability and procedures for uploading new application or configuration data.
4. Access to revision levels of data, application software and firmware.
5. The capability and procedures for uploading new firmware or application software.
6. Evidence that applicable data shall be broadcast to the network in an efficient manner such that the overall network integrity is not compromised.

ii. Any electronic vehicle components used on a network shall be conformance tested to the corresponding network standard.
All components on the Drive Train network shall communicate data over the network as specified herein. The Multiplex Level shall use a communications network that meets the requirements of these specifications. Components integrated on the Information Level shall communicate data over the network selected herein.
iii.) Propulsion System Level: Propulsion system components, consisting of the electric motors, energy storage, power electronics, ABS, and ATC and all related components, shall be integrated and communicate fully with respect to vehicle operation with data using SAE Recommended Communications Protocol such as J1939 and/or J1708/J1587 with forward and backward compatibilities or other open protocol. Data communication among components shall be ensured when the vehicle is in operation.
iv.) Diagnostics, Fault Protection and Data Access: Drivetrain performance, maintenance and diagnostic data, and other electronic messages shall be formatted and transmitted on the communications networks. The drivetrain level shall have the ability to record abnormal events in memory and provide diagnostic codes and other information to service personnel. At a minimum, this network level shall provide live/fail status, current hardware serial number, software/data revisions and uninterrupted timing function.

I. **Multiplex Level**

a. Data Access

At a minimum, information shall be made available via a communication port on the multiplex system. The location of the communication port shall be easily accessible.
Provide a 12 Vdc power outlet adjacent to each diagnostic port on the interior of the vehicle. The DTA will approve the exact location(s).

b. 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 either a personal computer (PC) or a handheld unit. Either unit shall have the ability to check logic function.

A mockup board, where key components of the multiplexing system are replicated on a functional model, shall be provided as a tool for diagnostic design verification and training purposes. The mock-up board should be priced separately in the Proposal pricing schedule.

c. 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: password protection, limited distribution of the configuration software, limited access to the programming tools required to change the software, and hardware protection that prevents undesired changes to the software.

Provisions for programming the multiplex system shall be possible through a PC/laptop. 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: hardware component identification where labels are included on all multiplex hardware to identify components; hardware series identification where all multiplex hardware displays the current hardware serial number and firmware revision employed by the module; and software revision identification where all copies of the software in service displays the most recent revision number, and a method of determining which version of the software is currently in use in the multiplex system.

The Contractor will work with the DTA to provide all requested changes free of charge during the full bus warranty period. Change requests to the software will be provided in a timely manner. The DTA requests to have full programming access to the multiplex system in the event of bankruptcy or material breach of the Contract. When legal liability concerns preclude such access, the vendor will provide DTA with a list of EPROM parameters and place a copy of all software revisions in escrow giving DTA access in case of Contractor default.

d. Electronic Noise Control: Electrical and electronic subsystems and components on all buses shall not emit electromagnetic radiation that will interfere with onboard systems, components or equipment, telephone service, radio or TV reception, or violate regulations of the Federal Communications Commission.

Electrical and electronic subsystems 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 buses, AC or DC power lines, RFI/EMI emissions from other vehicles.

As a recommendation, no vehicle component shall generate or be affected by RFI/EMI that can disturb the performance of electrical/electronic equipment as defined inn SAE J1113 and UNECE Council Directive 95/54(R10).

1.43 Fire Detection, Fire Suppression

1) ***Fire Detectors***: At least two temperature-sensitive sensors or linear wire will be provided. They will be located in the propulsion equipment compartment under all horizontal bulkheads, above and downwind of the major heat sources, and in areas likely to be wetted by leaking flammable fluids. Additional sensors will be located in other potentially critical areas. The sensors will detect high temperature in the critical areas and will activate the fire alarm bell and warning light in the driver's compartment. The sensors will return to normal setting and deactivate alarms when the temperature returns to normal.

2) **Fire Detection and Suppression System (Amerex V25 or Kidde Dual Spectrum shall be available at the DTA's option)**: A Fire Sensing and Suppression System (FSS) shall be provided to monitor the propulsion equipment compartment and auxiliary areas where a significant fire hazard exists. Upon detection, the system will alert the operator with visual and audible signals and initiate automatic engine shutdown, fuel shut-off, and extinguisher discharge sequences.

A) Fire Detection

Both thermal and optical fire detection shall be supplied.

Thermal fire detectors shall be spot (one-dimensional detection) or linear (two-dimensional detection) designed for use in engine compartments. Thermal fire detectors must be in close proximity to the fire in order to detect. Their mounting locations must be chosen per the installation instruction, certified by the manufacturer, and typically mounted so that airflow will act to move a fire in the protected area toward them. The thermal detector shall respond to being immersed in a fire in less than thirty seconds. The thermal detection system in the propulsion equipment compartment will be comprised of at least two each spot detectors or one linear detector of suitable length.

Fire detection sensors shall be located in an area not subject to corrosion.

B) SYSTEM ACTION

The FSS will detect fires in the protected areas. Upon detection, the system will alert the operator with visual and audible signals and initiate automatic shutdown, fuel shut-off, and extinguisher discharge sequences.

Alarm Indication: Upon detection of a fire, the system will provide a visual and audible fire alarm to the operator.

System Status and Trouble Indication: The status of the FSS shall be verified by inspection during maintenance.

Automatic Engine Shut-Down: After a fire is detected, the FSS shall cause the fuel flow to cease, and the engine to shut down. An operator override feature shall be provided. An automatic delay between the fire alarm and engine shutdown shall not exceed 30 seconds.

Extinguisher Discharge: The system shall provide a means for manually discharging the extinguisher with the control located in the driver's area. The installation shall be certified by the manufacturer of the suppression system.

System Reset: After a fire alarm and complete system sequence, the FSS shall have provision to be reset after the system is reconfigured per the instructions provided by the manufacturer.

C) FIRE SUPPRESSION SYSTEM

The fire suppression system shall be pre-engineered and designed for vehicle applications. The system shall have a minimum capacity of 20 pounds of BC or ABC dry

chemical agent. System cylinder shall have a minimum service pressure of 350 psi and be DOT rated. Nozzles and distribution shall be installed in accordance with the installation manual. Stored pressure type extinguishing units shall be provided with a gauge that can be visually inspected for pressure condition. The DTA requests the Amerex V25 system.

1.44 INTERIOR CLIMATE CONTROL

1) Capacity and Performance: The interior climate control system will maintain the interior of the bus at a level suitable for all climatological conditions found in Minnesota and shall provide the passenger with a "coatless experience" to the greatest extent possible. The heating, ventilating, and cooling systems shall maintain an average passenger compartment temperature between 65^0 F and 78^0F with a relative humidity of 50% or less. The system shall maintain these conditions in ambient temperatures of -30^0F to 95^0F with ambient humilities of 5 to 50% while the bus is running on the design operating profile with a full standee load of passengers. In ambient temperatures of -10^0 to -40^0F, the average interior temperature shall not fall below 55^0F while the bus is running on the design operating profile with no passengers. The temperatures measured from a height of 6" below the ceiling shall be within $\pm 5^0$F of the average temperature at the top surface of the seat cushions. Temperatures measured more than 3" above the floor shall be within $\pm 10^0$F of the average temperature at the top surface of the seat cushions. The interior temperature, from front to rear of the bus, shall not vary more than $\pm 5^0$F from the average. Supplemental heat will be provided to the passenger area with a Proheat X-30, 31,000 BTU diesel fuel fired auxiliary heater for the bus, a Valeo Thermoplus 300, or approved equal**.** A shut-off valve shall be provided for these units. Under seat units are required. A light on the dash showing when the heaters are activated is required. An LED back-lit toggle switch in lieu of the dash light is accepted as an approved equal.

The cooling mode shall be capable of reducing the passenger compartment temperature from 110^0 to 90^0F in less than 20 minutes after engine start-up under the following conditions. During the cool down period the refrigerant pressure shall not exceed 400 psi and the condenser discharge air shall not exceed 145^0F, measured 6 inches from the surface of the coil. The bus shall be parked in direct sunlight with the ambient temperature at 100^0F and humidity less than 20%. There shall be no passengers onboard and the doors shall be closed. The cooling mode may operate independent of the propulsion system and outside air may be cut off during the cool down period.

The pull up requirements for the heating system shall be in accordance with Section 9 of the APTA document, "Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System." With ambient temperature at –20F, and vehicle cold soaked at that temperature, the bus heating system shall warm the interior passenger compartment to an average temperature of 70±2 degrees F within 70 minutes.

Please note that HVAC testing is not required, but the system must be able to meet the performance requirements herein.

The climate control system shall be highly reliable since most failures are Class 2. Manually controlled shutoff valves in the refrigerant lines shall allow isolation of the compressor and receiver for service. To the extent practical, self-sealing couplings shall

be used to break and seal the refrigerant lines during removal of major components such as the refrigerant compressor or condenser. The condenser shall be located to efficiently transfer heat to the atmosphere and shall not ingest air warmed by the bus mechanical equipment above the ambient temperature or discharge air into any other system of the bus. The location of the condenser shall preclude its obstruction by wheel splash, road dirt or debris.

Manually controlled valves shall have shutoff valves in the refrigerator lines to allow isolation of the compressor and receiver for service. The condenser will be located in the rear, of the bus top to efficiently transfer heat to the atmosphere and will not ingest air warmed by the buses' mechanical equipment above the ambient temperature or discharge air into other systems of the bus.

The air conditioning unit will be the Thermo King RLFE rooftop A/C unit & TE15 Rear A/C unit, or approved equal. IN ALL CASES R134A MUST BE THE REFRIGERANT. R407C refrigerant is accepted as an approved equal.

Roof mounted condensers are accepted.

Air Conditioning Evaporators (Thermo King): The air conditioning evaporators will be located on the roof or in the rear of the bus in a location designed for ease of maintenance of the evaporators, the expansion valve, the return air filters, the electric controls and the blower motors (brushless). The evaporators will incorporate, as part of their design a drainage tube of sufficient size to remove all condensation.

Air Conditioning Compressor (Thermo King): A Scroll type compressor is required. The air conditioning compressor will have a minimum displacement of 25 cubic inches. The compressor must be designed to allow its engagement at any speed without damage to the compressor or any other components in the bus. The compressor must have a minimum useful life of five years on the standard operating profile. To facilitate the servicing of the compressor two back seated valves will be provided at the compressor to allow the compressor to be isolated.

Heat shall be applied to the front step tread to prevent accumulation of snow, ice, or slush. Stepwell heat shall be supplied via the supplemental heater and controlled by the driver's heater and defroster system.

1) A swing-out type guard with a minimum of screws will be provided for easy access to the air conditioning system. The HVAC can be roof mounted and accessed from inside the bus with a lockable access door.

2) ***Controls:*** All interior climate control system requirements shall be attained automatically; the driver shall control only the defroster and driver's heater. The interior climate control system shall switch automatically to the ventilating mode if refrigerant compressor or condenser fan fails. An option shall be available for a four-position controller (Off/Vent/Cool/Heat).

All interior climate controls will be directly under the control of the driver using toggle or rotary switches for each function. Actual bus temperatures are controlled by automatic

thermostats. These controls are in addition to the front defroster and driver's heater. If the air conditioning system fails, the climate control system will automatically switch to the vent mode.

3) Air Flow, Passenger Area: The cooling mode of the interior climate control system shall introduce air into the bus at or near the ceiling height at a minimum rate of 25 cubic feet per minute per passenger based on the standard configuration bus with full standee load. The air will be composed of no less than 10 percent outside air. Air flow shall be evenly distributed throughout the bus with air velocity not exceeding 60 feet per minute on any passenger. The ventilating mode shall provide outside air at a minimum flow rate of 20 cubic feet per minute per passenger.

Air flow may be reduced to 15 cubic feet per minute per passenger when operating in the heating mode with full standee load. Heated air introduced into the bus will contain no less than 20 percent outside air. The fans shall not activate until the heating element has warmed sufficiently to assure at 70°F air outlet temperature.

Sufficient floor level heaters shall be provided that evenly supply heated forced air through floor ducts across the length of the bus. Floor ducts may be discontinued at the upper level but additional provisions to prevent cold floor and ensure temperature uniformity shall be included. Control of the floor level heating shall be through the main heating system electronic control.

An escape hatch or roof ventilator combinations shall be provided in the roof of the bus approximately over the front axle. When open with the bus in motion, the escape hatch/roof ventilators shall provide fresh air inside the bus. The ventilator shall cover an opening area no less than 425 square inches and shall be capable of being positioned as a scoop with either the leading or trailing edge no less than 4-inches, or with all 4 edges raised simultaneously to a height no less than 3½-inches. A tool shall be provided that will allow the operator to open and close the roof hatches.

4) Load Shedding and Derating: HVAC control must include a method to provide multistage load shedding when required to conserve battery power. The HVAC system may be operated with reduced performance to allow the bus to operate when the high voltage batteries are below critical levels.

5) Driver's Area: The bus interior climate control system shall deliver at least 100 cubic feet per minute of air to the driver's area when operating in the ventilating and cooling modes. Adjustable nozzles shall permit variable distribution or shutdown of the air flow. Air flow in the heating mode shall be reduced proportionally to the reduction of air flow 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 driver's feet and legs.

The defroster or interior climate control system shall maintain visibility through the driver's side window. Two dash mounted fans (this are additional fans) will be provided to assist with defrosting the windshield. The switch for the fans will be mounted so that the bus operator does not have to leave the seat to activate the fans. The switch will

activate either one or both fans. The fan will be located out of the line of site of the operator and in such a fashion to prevent passengers from touching the fan. This area will also be equipped with a fresh air vent that is easily operable by the driver. DTA prefers, but does not require that the defrost system be capable of mixing drier outside air during winter months to reduce moister on the interior windows.

6) ***Air Intakes:*** Outside openings for air intake shall be located on the left side of the vehicle to ensure cleanliness of air entering the climate control system, particularly with respect to exhaust emissions from the bus and adjacent traffic. All intake openings shall be baffled to prevent entry of snow, sleet, or water. The filter shall meet the ASHRAE requirement for 5% or better atmospheric dust spot efficiency, 50 percent weight arrestance, and a minimum dust holding capacity of 120 gram per 1,000 cfm cell. More efficient air filtration may be provided to maintain efficient heater and or evaporator operation. Air filters shall be cleanable and easily removable for service. Moisture drains from air intake openings shall be located so that they will not be subject to clogging from road dirt.

7) ***Manual Control:*** The entire interior climate control system shall be controlled by a switch conveniently located to the driver. This switch shall have only OFF and ON positions. When the switch in ON the interior climate control system shall meet all specification requirements, and when in the OFF position no mechanical system within the climate control system shall be powered. See 1.36(2) for optional 4-way controller.

1.45 CHARGING SYSTEM SPECIFICATIONS

1) The bus shall be equipped with all electronic/electrical components to allow for depot charging.

2) The bus must be equipped with a communication system to transmit information on each charge event, including bus ID, charger status, beginning SOC, charge amount, ending SOC, charge duration, etc.

3) Immediately upon charging circuit activation and until the charging period is complete, the connected bus shall be automatically rendered inoperable. The bus shall remain inoperable until disconnected from the charger. Recharging of the bus must be dependent on the bus being completely stationary with the parking brake of the bus engaged.

4) The charging sequence shall automatically stop if faults or errors are detected. Emergency situations detected by either the equipment or the bus operator shall automatically terminate charging and release the bus from the equipment.

5) The bus shall have illuminated indicators on the dash clearly indicating the state of operation.

6) Inside the vehicle, power shall be distributed through a main distribution panel with individual circuit breakers and RCD/GFI protection on the input to the charging module(s). Each charger circuit shall also be protected on the output stage to the battery pack or packs.

Intelligent Technology Technical Specifications

Definitions

- ADA Americans With Disabilities Act of 1991, and all subsequent amendments and regulations thereto.
- APC Automated Passenger Counter (***APC***)
- AVA Automatic Vehicle Annunciation system
- AVC Automatic Volume Control
- AVL Automatic Vehicle Locator
- DDU Driver Display Unit
- EEC Electronic Equipment Compartment
- LAN, WLAN Local Area Network, Wireless Local Area Network
- LDM Load Dump Module
- MAR Mobile Access Router
- MDC Mobile Data Computer
- MTD Mobile Data Terminal
- MTU Memory Transfer Unit (synonymous with MTC)
- MTC Memory Transfer Card (synonymous with MTU)
- PA Public Address System
- TSP Transit Signal Priority system
- VLU Vehicle Logic Unit

Technical Specifications

1. Public Address System

Contractor shall install a public address (P.A.) system as indicated below:

1.1 VLU Specifications

a. The VLU (Vehicle Logic Unit) shall be an open-standards based PC controller installed on the bus. The VLU shall employ a vast array of connections and interfaces to all on-board systems via standard PC and Transit system communication standards. This shall allow for growth for future onboard ITS systems and many years of service.

b. The VLU system shall provide integration to bus systems via proven transit and PC communication standards with SAE J1708/J1939/J1587, SAE J1939/CAN, RS232, and RS485 with busy line, TTL, USB, Ethernet, TCP/IP, discrete inputs and outputs, odometer, spare I/O, audio inputs and outputs, and full IDE capability for PC-type devices. The VLU shall use RS232, J1939 and J1708 to transmit information to the in-vehicle electronic display signs.

C. The VLU shall be capable of integrating with farebox/sign/camera systems to support security setups.

d. VLU system shall be capable of handling GPS data in all areas. The VLU shall employ advanced location algorithms that utilize the GPS, gyroscopic heading, and odometer pulse to accurately report where the bus is along the route. The VLU shall employ these advanced location algorithms to ensure precise ADA compliant announcements as well as ridership data collection.

e. The VLU system functionalities shall include but not be limited to AVA (Automatic Vehicle Annunciation), WLAN (Wireless Local Area Network), Vehicle Health Monitoring, Predictive Arrival, APC (Automatic Passenger Counter) and CAD/AVL (Computer Aided Dispatch/Automatic Vehicle Location). The VLU shall employ integration that enables the necessary subsystems access to transmission of data through a single secure wireless LAN, which shall have the capability to integrate with a real-time communications network. In the event of an emergency causing a vehicle to lose communication links to the network VLU shall allow all on-board data to be retained locally on the bus.

f. The VLU shall be designed with forward looking, state-of-the-art technology and modularity. The VLU shall be designed to support easy installation and replacement. This design shall allow the VLU to withstand the harsh elements of the public transportation environment. A strong body casing shall protect against falling dirt, rain, sleet, snow, wind blow dust, vibration, pressurized hose-directed water, corrosion, extreme temperature variations, and external formation of ice. The VLU shall have a secure lock on the access door requiring a unique key to help protect the VLU from theft. The VLU systems minimum functions, power management, environmental, and capability requirements are summarized below:

1.2. Function and Design

- Single point logon
- 12 Year design life
- Real time voice & data communications
- Smart bus technology
- Replaceable and upgradeable solid-state storage
- Support for full color LCD touchscreen mobile data terminal
- Navigation with GPS, odometer, gyroscope, and map matching
- X86 and Windows 10 compatibility
- Non-volatile data storage and collection
- Secure Wireless (WPA2) uploading/downloading employing WLAN security, updates, and uploads
- Network routing and dynamic IP addressing
- SAE J1939 (CAN) and J1708 interfaces
- Radio interface with handset, EA and covert microphone
- I/O & multiplex system Interface
- PA system with a minimum of 3x 30-watt amps and driver speaker amp
- Automatic volume control for at least 4 zones
- LED display for maintenance and diagnostics
- Power supply conditioning and management
- Compliance with SAE J1455 for environmental conditions
- Commercial, off-the-shelf component expansion

An Amtek Dixson C-Com 2G CAN-Communicator is accepted as an approved equal.

1.3 Power Management

- 35 Watts Nominal Power Draw
- 1.5 Amp @ 24Vdc Current Draw 18 Vdc to 48 Vdc Input Voltage
- Overvoltage Protection
- Reverse Protection

- Short Circuit Protection
- Dedicated Power Management Micro
- Protected from Ignition Interruption
- Programmable Delayed Shutdown
- Low Voltage Detect & Auto Shutdown
- Hardware/Software Watchdog
- Application Watchdog

1.4 Option: An option shall be available for Clever Devices SpeakEasy system, including driver's control head, floor switch, internal and external switches.

1.5 Passenger Information

a. The AVA (Automatic Vehicle Annunciation) system shall provide override capability for the operator to announce and display "ad-hoc" or pre-recorded special announcement messages, including Public Service messages, to be announced and displayed through this annunciation system.
b. Initial audio files are to be provided by the contractor as digitally recorded announcements.
c. Updated and new messages shall be automatically downloaded to the fleet on-board system via wireless LAN when the busses are stopped at the maintenance facility at overlay or when the on- board system is powered up provided it is in range of the WLAN system.
d. The contractor shall provide its own voice annunciation system via the VLU, and an interior dynamic message sign. The proposed Automatic Voice Annunciation System meets the requirements of the ADA. The contractor shall provide a multi-lingual AVA system. The AVA system shall provide audible and visual annunciation for every timepoint, route, and route variation in the system.
e. The AVA system shall include at a minimum:
    i. Automatic and operator defined annunciation control: Enables announcements based on trigger-controlled parameters. Operator/manual override provisions for repeat, suspended, public safety announcements etc.
    ii. Route- and location-based annunciation: Off-route, end of route and special service and route changes are detected and annunciations adjusted
    iii. Visual Display: Supports a variety of sign types with coordinated text messages
    iv. Automatic Volume Control: Automatic noise volume adjustments based on ambient noise
    v. AVL-based announcements: Location determination with precise accuracy to ensure proper announcements
    vi. Destination Sign Control: Support of multiple vendors' destination signs including *Twin Vision, Luminator, Hanover, Balios, Sunrise*, or approved equal.
    vii. Automatic annunciation updates: Secure wireless bulk data transfer system via 802.11 WLAN system for automatic file download to the fleet.

1.6 Interior Next Stop Announcement

a. The interior “Next Stop” announcement shall be configurable, the proposed Data Management system to operate in either “Departing Audio” or “Approaching Audio” mode. In Departing Audio operation, the “Next Stop” announcements are made as the bus falls within the configured distance of the present stop enroute to the next stop. The distance the announcement is made from the present bus stop shall be a parameter of the VLU system and shall be configurable on the bus and through the server side.

b. In Approaching Audio operation, the “Next Stop” announcements shall be made as the bus approaches the next stop. The distance that the announcements are made from shall be a parameter of the VLU system and shall be configurable on the bus and through the server side.

c. The VLU System shall announce information regarding transfers to be made at the next stop after the phrase “Next Stop.” This shall be configurable at the time for design finalization, as well as changeable through the provided server.

1.7 Interior Public Service Automatic or Operator-Initiated Announcement

a. Public Service audio messages shall be triggered automatically by a random algorithm defined within the server or manually by the Operator by selecting from canned, pre-recorded public service announcements.

b. All the public service announcements shall be stored on the on-board VLU System with the other operational data for the entire service area. The Operator shall be able to select and play a public service announcement from a list displayed on the Operator Interface.

c. Each message shall be represented by an easy to understand, text description of the announcement. The public service announcement shall be played over the PA speakers in the same voice as the pre-recorded ADA compliant AVA announcements.

d. The AVA system shall provide the capability for Automatic or Scheduled public service messages without Operator Intervention. DTA personnel shall be able to configure the system to automatically play public service announcements throughout the day with no operator intervention. These announcements shall play at intervals throughout the day.

1.8 Exterior Route and Destination

a. The VLU System shall integrate with destination signs to automatically display the exterior destination messages after operator logon.

1.9 Announcement Priority

a. The VLU System shall control the priority of the announcements over the speakers. The prioritization system variable shall be managed through the server system and locally via the Operator through the Operator Interface. This feature shall control the priority of which of the two announcements, (live

Operator announcement or the automatic announcement) gets played over the PA system speakers, in the event that they occur at the same time. The DTA shall have the ability to change the priority using the server system.

1.10 Inside Signage

a. The VLU System shall control and provide stop description information to the LED signs automatically based on location-based algorithms. The system shall also provide the date, time, and Stop Requested information.

1.11 Automatic Volume Control

a. AVC (Automatic Volume Control) shall be provided as part of the AVA solution. AVA shall monitor the ambient noise of the vehicle and raise and lower the volume of the automated announcements so that it is comfortably audible over the existing noise. The announcement volume shall be automatically compensated within a pre-defined acceptable range.

b. The system shall be capable of detecting ambient noise and performing AVC functions with microphones on the inside and speakers or microphones for outside detecting. The AVC system shall control and adjust the interior and exterior volume levels independent of one another. The interior and exterior volumes shall have an adjustable minimum and maximum volume. The AVC system shall adjust the volume within those set ranges. The AVC sensitivity shall also be adjustable. The server system shall manage these adjustments and all other AVA system parameters. Maintenance personnel shall also have access to volume adjustments on the vehicle via the Operator Interface.

1.12 Automatic Passenger Counter Installation/Integration

a. The Automatic Passenger Counter controller shall be integrated with the on-board Mobile Data Computer, based on the standard SAE J-1708/J-1587 or J-1939 VAN. Automatic Passenger Counter sensors shall be mounted so as to avoid any protrusions into the doorway passage, with sealed windows for the infrared beams.

b. Cabling to the doorway sensors shall be shielded and routed to avoid sources of electromagnetic interference, such as fluorescent lighting ballasts. The doorway sensors and Automatic Passenger Counter controller shall be mounted in locations that are not accessible to the vehicle operator. The alignment of the doorway sensors shall be calibrated after installation to establish the alignment settings for each vehicle that achieve the most accurate performance.

1.13 Data Communication

a. The Mobile Data Computer shall use the wireless data communications to send and receive messages with the central software at any time. The data protocol used for transmission shall accommodate the required functionality for up to at least 300 vehicles at a 30 second polling interval. The system shall store data if communications are interrupted and forward data to the central system once communications are restored.

b. It shall be a rugged, all-in-one 3G/4G FirstNet mobile communications solution with true enterprise class routing, security and firewall. It shall be ruggedized with integrated Wi-Fi access point, and minimum 4 port Ethernet switch.

1.14 Voice Communication

a. The radio shall be a Tait radio, or approved equal, with the remote mount

option and include an operator Handset that integrates the radio to the VLU system.

2. Automatic Vehicle Locator (AVL) System
   a. Contractor shall supply and install a fully functional Automatic Vehicle Locator. Parts list is as follows:

	CradlePoint R1900 FirstNet Ready Cellular, Passenger WIFI, and WLAN cellular modem and applicable cabling/antenna
10T0014-001	SIGN, 1-LINE ADAPTIVE
10T0519-001	V8 IVLU Assembly
45T0190-002	Radio, altered, TAIT, TM9355, 450-520
24T0016-001	Covert Mic
24T0028-003	Antenna, Radio, 450-520 MHz
24T0058-001	COVERT SWITCH
24T0486-002	ANTENNA, DUAL-BAND, GPS / WLAN
25T0128-104	HANDSET, 48" ARMORED
50T0035-001	J1708 DISTRIBUTION BOX
50T0056-001	Relay Assembly
50T0120-001	MDT Touch, 10.2” Color, W / Panavision
61T0384-005	Mount, MDT 5"
61T0773-001	MOUNT, HANDSET
75T0016-005	CABLE, MDT, LVDS, 5M
75T0169-025	Cable, RF, Mini UHF to PL 259, 25 FT
75T0321-011	Cable, Extension, J1708, 10 FT
75T0321-012	Cable, Extension, J1708, 30 FT
75T0417-025	CABLE, J1708 BOX TO FARE BOX, 25 FT
75T0462-001	Cable, Ext, J1708 to Hanover Destination Sign
75T0793-025	CABLE, GPS, FAKRA CONN, 25 FT
75T0793-125	CABLE, WLAN, FAKRA CONN, 25 FT
75T0955-001	CABLE, HARNESS, V8 IVLU, POWER
75T1114-001	CABLE, HARNESS, W1B, V8 IVLU
Trapeze APC (list below)	
50T0134-001	Receiver Assembly, TransitMaster APC
50T0135-001	Transmitter Assembly, TransitMaster APC
75T0756-001	Cable, Harness, Junction, TransitMaster APC, with J4
75T0756-002	Cable, Harness, Junction, TransitMaster APC, Without J4
75T0763-001	Cable, Harness, TransitMaster APC, Receiver, OEM
75T0763-002	Cable, Harness, TransitMaster APC, Transmitter, OEM
75T0763-003	Cable, Harness, TransitMaster APC, Receiver, OEM
75T0763-004	Cable, Harness, TransitMaster APC, Transmitter, OEM
75T1527-001	Cable, Harness, W2 V8 IVLU Power, 1-Radio
75T1529-001	CABLE, HARNESS, W1A, V88I IVLU, OEM or equal
50T0134-001	Receiver Assembly, TransitMaster APC
50T0135-001	Transmitter Assembly, TransitMaster APC

Cradlepoint IBR1700 router with WiFi is accepted as an approved equal.

3. Electronic Equipment Compartment (EEC)

3.1 Each bus shall be equipped with a fully lit and sealed compartment located on the left front wheelhouse to provide a mounting location for a radio transceiver, security camera digital video recorder, onboard systems equipment and other electronic equipment. The compartment shall contain a combination of slide out shelves and a 19-inch rack, capable of height adjustment. Shelves shall securely latch in the stowed position. Provide an easily removable locking bar to retain the slide-out shelves in the stowed position. The compartment shall be rattle-free loaded or unloaded.

ENC's 22.5-inc deep by 36-inch wide by 63-inch-high powder coated Cabinet is accepted as an approved equal.

3.1.2 The compartment shall be equipped with a power supply per section C6.03.02.05, and shall be a minimum 32.5 inches high by 15 inches wide by 19.5 inches deep. The compartment shall be sealed against the entry of water, and equipped with a door, retained with a key lock. Supply 'approved interchangeable equal cores and keys to match the DTA's existing system. The DTA shall approve the box design, shelves, and power supplies.

3.3 Destination Signs

3.3.1. General. An automatic electronic destination sign system manufactured by *Hanover* that interfaces with the MDT shall be provided on each bus. The route names will be expanded by not more than 10 entries from the current configuration. The colors of the signs will be amber or white dots on black background, color as an option. The glass in front of the destination sign shall be heated and the compartment shall be ventilated (fans required) so as to prevent fogging in cold weather.

Luminator Gen 4 signs and Luminator Twin Vision Smart Series III are accepted as approved equals.

a. Front Sign

The front destination sign shall be in a 17 row by 160 column configuration, with a display dimension of 8.01 inches (20.3 cm) high by 64.6 inches (164 cm) wide. The front sign will be located as close to the sign box glass as possible and the installation shall be designed to minimize glare and maximize readability. The Contractor and the sign manufacturer shall jointly engineer the installation of the sign into the bus as an integral component. Evidence of sign manufacturer's installation signoff shall be made available to the DTA.

b. Curb Side Sign

The curb side destination sign shall be an 8x96 matrix with display dimensions of 2.8 inches (7.1 cm) high by 36.3 inches (92.2 cm) wide, 15 row by 112 column amber dots on black background, viewable from the exterior of the bus and be sufficiently compact so as to fit neatly in the side window. It shall be located on the right (curb) side of the bus in the top of the second window behind the front door.

c. Rear Sign

Provide 15 x48 matrix signs in the rear of the bus amber dots on a black background.

Gillig's request to mount the rear destination sign on the rear HVAC panel is approved.

d. Sign Control

Signs shall be controlled from the driver's station using a back-lit keypad. This control / display unit shall be used to view and update display messages. It shall be recess mounted on the front sign box door or above the driver's side window. The control shall utilize a conductive rubber pad keyboard with tactile feel and be designed to withstand the bus environment.

The control shall contain a two line by 20-character display. This system shall inform the driver on the status of the sign system. It shall contain an audio annunciator that beeps to alert the operator to view the display for a message, or beeps indicating that a key is depressed.

The control shall allow two destination messages to be pre-selected. The driver shall be able to quickly change the pre-selected message without re-entering the message code. Additionally, the control unit shall be able to access diagnostic functions and display corresponding results relative to sign maintenance.

Up to four-digit route numbers shall be selectable by the driver and shall be independent from the destination sign message. Leading zeroes shall not be displayed. The system shall have the additional ability to sequentially display multi-line destination messages, but with the route number portion remaining stable in a constant 'on' mode at all times.

Sign readings shall also be controllable without driver intervention via AVL information using a J1708 interface.

ENC's request to provide a destination sign control panel located left and in reach of the driver in an overhead switch panel is accepted as an approved equal.

e. Sign Features

No blank messages shall be shown during a message sequence unless specifically programmed. Sequential messages shall be displayed in a manner and at a rate that makes it easy to read and comprehend the complete reading. Readings shall be stored in electronic memory on plug-in circuit boards. The message displays shall not be adversely affected by continued exposure to sunlight or other environmental conditions normally associated with bus operation. The system shall incorporate an auto-blanking feature that will cause the entire display area to be blank (black) within 30 seconds after the vehicle master power switch is turned off.

f. Sign Electronics

Each sign system shall have a system processor board, mounted in the front destination sign, capable of controlling up to 10 components. The system shall be capable of operating additional information displays or signs, such as interior information signs, as a future expansion possibility.

The system shall be designed so that the destination signs can display independent messages or the same message, as chosen by the message programmer during creation of the message listing.

There shall be the capability of storing at least 10,000 message lines with a capability of increasing this amount to at least 12,000 message lines. The sign memory shall be programmed with listing codes supplied by the DTA prior to delivery. There shall be no public relations messages programmed into the system.

g. Sign Programming

The sign system shall be re-programmable on the coach with the use of a Memory Transfer Unit (MTU), USB or Memory Transfer Card (MTC). A wireless option must be provided.

A list of destination sign readings will be supplied to the manufacturer to allow the signs to be preprogrammed with the correct readings.

Destination sign power will be supplied in all settings of the Master Run Switch except ENGINE STOP/OFF.

h. Component Quality

Electronic circuit boards shall be of a quality to facilitate repeated repair cycles. All I.C. sockets shall be machined pin, plated with a noble metal, preferably gold. All connectors, including I.C. sockets and board edge connectors shall be plated with a noble metal, preferably gold. Boards shall be mounted to reduce vibrational stress. The system shall operate at a nominal input voltage of 24 Vdc (+/- 6 Vdc). The sign system shall be internally protected against voltage transients and/or R.F. interference. Sufficient transient interference suppression will be included so the system will withstand transient pulses of 600 V for 10 microseconds and 100 V for 10 milliseconds. Sign interface cabling shall be shielded throughout the coach.

i. Visibility

The signs shall be visible and legible to a 5-foot 3 inch (160 cm) tall person standing as described below.
Front and rear signs: 3 feet (914 mm) from the front (rear) of the bus and 1 foot (305 mm) from the side.
Side sign: directly in front of the sign and 1 foot (305 mm) away from the side of the bus.
These are minimum requirements; the signs shall also be visible at greater distances.
Characters on signs shall have a width-to-height ratio between 3:5 and 1:1 and a stroke width-to-height ratio between 1:5 and 1:10, with a minimum character height (using an upper case 'X') of 1 inch (25 mm) for signs on the boarding side and a minimum character height of 2 inches (51 mm) for front 'head signs', with 'wide' spacing (generally, the space between letters shall be 1/16 the height of upper case letters), and shall contrast with the background, either dark-on-light or light-on-dark.

3.3.2 Sign Lighting and Boxes

a. The LED intensity automatically adjusts to the ambient light. Special attention will be given to using and mounting LEDs that will not fail due to vibrational stress when the coach is used in normal revenue service.

b. Sign mechanisms and boxes shall be constructed of materials designed to minimize static build-up and subsequent dirt accumulation. The front and rear destination sign cavities shall be sealed to prohibit the entry of dirt, dust, water and insects during normal revenue service or when coach interior is cleaned with a ”cyclone” type cleaner.
Sign boxes shall not vibrate or rattle and shall be sealed to exclude dirt, dust, water and insects. Each sign shall be housed in a protective cover that is removable with the sign.
A means shall be provided on the side sign to prevent accumulation of dirt on the inside of the bus window or on the outside of the sign box window. Heated front sign glass shall be supplied. Signs shall be visible at all times with no fogging of any glass.

c. Sign boxes shall have access doors to allow replacement of sign mechanisms and to allow servicing and cleaning. The front sign compartment access door shall have quarter turn adjustable spring latches with handles. The front sign compartment access door shall have a metallic piano hinge running the entire width of the access door; if bottom hinged, provide appropriate retaining straps. No components shall need to be removed to allow full opening of the sign door. The sign is removed and installed through this door unless the DTA agrees to other methods.

New Flyer's request to provide a front destination sign compartment that is open on each end and does not provide fans is accepted as an approved equal at the Procuring Agency's option.

d. Front and rear exterior sign glass (defined as the glass attached to the coach body) shall be masked to keep sign wiring and other compartment items hidden from view. Sign visibility shall not be affected with masking installed. Material used shall be black. Installation, visibility and type of material used will require approval of the DTA.

3.4 Communication Antennas

a. All buses shall be equipped with the following antennas. Placement of the antennas shall not interfere with numbers painted on the roof. Unpainted antennas are mounted with rivnuts and machine screws, sealed with waterproof caulk; installation to be approved by the DTA. If the bus does not have a metal roof, suitable ground planes, to be approved by the DTA, shall be installed. Antennas shall be mounted in the center of their ground planes. All antenna provisions shall be approved by the DTA.

New Flyer is approved to supply 5/8-inch inside diameter plastic conduit from radio compartment to the driver's area and 0.56 inches inside diameter plastic conduit for antenna.

3.5 Radio (See Technical Specification 2.0 for part numbers)

All buses shall come equipped with the radio antenna-mounting top hat with 13" ground plane as well as the connectors, mounting hardware and antenna.

3.6 GPS (See Technical Specifications 2.0 for part numbers)

a. In addition to the antenna is a Dual Band, GPS/WLAN antenna. This antenna will be located on the roof at the front of the bus, have an unobstructed view for satellites reception and not interfere with other communication devices. The cable will run from the GPS location to the equipment box with three feet of cable coiled at non-terminated ends.

b. Mobile Access Router (MAR)

Provide and install a CradlePoint 6-in-1 Dome Antenna – 2xLTE, GNSS, 3x WiFi, 2.4 and 5 GHz, Bolt Mount, 5m, White or approved equal antenna with the cable leading into the EEC and ending in a 3-foot coil of extra length. This antenna shall be mounted near the front edge of the roof.

c. Antenna lead-in cables, unless otherwise noted, shall be changed to CNT-240 *'Andrew'* or approved equal coaxial cable connecting each antenna with the electronic equipment compartment. Provide 3 feet (914 mm) of excess cable at each end. The antenna cables shall be routed through continuous 0.75-inch (19 mm) rigid thin wall metallic conduit or nylon tubing installed to allow easy replacement of the wire and prevent rubbing and chafing. All

connectors shall be installed; supply and install coaxial cable connectors. An interior ceiling access panel must be supplied directly under antenna. The antenna must be installed to not interfere with the roof top vehicle identification numbers.

d. Access covers, painted to match the adjacent ceiling panels, shall be supplied on the interior ceiling allowing access to the antennas. Mounting of these covers will be with rivnut and machine screws. A metal backing plate shall be used.

ENC's request to provide which access covers is accepted as an approved equal.

f. Static Ground A method of grounding static electricity shall be provided on each bus and will be approved at the design review.

3.7 Passenger Signal

a. General

The main function of the chime signal systems is to enable any mobile passenger to inform the driver and the other passengers that the bus is requested to stop at the next bus stop (system A) and to alert the driver that a mobility aid passenger wishes to disembark (system B). These systems shall alert the driver, both visually and audibly, and separately from each other. The Contractor may propose integrated or separate system(s) that accomplish this. The DTA shall approve the design, position, materials and operation of both passenger signal systems.

1. System A

The purpose of this system is to request stops and to alert the driver that a fully mobile passenger wishes to disembark. One solid-state electronic chime signal shall be provided. A separate light signal shall be provided on the driver's instrument panel and shall illuminate when the system is activated. One lighted display signs shall be mounted near the centerline on the ceiling.

System A signals shall be actuated by wire-centered yellow plastic cords running horizontally for the full length of each side of the bus except at door openings. These cords shall be located along the imaginary line separating the upper bin windows from the lower sections of the side windows and shall not interfere with opening of the side destination sign and route number sign for inspection. If the cord is not usable in the rear door area, a button to actuate the signal shall be placed on a nearby stanchion. Vertical drop cords shall be located at every side window pillar. These cords shall be secured to the horizontal chime cord with tiller clamps so they will not slide or travel. They shall be anchored at the opposite (bottom) end by means of an eyelet attached to the bus sidewall and secured with a tiller clamp. Use dual half-shell 'Atwood Corp.' tiller clamps, p.n. 8043-3 or approved equal with Torx screws at each chime cord crimp location. Cords shall not interfere with any window operation.

ENC's request to provide Hydroserve brand tiller rope guides is accepted as an approved equal.

Gillig's request to provide pull cord clamps with a Phillips head screw is accepted as an approve equal.

When system A is actuated by a passenger, chime shall sound, the passenger display signs shall be illuminated and the driver's dash mounted lamp shall illuminate. The chime shall be

disabled while the displays are on. When any door is opened, the displays shall be on with the chime disabled. After all doors close, the system shall be reset.

2. System B

This system shall allow a mobility aid user to request a stop and alert the driver that he/she wishes to disembark. One solid-state electronic chime signal shall be provided. This chime shall produce a different sound than the system A chime. A separate light signal shall be provided on the driver's instrument panel and shall illuminate when the system is activated. Activation of this system shall illuminate the two lighted display signs referenced in section C3.04.02 (system A).
Controls for system B shall be mounted no higher than 48 inches (1219 mm) and no lower than 15 inches (381 mm) above the floor, shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls shall be no greater than 5 lb. (22.2 N). Provide a touch pad on the bottom of the two-passenger folding seat in each tie down location. This touch pad shall be located where it will not be accidentally activated by movement of the secured mobility aid device. The flip-up seats with the touch pads shall have an electrical disconnect plug to facilitate removal of the flip-up seat for maintenance. Plug to be accessible to maintenance and not visible to passengers.
When any tie down area stop request signal is activated, the system B chime shall sound and the driver's dash mounted lamp shall illuminate. The chime shall be disabled while the display is on. When any door is opened, the display shall be on with the chime disabled. After all doors close, the system shall be reset.

3.8 Public Address System/OBS Provisions

a. Public address system provisions shall be provided on each bus for facilitating radio system and driver-originated announcements to passengers. The PA system uses the radio transceiver or other equipment as an amplifier. Contractor-supplied components shall not contribute distortion or low voltage noise interference and shall produce a clean, clear sound. The DTA at the design review shall approve the equipment and the locations of the PA system components.

b. At least 6 interior loudspeakers shall be provided, semi-flush overhead mounted on alternate sides of the bus passenger compartment, installed with proper phasing. The interior speakers shall be split into two zones of at least 3 speakers each for the current On-Board System PA function. These zones shall divide the bus into a “front half” and a “rear half”. Total impedance for each zone seen at the input connecting end shall be 4 to 8 ohms. Mounting shall be accomplished with rivnuts, machine screws and utilize a metal backing plate. One exterior speaker of weatherproof design shall be provided on the curbside no more than 1 foot from the front door. The wire for this speaker shall be routed to the EEC. Speakers shall be installed so as to facilitate testing and replacement when necessary.

Gillig’s request to provide 4 interior speakers on 29-foot buses is accepted as an approved equal.

Gillig’s request to provide an external P.A. Midwest #1180 weatherproof speaker mounted in the curbside skirt panel adjacent to the front door is accepted as an approved equal.
New Flyer’s request to provide interior speakers mounted with flat screws, flat washers and nuts is accepted as an approved equal.

A Trapeze-supplied antenna for the Public Address System is approved.

3.9 Automatic Passenger Counter Provisions (see Technical Specification 2.0 for part numbers)

a. The bus will have an infrared Automatic Passenger Counter (APC) system.

b. Provide mounting space within each doorway, either above or on both sides, depending on doorway width, direction doors open and space to mount the APC Analyzer. APC mount location will be approved by DTA prior to manufacture.

3.10 The following visual indicators shall be provided, augmented as shown below with audible warnings. Indicators may be located on the instrument panel or other approved location. The audible alarm buzzer shall be noticeable to the driver, but not at a sound level or pitch that is objectionable. Audible alarms shall be electronic.

Condition	Telltale Alarm	Lamp Text or Symbol	Color
Rear door open	None	EXIT DOOR	Red
Air brake application (not retarder)	None	STOP LAMP	Red
Headlight high beam	None	Symbol	Blue
Low air pressure	Buzzer	LOW AIR	Red
High propulsion system temp.	Buzzer	SYSTEM HOT	Red
High EV Drive Unit temp.	Buzzer	DRIVE HOT	Red
Turn indicator, R	None	Symbol	Green
Turn indicator, L	None	Symbol	Green
Emergency flashers	Tone	Symbol	Green
Parking brake on	None	PARK BRAKE	Red
DC/DC converter not charging	Buzzer	DISCHARGE	Red
Passenger stop	Chime 1	PASS STOP	Yellow
Mobility aid user stop	Chime 2	(International Wheelchair Symbol)	Yellow
Propulsion system fire alarm	Buzzer	ENGINE FIRE	Red
Rear door interlock off	Buzzer	WARNING INTERLOCK Deactivated	Red
Ramp enabled	None	RAMP	Red
ABS failure	None	ANTI-LOCK	Red
ATC failure	None	TRACTION CONTROL	Yellow
Rear door sensitive edge	Buzzer	DOOR ALARM	Red
Propulsion system status	Light	MANUFACTURER TO DECIDE	Red/Yellow

New Flyer's hot engine indicator in lieu of a High EV Drive Unit temperature alarm is accepted as an approved equal.

3.11 Radio Handset and Control System Provisions

a. Where noted, the Contractor shall be responsible to design mounting provisions for the radio handset, driver display unit (DDU) plus its active cradle and radio transceiver. The Contractor shall supply and install all components noted in this section unless otherwise indicated.
The locations and mounting arrangements for components referenced in this section shall be reviewed by the DTA at the design review.

b. Each bus shall have a recessed speaker in the ceiling panel above the driver. This speaker shall be the same component used for the speakers in the passenger compartment. It shall have 4 ohms of impedance. It shall be painted the same color as the surrounding area. Mounting shall be accomplished with rivnuts, machine screws and utilize a metal backing plate.

Trapeze supplied speakers on the driver's sawtooth is accepted as an approved equal.

c. Handset
Each bus shall have provision for mounting a radio handset on the right side of the dashboard convenient to the driver. It is preferred that the bracket be mounted on a horizontal plane.

3.12 Driver Display Unit

a. Each bus shall have provision for mounting a Driver Display Unit (DDU) and its active cradle as close to the right side of the instrument panel as possible. The DDU and its bracket are supported on a Contractor-supplied 'RAM Mount Systems' model 101 or approved equal double-ball adjustable clamp. The RAM mount must be attached to bus structure by means of Contractor-supplied bracket(s) and reinforcing plate(s). Attachment solely to the dashboard or instrument panel sheet metal or FRP is prohibited. The DTA will select the style and length of the RAM mount clamp depending on the design of the Contractor's bus and the final location of the DDU. The mounting location and RAM mount clamp will allow all drivers defined in Section C4.01 to easily reach the DDU.

b. Provide conduit and fittings by '*Adaptaflex'* or approved equal to carry harnesses from the DDU active cradle. The conduit carries a harness to the under-dash area, where it will split off to a power supply and Ethernet communications. The '*Adaptaflex*' conduit is part no. PAFS16/BL/50M, and the '*Adaptaflex*' fittings are part no. AL16/M20/A.

Gillig's request to provide RG 58 coaxial cable routed to protect the cable in lieu of conduit is accepted as an approved equal.

New Flyer's request to provide PVC conduit in lieu of Adaptaflex is accepted as an approved equal.

3.13 Emergency Alarm (see Technical Specification 2.0 for part numbers)

Provide and install an emergency covert alarm, including associated programming, to activate an emergency radio alarm at dispatch and permits covert microphone. Alarm button shall be Otto Engineering, part #21649 or approved equal, located on the side console next to the driver's seat, in a location to be approved by the DTA prior to manufacture.

3.14 Cable Installation

Provide and install the following wiring, leaving an extra three-foot coil at locations outside the electronic equipment cabinet (EEC), and a five-foot coil for wiring at the EEC end. Label each end of the wire with the "W" numbers or description. The DTA will supply and install the connectors.

- **W1** DDU location to the EEC – 'Alpha' 2461C or approved equal.
- **W2** P.A. speakers to the EEC – 'Belden' 8761 2 core or approved equal.
- **W3** Handset location to the EEC – 'Alpha' 1296C 6 core or approved equal.
- **W4** Emergency alarm switch location to the EEC – 'Belden' 8761 2 core or approved equal.
- **W5** EEC to the Tag Interface Unit location (in sign compartment) – 'Carol' E2004S 4 core or approved equal.
- **W6** Camera activation switch location to the EEC – 'Belden' 8761 2 core or approved equal.
- **W7** P.A. microphone receptacle to the EEC – 'Belden' 8761 2 core or approved equal.
- **W8** Driver's speaker to the EEC – 'Belden' 8761 2 core or approved equal.
- **W9** P.A. aux. microphone receptacle to the EEC – 'Belden' 8761 2 core or approved equal.
- **W10** Exterior speaker to the EEC – 'Belden' 8761 2 core or approved equal.

The DTA will work with the Contractor to determine equipment locations.

Section 4 General Electronic Requirements

4.1. a If an electronic component has an internal clock, it shall provide its own battery backup to monitor time when battery power is disconnected. Any component with its own real-time clock will be set to Central Standard Time.

All electronic component suppliers shall ensure that their equipment is self-protecting in the event of shorts in the cabling, and also 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 without prior approval of the DTA.

Kinking, grounding at multiple points, stretching, and exceeding minimum bend radius shall be prevented.

b. 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. Labels shall be resistant to rubbing (hot stamped tubing and protected printing are service-proven examples of acceptable labels). 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 of each I/O terminal.

c. Shielding

All wiring that requires shielding 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.

d. Communications

The data network cabling shall be selected and installed according to the selected protocol requirements. The physical layer of all network communication systems shall not be used for any other 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 24 V-power line) shall meet the most stringent applicable wiring and terminal specifications.

e. 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 has a loss, which will contribute to attenuation of the signal. Cabling should allow for the removal of antennas or attached electronics without removing the installed cable between them. The corresponding component vendors shall be consulted for proper application of equipment including installation of cables.

f. Audio

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

4.2 Multiplexing

a. General

All vehicles shall be equipped with a multiplexing system. 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. This system shall meet the network communications requirements of DTA IT Specifications. The DTA shall approve the multiplex system.

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 the spare inputs and outputs provided on each module. 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 (10%) of the total number of inputs and outputs (or at least one each) at each zone location shall be designated as spares. Zone locations are: (1) behind the rear bulkhead; (2) forward of the bulkhead above the window line; and (3) forward of the bulkhead below the window line.

b. System Configuration

Multiplexing may either be distributed or centralized. A distributed system shall process information on multiple control modules within the network. A centralized system shall process the information on a single control module. Both systems shall consist of several modules connected to form a control network.

c. I/O (Input/Output) Signals

The input/output for the multiplex system may contain three types of electrical signals: discrete, analog, or serial data.
Discrete signals shall reflect the on/off status of switches, levers, limit switches, lights, etc. Analog signals shall reflect numerical data as represented by a voltage signal (0-12 V, 10-24 V, etc.) or current signal (4-20 mA). Both types of analog signals shall represent the status of variable devices such as rheostats, potentiometers, temperature probes, etc. Serial data signals shall reflect ASCII or alphanumeric data used in the communication between other on-board components.

4.3 Data Communications Systems

a. General

All data communication networks shall be either in accordance with a nationally recognized interface standard such as those published by SAE, IEEE, or ISO, or shall be published to the DTA with the following minimum information:

7. Protocol requirements for all timing issues (bit, byte, packet, inter-packet timing, idle line timing, etc.) packet sizes, error checking, and transport (bulk transfer of data to/from the device).
8. Data definition requirements that ensure access to diagnostic information and performance characteristics.
9. The capability and procedures for uploading new application or configuration data.
10. Access to revision levels of data, application software and firmware.
11. The capability and procedures for uploading new firmware or application software.

b. Any electronic vehicle components used on a network shall be conformance tested to the corresponding network standard.
All components on the Drive Train network shall communicate data over the network as specified in Section C6.03.05.02. The Multiplex Level shall use a communications network that meets the requirements of Section C6.03.05.03. Components integrated on the Information Level shall communicate data over the network selected in Section C6.03.05.04.

4.4 Multiplex Level

a. Data Access

At a minimum, information shall be made available via a communication port on the multiplex system. The location of the communication port shall be easily accessible.
Provide a 12 Vdc power outlet adjacent to each diagnostic port on the interior of the vehicle. The DTA will approve the exact location(s).

Gillig's request to provide three diagnostic connector ports with one accompanied with a 12v power outlet, one near the rear run box in the engine compartment, one under the dash at the driver's left knee and one with a 12-v power port located in the overhead I/O Controls multiplexing system compartment is accepted as an approved equal.

b. 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 either a personal computer (PC) or a handheld unit. Either unit shall have the ability to check logic function.

c. 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: password protection, limited distribution of the configuration software, limited access to the programming tools required to change the software, and hardware protection that prevents undesired changes to the software.

Provisions for programming the multiplex system shall be possible through a PC/laptop. 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: hardware component identification where labels are included on all multiplex hardware to identify components; hardware series identification where all multiplex hardware displays the current hardware serial number and firmware revision employed by the module; and software revision identification where all copies of the software in service displays the most recent revision number, and a method of determining which version of the software is currently in use in the multiplex system.

The bus builder will work with the DTA to provide all requested changes free of charge during the full bus warranty period. Change requests to the software will be provided in a timely manner. The DTA requests to have full programming access to the multiplex system in the event of bankruptcy or material breach of the contract. When legal liability concerns preclude such access, the vendor will provide the DTA with a list of EPROM parameters and place a copy of all software revisions in escrow giving the DTA access in case of vendor default.

4.5 Fare boxes

a. Provide all connections for 'GFI' Fast Fare electronic fare boxes to include single sign-on J1708 connection. DTA to install the fareboxes.

4.6 Camera Surveillance System

Provide and install a complete operating and tested on-board IP video surveillance system from TSI. The system will include a RR-MRH8 digital video recorder (DVR) with internal heater option, eight (8) IP cameras with audio, license-free operating software, and all necessary interconnecting cables, wiring harnesses, mounting brackets, and miscellaneous hardware. The system will have the capability to connect via Ethernet to wireless communication devices for the purposes of system maintenance and access by first responders and police. Provide a 12VDC battery circuit to the DVR main power and a switched 12 VDC circuit to the DVR to be used as a 'RUN' signal only. Installation of Door Open/Close Discrete Signals.

Mount the cameras as shown in the DTA Order form. Mount the DVR on the top shelf of the Electronic Equipment Cabinet.

b. Camera system part list:

TSI PART #	DESCRIPTION	QTY PER BUS
NEX-HVR	TSI Nexus-HVR Hybrid Video Recorder (without switch)	1
NSW-8PT-KIT	TSI 8 port PoE Switch Kit	1
HDD-NEX-4TB	TSI Nexus-HVR 4TB SSD (with failover capability)	1
NEX-PWR-DIS-002	TSI Power Distribution Harness For Nexus-HVR With IP Cameras	1
TSIP-07	TSI Slim Line IR Wedge 3MP IP Camera [Internal With Mics]	4
	Fish Eye Camera to replace rear facing and rear door	1
TSIP-08	TSI Slim Line IR Wedge 3MP IP Camera [External Cameras]	2

BRK-UNIV-MNT	TSI Universal Front Camera Mount	1
ACC-00002	TSI LED Status For Nexus-HVR	1
ACC-00005-V2	TSI Event Button/Switch With Connector	1
WLS-00301	TSI 802.11n Wireless AP	1
WLS-00302	TSI 802.11n Wireless Antenna	1
WLS-00303	TSI 802.11n AP Bracket	1
ACC-03-RJ45	TSI Garmin GPS Receiver/Antenna	1
TBD	TSI cable harness for 8 camera Duluth DTA equipment set shown above	1

The Luminator Mobile Video System, RR-AHD8 DVR is an approved equal.

4.4 Transit Signal Priority System

"Provide and install Opticom Transit Signal Priority Multimode Emitter, Low Priority, model 794TM, part number 76-100-114-0, and GPS Control Unit, Low Priority, part number 76-1000-116-00 (kit) in accordance with these specifications and manufacturer's instructions.

Provide and install a Tyco Electronics Relay, part number 1432793-1.

Emitter shall be located in the top of the bus (exterior) upper right front corner of the bus. GPS Control Unit roof mount and cable path shall be approved by the DTA.

Vendor Part Number	Description	Quantity
76-1000-1156-0 (kit)	Radio GPS Control Unit Low Priority	1
76-1000-1156-0 (kit)	Radio GPS Antenna and cable	1
76-1000-1156-0 (kit)	Opticom, 210 Vehicle Interface Harness (J1708)	1
76-1000-1047-0	Model 794T, Opticom Strobe Low Priority Emitter	1
1432793-1	Tyco Electronics Relay (not available through Opticom)	1
76-1000-1242-0	Vehicle Interface Cable	1

4.8. Mobile Fare Collection Solution

a. Provide all connections for Masabi Validator to Cellular Modem. DTA to install the validators.