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**STATE of GEORGIA**

**2022 TECHNICAL AND PERFORMANCE**

**SPECIFICATIONS**

**35 AND 40 FOOT HEAVY DUTY, LOW FLOOR**

**FAST CHARGE BATTERY ELECTRIC**

**TRANSIT BUS**

**NOTICE:** This specification is NOT intended to restrict competition. Manufacturers/Dealer may bid their bus(es) in accordance with their standard manufacturing process. In the case where that process varies for this specification, Deviations must be submitted on the provided Request for Specification Deviation Document Form and Specification Deviation Certification and Compliance Form. Any deviation documented shall be “brand name, equivalent, or equal in performance” and must meet or exceed all FTA requirements (for FTA compliant vehicles), and all Federal, State, and Local requirements. The state may, at any time during the evaluation and/or contract period, require the bidders to provide proof that the deviation meets the “brand name, equivalent or equal” in performance.

**GENERAL**

* 1. Unless otherwise specifically provided in the specifications, reference to any equipment, material, article or patented process by trade name, make or catalog number shall be regarded as establishing a standard of quality and shall not be construed as limiting competition. A bidder may document deviations of any equipment, material, article, or process if the deviation is “brand name, equivalent or equal” in performance. All such deviations shall be accompanied by supporting technical data and background information, test results as may be required. All requests for deviations must be submitted on the supplied Bidder Specifications Deviations (Attachment N) and shall be included with the proposal. These deviations will not be evaluated as part of the proposal, however, the customer may use the “a la carte” process or not accept the vehicle for purchase as deviated.
* All units or parts not specified shall be manufacturer’s best quality and shall conform in materials, design, or workmanship to the best practice known in the transit industry. All parts shall be new and function for their intended purpose
  1. Bidder shall provide a Certification for Specifications Compliance Form at Attachment O for all deviations from the specifications on Attachment N. A copy of Form CER 10, located in Attachment M, will be submitted with each bus bid regardless of if it is an FTA bus or not.

NOTE: This spec was taken from an APTA document, and the numbering remains unchanged. The numbering sequence starts at number 5.

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### GENERAL

#### SCOPE

Part 5: Technical Specifications define requirements for a heavy duty, low floor, Fast Charge Battery Electric transit bus which, by the selection of specifically identified alternative configurations, may be used for both suburban express service and general service on urban arterial streets. It shall have a minimum expected life of 12 years or 500,000 miles whichever comes first and is intended for the widest possible spectrum of passengers, including children, adults, the elderly, and persons with disabilities

5.1.2 DEFINITIONS

The following are definitions of special terms used in Part 5. **Additions in Bold Print**

(1) dBA. Decibels with reference to 0.0002 microbar as measured on the "A" scale.

(2) 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.

Battery Compartment: Low-voltage energy storage, i.e. 12/24 VDC batteries.

Battery Management System (BMS): Monitors energy, as well as temperature, cell or module voltages, and total pack voltage. The BMS adjusts the control strategy algorithms to maintain the batteries at uniform state of charge and optimal temperatures.

Cells: Individual components (i.e., battery or capacitor cells). (3) Standee Line. A line marked across the bus aisle to designate the forward area that passengers may not occupy when the bus is moving.

(4) Free Floor Space. Floor area available to standees, excluding the area under seats, area occupied by feet of seated passengers, the vestibule area forward of the standee line, and any floor space indicated by manufacturer as non-standee areas such as, the floor space “swept” by passenger doors during operation. Floor area of 1.5 square feet shall be allocated for the feet of each seated passenger that protrudes into the standee area.

(5) Curb Weight. Weight of vehicle, including maximum fuel, oil and coolant, and all equipment required for operation and required by this Specification, but without passengers or operator.

(6) Seated Load. One hundred fifty pounds for every designed passenger seating position and for the operator.

(7) Gross Load. One hundred fifty pounds for every designed passenger seating position, for the operator, and for each 1.5 square feet of free floor space.

(8) SLW (Seated Load Weight). Curb weight plus seated load.

(9) GVW (Gross Vehicle Weight). Curb weight plus gross load.

1. 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.
2. GAWR (Gross Axle Weight Rated). The maximum total weight as determined by the axle manufacturer, at which the axle can be safely and reliably operated for its intended purpose.
3. Heavy Heavy-Duty Gas Engine (HHDG). Heavy heavy-duty gas engines have sleeved cylinder liners, are designed for multiple rebuilds, and a rated horsepower that generally exceeds 250.
4. Operator's Eye Range. The 95th-percentile ellipse defined in SAE Recommended Practice J941, except that the height of the ellipse shall be determined from the seat at its reference height.
5. Fireproof. Materials that will not burn or melt at temperatures less than 2,000° F.
6. Fire Resistant. Materials that have a flame spread index less than 150 as measured in a radiant panel flame test per ASTM-E 162-90.
7. Human Dimensions. The human dimensions used in Part 5: Technical Specifications are defined in Humanscale 1/2/3, N. Diffrient, A. R. Tilley, J. C. Bardagjy, MIT Press.
8. HIC (Head Injury Criteria). The following equation presents the definition of head injury criteria:

┌ ┐2.5

│ 1 ⌠t1 (a) dt │ (t2 – t1)

│ t1 – t2 ⌡t2 │

└ ┘

where:

a = the resultant acceleration at the center of gravity of the head form expressed as a multiple of g, the acceleration of gravity.

t1 and t2 = any two points in time during the impact.

1. Baseline Configuration Bus. The bus described by Part 5: Technical Specifications if no alternatives are selected. Signing, colors, the destination sign reading list and other information must be provided by CUSTOMER in attachments to Part 5: Technical Specifications.
2. Alternative. An alternative specification condition to the baseline configuration bus. CUSTOMER may define alternatives to the baseline configuration to satisfy local operating requirements. Alternatives for the baseline configuration will be clearly identified.

**NOTE**: If CUSTOMER selects "Baseline" as a checked box, then CUSTOMER requires the baseline configuration. If CUSTOMER has "Alternative" checked, then CUSTOMER requires the alternative configuration described. If "Option" is checked, the configuration should be priced separately under "Optional Items" in the Schedule.

1. Central Business District (CBD) Phase of the Design Operating Profile. *CBD Phase* of the design operating profile for design/test verification purposes shall consist of simulated transit type service. The duty cycle is described in Figure 1. The Test cycle consists of a CBD phase of 2 miles with 7 stops per mile and a top speed of 20 mph.

The bus shall be loaded to SLW with air conditioning operating while operating on this duty cycle. Operation shall continue regardless of the ambient temperature or weather conditions. The passenger door shall be opened and closed at each stop, and the bus shall be knelt (if applicable) at each stop during the CBD phase. The braking profile shall be:

16 percent of the stops at 3 fpsps (feet per second per second)

50 percent of the stops at 6 fpsps

26 percent of the stops at 9 fpsps

8 percent of the stops at 12 fpsps.

These percentages of stops shall be evenly distributed over the CBD phase of the duty cycle. For scheduling purposes, the average deceleration rate is assumed. One additional hour of idle operation shall be included in the test cycle.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Phase** | **Stops/** | **Top** | **Miles** | **Accel.** | **Accel.** | **Cruise** | **Cruise** | **Decel.** | **Decel.** | **Decel.** | **Dwell** | **Cycle** | **Total** |
|  | **Mile** | **Speed** |  | **Dist.** | **Time** | **Dist.** | **Time** | **Rate** | **Dist.** | **Time** | **Time** | **Time** | **Stops** |
|  |  | **(mph)** |  | **(ft.)** | **(s)** | **(ft.)** | **(s)** | **(fpsps)** | **(ft.)** | **(s)** | **(s)** | **(min-s)** |  |
| CBD | 7 | 20 | 2 | 155 | 10 | 540 | 18.5 | 6.78 | 60 | 4.5 | 7 | 9.20 | 14 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total |  |  | 2 |  |  |  |  |  |  |  |  | 9.20 | 14 |
|  | |  |  |  |  |  |  |  |  |  |  |  |  |



1. Class of Failures. Classes of failures are described below.

a. Class 1: Physical Safety. A failure that could lead directly to passenger or operator injury or represents a severe crash situation.

b. Class 2: Road Call. A failure resulting in an en route interruption of revenue service. Service is discontinued until the bus is replaced or repaired at the point of failure.

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

d. Class 4: Bad Order. A failure that does not require removal of the bus from service during its assignments but does degrade bus operation. The failure shall be reported by operating personnel.

1. Maintenance Personnel Skill Levels. Defined below are maintenance personnel skill levels used in Part 5: Technical Specifications.

a. 5M: Specialist Mechanic or Class A Mechanic Leader

b. 4M: Journeyman or Class A Mechanic

c. 3M: Service Mechanic or Class B Servicer

d. 2M: Mechanic Helper or Bus Servicer

e. 1M: Cleaner, Fueler, Oiler, Hostler, or Shifter

In attachments to Part 5: Technical Specifications, the Procuring Agency may relate the skill levels and ratings of mechanics in its operation to the above definitions.

Note: Whenever a specific time is indicated to access components or complete a task, it is assumed the vehicle is in the location where the work is to be performed. All necessary equipment is in its correct position (tools, jacks, vehicle lifts, lighting, fluid recovery systems, etc.) and ready for use.

1. Standards. Standards referenced in Part 5: Technical Specifications are the latest revisions unless otherwise stated.
2. Wheelchair. A mobility aid belonging to any class of three or four-wheeled devices, usable indoors, designed for and used by individuals with mobility impairments, whether operated manually or powered. A “common wheelchair” is such a device that does not exceed 30 inches in width and 48 inches in length measured two inches above the ground, and does not weigh more than 600 pounds when occupied.
3. Structure. The structure shall be defined as the basic body, including floor deck material and installation, load bearing external panels, structural components, axle mounting provisions and suspension beams and attachment points.
4. Low Floor Bus. A bus which, between at least the front (entrance) and rear (exit) doors, 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.
5. F/2.8. Defines the opening size of a camera iris. The lower the f-stop, the better the image quality available at low light conditions.
6. Discrete Signals. A signal which can take only pre-defined values, usually of a binary 0 or 1 nature where 0 is battery ground potential and 1 is a defined battery positive potential.
7. Analog Signals. A continuously-variable signal that is solely dependent upon magnitude to express information content. Note: Analog signals are used to represent the state of variable devices such as rheostats, potentiometers, temperature probes, etc.
8. Serial Data Signals. Serial data signals are a current loop based representation of ASCII or Alphanumeric data used for transferring information between devices by transmitting a sequence of individual bits in a prearranged order of significance. Note: An example is the communication that takes place between two or more electronic components with the ability to process and store information.
9. Physical Layer. The first layer of the seven-layer International Standards Organization (ISO) Open Systems Interconnect (OSI) reference model. This provides the 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.
10. Fuel Management System. Natural gas fuel system components that control or contribute to engine air fuel mixing and metering, and the ignition and combustion of a given air-fuel mixture. The fuel management system would include, but is not limited to, reducer/regulator valves, fuel metering equipment (e.g. carburetor, injectors), sensors (e.g. main throttle, wastegate).
11. Ambient Temperature. The temperature of the surrounding air. For testing purposes, ambient temperature must be between + 16° C (+50° F) and +38° C (+100° F).
12. Burst Pressure. The highest pressure reached in a container during a burst test.
13. Capacity (fuel container). The water volume of a container in gallons (liters).
14. Code. A legal requirement.
15. Container Appurtenances. Devices connected to container openings for safety, control, or operating purposes.
16. Container Valve. A valve connected directly to a container outlet.
17. DC to DC Converter: A module that converts a source of direct current from one voltage level to another.
18. Drive System – Consists of Drive Motor, Drive Motor Controller (Inverter), gearbox or transmission and drive shaft along with related mounting hardware.
19. Destroyed. Physically made permanently unusable.
20. Energy Density. The relationship between the weight of an energy storage device and its power output in units of watt-hours per kilogram (Wh/kg).
21. 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.
22. Fusible Material. A metal, alloy, or other material capable of being melted by heat.
23. Hybrid System Controller (HSC):Regulates energy flow throughout hybrid system components in order to provide motive performance and accessory loads, as applicable, while maintaining critical system parameters (voltages, currents, temperatures, etc.) within specified operating ranges.
24. Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization, that 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 labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
25. Leakage. Release of contents through a defect or crack. See "Rupture."
26. Liner. Inner gas tight container or gas container to which the overwrap is applied.
27. Lower Explosive Limit. The lowest concentration of gas where, given an ignition source, combustion is possible.
28. Maximum Service Temperature. The maximum temperature to which a container/cylinder will be subjected in normal service.
29. Metallic Hose. A hose whose strength depends primarily on the strength of its metallic parts; it can have metallic liners or covers, or both.
30. Metering Valve. A valve intended to control the rate of flow of natural gas.
31. Motor (Electric): A device that converts electrical energy into mechanical energy.
32. Motor (Traction): An electric motor used to power the driving wheels of the bus.
33. Mpa. Megapascals. A unit of pressure. One (1) Mpa = 20,885.4 psi Operating Pressure. The varying pressure which is developed in a container during service.
34. Power: Work or energy divided by time
35. Power Density: Power divided by mass, volume or area.
36. Propulsion System: System that provides propulsion for the vehicle proportional to operator commands. Includes, as applicable, engine, transmission, traction motors, the hybrid drive system, (HDS), energy storage system (ESS), and system controllers including all wiring and converter/inverter.
37. Pressure Activated Gas Relief Device. A pressure and/or temperature activated device used to vent the container/cylinder contents and thereby prevent rupture of a NGV fuel container/cylinder, when subjected to a standard fire test as required by fuel container/cylinder standards.
38. Note: Since this is a pressure activated device, it may not protect against rupture of the container when the application of heat weakens the container to the point where its rupture pressure is less than the rated burst pressure of the relief device, particularly if the container is partially full.
39. Real-Time Clock (RTC): Computer clock that keeps track of the current time.
40. Regenerative Braking: Deceleration of the bus by switching motors to act as generators, which return vehicle kinetic energy to the energy storage system.
41. Rejectable Damage. In terms of NGV fuel containers/cylinders, this is damage as outlined in CGA C-6.4, Methods for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Installations and in agreement with the manufacturer's recommendations.
42. Rupture. Sudden and unstable damage propagation in the structural components of the container resulting in a loss of contents. See "Leakage."
43. Specification. A particular or detailed statement, account, or listing of the various elements, materials, dimensions, etc. involved in the manufacturing and construction of a product.
44. Service Pressure. The settled pressure at a uniform gas temperature of 21°C (70°F) and full gas content. It is the pressure for which the equipment has been constructed, under normal conditions. Also referred to as the nominal service pressure or working pressure.
45. Settled Pressure. The gas pressure when a given settled temperature, usually 21°C (70°F) is reached.
46. Settled Temperature. The uniform gas temperature, after any change in temperature caused by filling, has dissipated.
47. Standard. A firm guideline from a consensus group.
48. 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 energy storage system. A full SOC indicates that the energy storage system cannot accept further charging from the engine-driven generator or the regenerative braking system.
49. Stress Loops. The "pig-tails" commonly used to absorb flexing in piping.
50. Sources of Ignition. Devices or equipment that, because of their modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable compressed natural gas-air mixtures when introduced into such a mixture, or when such a mixture comes into contact with them

Thermally Activated Gas Relief Device. A relief device that is activated by high temperatures and generally contains a fusible material.

NOTE: Since this is a thermally activated device, it does not protect against over-pressure from improper charging practices.

#### 5.1.3 ABBREVIATIONS

The following is a list of abbreviations used in Part 5: Technical Specifications.

1. **ABS** Anti-Lock Braking System
2. **ADA** Americans with Disabilities Act
3. **AFC** Automated Fare Collection
4. **ANSI** American National Standards Institute
5. **ASHRAE** American Society of Heating, Refrigerating and Air Conditioning Engineers
6. **ASTM** American Society for Testing and Materials
7. **ATC** Automatic Traction Control
8. **CAN** Controller Area Network
9. **CFR** Code of Federal Regulations
10. **CGA** Compressed Gas Association
11. **CHP** California Highway Patrol
12. **CNG** Compressed Natural Gas
13. **DM1** Diagnostic Message (Active Fault)
14. **DOE** U.S. Department of Energy
15. **DOT** U.S. Department of Transportation
16. **DTC** Diagnostic Trouble Code
17. **EMI** Electromagnetic Interference
18. **EPA** U.S. Environmental Protection Agency
19. **FMEA** Failure Modes and Effects Analysis
20. **FMCSR** Federal Motor Carrier Safety Regulations
21. **FMI** Failure Mode Identifier
22. **FMVSS** Federal Motor Vehicle Safety Standards
23. **FPSPS** Feet per second per second
24. **G** Acceleration due to gravity, 32.2 feet per second per second
25. **FTA** U.S. Federal Transit Administration
26. **IAS** International Approval Services
27. **I/O** Input/Output
28. **IRS** Integrated Radio System
29. **ISO** International Organization for Standardization
30. **JIC** Joint Industrial Council
31. **LCD** Liquid Crystal Display
32. **LED** Light Emitting Diode
33. **LEL** Lower Explosive Limit
34. **MAWP** Maximum Allowable Working Pressure
35. **MDS** Methane Detection System
36. **MID** Message ID
37. **MPEG** Moving Pictures Experts Group
38. **MPH** Miles Per Hour
39. **NAFTP** The National Alternative Fuel Training Program
40. **NATEF/SAE** The National Automotive Technicians Education Foundation/

Automotive Service Excellence

1. **NFPA** National Fire Protection Association
2. **NGV** Natural Gas Vehicle
3. **NHTSA** National Highway Traffic Safety Administration
4. **OEM** Original Equipment Manufacturer
5. **ORS** O-Ring Seal
6. **OSHA** Occupational Safety and Health Administration
7. **PCB** Printed Circuit Board
8. **PCMCIA** Personal Computer Memory Card International Association
9. **PGN** Parameter Group Number
10. **PID** Parameter ID
11. **PPM** Parts Per Million
12. **PRD** Pressure Relief Device
13. **PSI** Pounds per Square Inch
14. **RFI** Radio Frequency Interference
15. **RRC** The Railroad Commission of Texas (formerly TRRC)
16. **SA** Signal Attribute
17. **SAE** Society of Automotive Engineers International
18. **SCFM** Standard Cubic Feet per Minute
19. **SID** Subsystem ID
20. **SPI** Society of the Plastics Industry
21. **SPN** Suspect Parameter Number
22. **TAC** Texas Administrative Code
23. **UL** Underwriters Laboratories
24. **USDOT** United States Department of Transportation
25. **VDL** Vehicle Data Logger
26. **VLU** Vehicle Logic Unit

##### 5.1.3.1 REFERENCED PUBLICATIONS

The documents or portions thereof referenced within this specification shall be considered part of the requirements of the specification. The edition indicated for each referenced document is the current edition, as of the date of the APTA issuance of this specification.

#### 5.1.4 LEGAL REQUIREMENTS

The contractor shall comply with all applicable Federal, state and local regulations. Local regulations are defined as those below the state level. These shall include, but not be limited to, Federal ADA as well as state and local accessibility, safety and security requirements.

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

In the event of any conflict between the requirements of this Specification and any applicable legal requirement, the legal requirement shall prevail. Technical requirements that exceed the legal requirements are not considered to conflict.

The Contractor shall ensure that each manufacturer of major items of equipment (e.g., engine, transmission, brakes, air conditioning, heating and cooling controls, doors and controls, seats, lighting) has a complete copy of the Technical Specifications. Sub-suppliers shall approve of and sign-off on the Contractor’s specific application of the supplied component(s). Proof of sub-suppliers installation approval shall be provided to customer, prior to acceptance of both 1st Article vehicle(s) - - [30 ft. and 40 ft. bus(es)].

#### 5.1.5 Pre-production Process / Meeting

The pre-production meeting(s) shall be held at the Bus Manufacturer's (OEM) production facility. The purpose of these meetings is to address questions and issues that arise during the design stage of the bus. Examples include:

a. Presentation of component testing, where applicable.

b. For those items that are safety-critical (e.g., fuel system), review of a FMEA, to be prepared by the bus manufacturer in conjunction with the component supplier.

c. A planned layout of the bus interior, showing dimensions to scale ("Bus on paper").

d. Any issues that could not be resolved during the Approved Equals process.

The Contractor shall provide sufficient information that explains how the bus meets the specification requirements. Pre-Production process includes a Pre-Production meeting and a two-tier Design Review, which consists of an Initial Design Review and Follow-Up Design Reviews as needed.

#### OVERALL REQUIREMENTS

The contractor shall ensure that the application and installation of major bus sub-components and systems are compliant with all such sub-component vendors’ requirements and recommendations. Components used in the vehicle shall be of heavy-duty design and proven in transit service.

1. Vendor (Sub-Supplier) certification - is required for critical systems as defined by CUSTOMER. The specific tests and demonstrations (as defined in Exhibit J), shall be completed on the pilot (first article) bus, and shall be verified by a final configuration audit.
2. **Vehicle Weight Slip -** Bus Manufacturer shall furnish with each vehicle a certified weight slip indicating the curb weight of the completed vehicle being procured under this contract.
3. **Front End and/or 4-Wheel Alignment -** Bus Manufacturer shall perform front-end alignment and/or 4-wheel alignment on each vehicle and furnish certified or verifiable documentation indicating the completed vehicles' alignment results.
4. **First-to-last configuration -** All vehicles within each order group are to be configured alike; first-to-last production units. Bus Manufacturer will ensure all (latest) OEM Service Bulletins configurations shall be incorporated in each bus produced under this contract. A configuration management system shall provide tracking of changes and require customer approval of all configuration changes. Changes from order group-to-order group will be permitted only for product obsolescence or product supersession / improvement. All changes will require customer’s approval. Notification of changes from order group to order group will require Contractor to notify customer a minimum of 6 months before start of production.

##### 5.1.6.1 DIMENSIONS

###### 5.1.6.1.1 Physical Size

With the exceptions of exterior mirrors, marker and signal lights, bumpers, fender skirts, washers, wipers, bicycle racks, ad frames and rubrails, the bus shall have the following overall dimensions as shown in the figure “Transit Bus Exterior Dimensions” at static conditions and design height.

* *Baseline: Use for 40 -ft length bus.*

Body Length: 40 feet ± 18 inches

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| * *Baseline: Use for 35 -ft length bus.*   Body Length: 35 feet ± 12 inches |

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| * *Baseline: Use for 102-inch width bus.*   Body Width: 102 inches (+0, -1 inch) |

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| * Maximum Overall Height: 140 inches, includes all rigid roof-mounted items such as A/C, exhaust, fuel system and closed hatch, etc*.* |



###### 5.1.6.1.2 Underbody Clearance

The bus shall maintain the minimum clearance dimensions as shown in the figure “Transit Bus Minimum Road Clearance” and defined in SAE Standard J689, regardless of load up to the gross vehicle weight rating.

Ramp Clearances: Approach angle shall be no less than 8.5 degrees.Breakover angle shall be no less than 8 degrees. Departure angle shall be no less than 8.6 degrees.

The approach angle (>8.5°) is the angle measured between a line tangent to the front tire static loaded radius arc and the initial point of structural interference forward of the front tire to the ground.

The departure angle (>8.75°) is the angle measured between a line tangent to the rear tire static loaded radius arc and the initial point of structural interference rearward of the rear tire to the ground.

The breakover angle (>8°) is the angle measured between two lines tangent to the front and rear tire static loaded radius and intersecting at a point on the underside of the vehicle that defines the largest ramp over which the vehicle can roll.

Ground Clearance: (>8.1") Ground clearance shall be no less than 8.1 inches, except within the axle zone and wheel area.

Axle Clearance: (>5 ½ ") Axle zone clearance, which is the projected area between tires and wheels on the same axial centerline, shall be no less than 5 1/2 inches.

Wheel Area Clearance: (>8.0") Wheel area clearance, shall be no less than 8 inches for parts fixed to the bus body and 6 inches for parts that move vertically with the axles.

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###### 5.1.6.1.3 Floor Height

Height of the floor above the street shall be no more than 16.5 inches measured at the centerline of the front and rear doorway. The floor may be inclined along the longitudinal axis of the bus, and the incline shall be less than 3 1/2° off the horizontal except locally at the doors where 2o slope toward the door is allowed. All floor measurements shall be with the bus at the design running height and on a level surface and with the manufacturer’s tires furnished per 5.3.1.3.2 and approved by CUSTOMER.

###### 5.1.6.1.4 Interior Headroom

Headroom above the aisle and at the centerline of the aisle seats shall be no less than 78 inches forward of the rear raised area tapering to no less than 74 inches forward of the rear settee. At the centerline of the window seats, headroom shall be no lower than 65 inches. Headroom at the back of the rear bench seat may be reduced to a minimum of 56 inches, but it shall increase to the 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 paneling.

##### 5.1.6.2 WEIGHT

Curb weight of the bus, as defined in Section 5.1.2 of these Specifications, shall be minimized to the extent practical without compromising its integrity and durability.

##### 5.1.6.3 CAPACITY

The vehicle shall be designed to carry the Gross Vehicle Weight as defined in Section 5.1.2, which shall not exceed the bus GVWR. The vehicle shall not exceed the individual gross axle weight rating (GAWR) at curb weight plus gross load.

##### 5.1.6.4 SERVICE LIFE AND MAINTENANCE

###### 5.1.6.4.1 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 twelfth year.

###### 5.1.6.4.2 Maintenance and Inspection

Scheduled maintenance or inspection tasks as specified by the Contractor shall require a skill level of 3M or less. Scheduled maintenance tasks shall be related and shall be grouped in maximum mileage intervals. Based upon the Design Operating Profile defined in Section 5.1.2, routine scheduled maintenance actions, such as filter replacement and adjustments, shall not be required at intervals of less than 6,000 miles, or as indicated from a regular oil analysis program and routine daily service performed during the fueling operations. Higher levels of scheduled maintenance tasks shall occur at even multiples of mileage for lower level tasks.

Special tools required to maintain the bus shall be provided in quantities as specified in Section 5.6, "Attachments to Technical Provisions," reference section 5.1.5.4.2.1, and Exhibit "K," Training.

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| * *Alternative*: Test ports shall be provided for commonly checked functions on the bus such as hydraulic and pneumatic systems. |

The Contractor shall provide a manual listing the times required for typical repair and service items on the bus, as specified in Exhibit K Training.

###### 5.1.6.4.3 Accessibility

All systems or components subject to periodic maintenance or that are subject to periodic failures shall be readily accessible for service and inspection. To the extent practicable, removal or physical movement of components unrelated to the specific maintenance and/or repair tasks involved shall be unnecessary.

As a goal, relative accessibility of components, measured in time required to gain access, shall be inversely proportional to frequency of maintenance and repair of the components. Specific maintainability requirements are defined in other sections of Part 5: Technical Specifications.

The location of the propulsion battery packs shall be beneath the bus housed within recessed cavities molded into the underside of the bus body. Location of the battery packs shall be such that the lower surface of any pack does not extend below the actual bus body. Pack removal shall consist of removal of ten (10) bolts and the disconnection of the main power cables, control cables and coolant lines. Removal is by hydraulic table while the bus is elevated on bus wheel lifts.

###### 5.1.6.4.4 Interchangeability

Components with identical functions shall be interchangeable to the extent practicable. These components shall include, but not limited to, passenger window hardware, interior trim, lamps, lamp lenses, and seat assemblies. Components with non-identical functions shall not be, or appear to be, interchangeable. A component shall not be used in an application for which it was neither designed nor intended.

Any one component or unit used in the construction of these buses shall be an exact duplicate in design, manufacture, and assembly for each bus in each order group in this Contract.

##### 5.1.6.5 OPERATING ENVIRONMENT

The bus shall achieve normal operation in ambient temperature ranges of 10º F to 115º F, at relative humidity between 5 percent and 100 percent, and at altitudes up to 850 feet above sea level. Degradation of performance due to atmospheric conditions shall be minimized at temperatures below 10° F, above 115°F, or at altitudes above 850 feet.

Special equipment or procedures may be employed to charge the bus after being exposed for more than 4 hours to temperatures less than 30° F without the batteries in operation. Speed, gradability, and acceleration performance requirements shall be met at, or corrected to, 77° F, 29.31 inches Hg, dry air per SAE J1995. The interior climate control system shall perform in accordance with Section 5.4.8 of Part 5: Technical Specifications.

##### 5.1.6.6 NOISE

###### 5.1.6.6.1 Interior Noise

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

The bus-generated noise level experienced by a passenger at any seat location in the bus shall not exceed 83 dBA and the operator shall not experience a noise level of more than 75 dBA under the following test conditions. The bus shall be empty except for test personnel, not to exceed 4 persons, and the test equipment. All openings shall be closed and all accessories, including air conditioning, 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 bus path. During the test, the ambient noise level in the test area shall be at least 10 dBA 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 as defined in Section 5.1.2, a penalty of 5 dBA shall be added to the sound level measured.

###### 5.1.6.6.2 Exterior Noise

Airborne noise generated by the bus and measured from either side shall not exceed 70 dBA under full power acceleration when operated at or below 35 mph at curb weight and just prior to transmission upshift. The maximum noise level generated by the bus pulling away from a stop at full power shall not exceed 73 dBA. The bus-generated noise at curb idle shall not exceed 60 dBA. If the noise contains an audible discrete frequency as defined in Section 5.1.2, a penalty of 5 dBA shall be added to the sound level measured. All noise readings shall be taken 50 feet from and perpendicular to, the centerline of the bus with all accessories operating. Instrumentation, test sites, and other general requirements shall be in accordance with SAE Standard J366. The pull away test shall begin with the front bumper even with the microphone. The curb idle test shall be conducted with the rear bumper even with the microphone.

In addition, the Contractor shall comply with the exterior noise requirements defined in local laws and ordinances identified by customer.

##### 5.1.6.7 FIRE SAFETY

The bus shall be designed and manufactured in accordance with all applicable fire safety and smoke emission regulations. These provisions shall include the use of fire-retardant/low-smoke materials, firewalls, and facilitation of passenger evacuation.

All materials used in the construction of the Passenger Compartment of the bus shall be in accordance with the Recommended Fire Safety Practices defined in FTA Docket 90, dated October 20, 1993. Smaller components and items, such as seat grab-rails, switch knobs and small light lenses, shall be exempt from this requirement.

Fire sensing and suppression systems as required in Section 5.4.10 shall be provided.

Requirements for firewalls are contained in Section 5.4.1.6.

The requirements for passenger evacuation provisions related to doors, windows, and escape hatches are defined in Section 5.4 of Part 5: Technical Specifications.

##### 5.1.6.8 ELDERLY AND DISABLED PASSENGERS

The contractor shall comply with all applicable Federal requirements defined in the Americans with Disabilities Act, 49 CFR Part 38, as amended, and all state and local regulations regarding mobility-impaired persons. Local regulations are defined as those below the state level.

###### 5.1.6.8.1 Respect for the Environment

In the design and manufacture of the bus the Contractor shall make every effort to reduce the amount of potentially hazardous waste generated by customer when maintaining the bus in accordance with the procedures contained in the manufacturer’s maintenance manuals. The manufacturer shall use, whenever possible, commercially available, light-emitting diode (LED) lighting, PCB free ballast units (as applicable), cleanable filters (unless required otherwise by), and non-asbestos brake blocks and gaskets. In accordance with Section 6002 of the Resource Conservation and Recovery Act the Contractor shall use, whenever possible and allowed by the specifications, recycled materials in the manufacture of the bus.

### PROPULSION SYSTEM

#### VEHICLE PERFORMANCE

##### POWER REQUIREMENTS

Propulsion system and drive train shall provide power to enable the bus to meet the defined acceleration, top speed, and gradability requirements, while operating all propulsion-driven accessories. Power requirements are based on heavy, heavy-duty gas (HHDG) engines certified for use in all 50 states using actual road test results or computerized vehicle performance data.

##### TOP SPEED

The bus shall be capable of achieving a speed of 65 mph, but shall be governed at a top speed of 65 mphon a straight, level road at GVWR with all accessories operating.

##### GRADABILITY

Gradability requirements shall be met on grades with a dry commercial asphalt or concrete pavement at GVWR with all accessories operating. The propulsion system and drive train shall enable the bus to achieve and maintain a speed of 40 mph on a 2-1/2 percent ascending grade and 7 mph on a 16 percent ascending grade.

##### ACCELERATION

The acceleration shall meet the requirements below and shall be sufficiently gradual and smooth to prevent throwing standing passengers off-balance. Acceleration measurement shall commence when the accelerator is depressed – (Idle Start, with the A/C on.)

MAXIMUM IDLE START ACCELERATION TIMES ON A LEVEL SURFACE

(Vehicle weight = GVWR, 50-State Power Plant)

|  |  |
| --- | --- |
| **SPEED**  (MPH) | **TIME**  (SEC) |
| 10 | 5.0 |
| 20 | 10.0 |
| 30 | 20.0 |
| 40 | 31.0 |

##### OPERATING RANGE

The operating range of the bus when run on the specified bus duty cycle shall be at least 30 miles with a 95% State of Charge (SOC) at 70°F (21°C), with all systems operating (including air conditioning) loaded to SLW. The Central Business District (CBD) Phase of the Design Operating Profile (as defined under 5.1.2, item 20) shall be used.. A customer approved test plan is required before testing begins.

##### FUEL ECONOMY

The drive system shall be tuned when delivered to provide optimized performance as specified above, including fuel economy. All related components and configuration that affect fuel economy, such as, fan control/operation, transmission, axle ratio, etc, shall be selected accordingly. The bus shall achieve a range of 30 miles minimum when run on the Central Business District (CBD) Phase of the Design Operating Profile (as defined under 5.1.2 (20))loaded to SLW. Reference SAE J1376, Fuel Economy Measurement Test (Engineering Type) for Trucks and Buses.

#### DRIVETRAIN

##### Propulsion System

The propulsion system shall be arranged so that accessibility for all routine maintenance is ensured. No special tools, other than dollies and hoists, shall be required to remove the propulsion system or any subsystems. However, the Agency shall recognize that properly rated test equipment and safe electrical work practices are essential when servicing high-voltage electric drive components. The radiator, all accessories, and any other component requiring service or replacement shall be easily removable. The Contractor shall provide all specialty tools and diagnostic equipment required for maintaining the propulsion system in accordance with the Special Tools List

###### 5.2.2.1.1 Primary Propulsion Unit and Traction Motor

The traction motor shall be a permanent magnet (PM) motor with at least 220 kW Peak Power and 120 kW of continuous power at 340 to 450 volts DC. Peak torque shall be 900 Nm. Maximum motor rpm shall be 6000 RPM.

All components in the drive compartment shall be suitable for service over a range of temperatures from –10° F to 180° F. All other components shall be suitable for service over a range of +10° F to 180° F.

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

The drive motor shall be equipped with an electronically controlled management system, compatible with either 12 or 24-volt power distribution. The motor control system shall be capable of transmitting and receiving electronic inputs and data from other drivetrain components, and broadcasting that data to other vehicle systems. Communication between electronic drivetrain components and other vehicle systems shall be made using the communications networks specified in Section 5.5.5.2.1

In order to avoid potential warranty disputes during the motor warranty period, initial performance settings shall only be changed with the authorization from the bus manufacturer.

The battery electric drive system shall have onboard diagnostic capabilities able to monitor vital motor functions, store and time stamp parameter conditions in memory, and communicate faults and vital conditions to service personnel. Diagnostic reader device connector ports, suitably protected against dirt and moisture, shall be provided in operator’s area and near the motor drive controller. Optional requirements for additional ports are identified in Sections 5.5.6.2 and 5.5.6.3. The onboard diagnostic system shall inform the operator via visual and/or audible alarms when out of parameter conditions exist for vital engine functions. Conditions that require an operator alarm are identified in Section 5.4.6.1.6. Data communication requirements for the on-board Drivetrain diagnostic system are identified in Section 5.5.5.2.2.The on-board diagnostic system shall have capabilities for storing hard and soft codes and processing data and provide detailed information/reports on various aspects of fleet usage. The information shall be retrievable via cabling or wireless transmission to a laptop and/or PDA handheld unit.

The motor drive control system shall protect the drive system against progressive damage. The system shall monitor conditions critical for safe operation and automatically derate power and/or speed and initiate motor shutdown as needed. The on-board diagnostic system, as described in Section 5.4.6.1.6, shall trigger a visual and audible alarm to the operator when the motor control unit detects a malfunction and the engine protection system is activated.

Automatic shutdown shall only occur when parameters established for the functions below are exceeded:

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

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| * + *Baseline: No requirement for an automatic engine protection/shutdown override feature.* * ***Alternative****: Use for automatic motor protection/shutdown override feature.*   A control shall be available to the operator to allow a 30-second override, which, when depressed, will allow the operator to delay the drive system shutdown but not the FSS System activation and alarm system. |

###### 5.2.2.1.2 Cooling Systems

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

5.2.2.1.2.1 Drive Motor Cooling

The drive motor shall be cooled by a water-based, pressure type, cooling system that does not permit boiling or coolant loss during the operations described above. Drive motor thermostats shall be easily accessible for replacement. The cooling fan shall be temperature controlled, preventing the drive motor from exceeding manufacturer’s recommended operating temperatures. The temperature-controlled fan shall idle or not be driven when the coolant temperature falls below the minimum level recommended by the engine manufacture. Air vent valves shall be fitted at high points in the cooling system unless it can be demonstrated that the system is self-purging.

A low level coolant sensor shall be provided and shall be accessible by opening one of the Prodrive compartment's access doors. The sensor shall display both at the filler location as well as on the dash. The water filler shall be no more than 60 inches above the ground and both shall be accessible through the same access door.

The radiator, shall be of durable corrosion-resistant construction with bolted-on removable tanks, unless the EMP Mini-Hybrid System is installed. Plastic tanks are not permitted. All radiators shall be designed so a 2M mechanic can gain access to a substantial portion for the purpose of cleaning the radiators in five minutes or less.

Radiators with a fin density greater than 12 fins per inch, and louvered/slit designs, are more susceptible to clogging and deteriorating cooling performance over time and shall not be used.

Radiator piping shall meet the requirements of Section 5.2.2.2.4. All hose clamps shall be constant tension.

The radiators shall be designed to withstand thermal fatigue and vibration associated with the installed configuration.

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| * ***Baseline****: Standard requirement for coolant filtration.*   The engine cooling system shall utilize a glycol 50-50 mix with organic acid technology that is free of nitrite, silicate, phosphate and borate. .The system shall employviewable PVC inline filters with 35 mesh stainless steel screen cleanable elements.   * + *Alternative: Delete the requirement for coolant filtration.*   The water filter and its plumbing shall not be provided. |

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| x *Baseline: Standard requirements for cooling fan operation.*  The cooling fan shall be temperature controlled, allowing the motor to reach operating temperature quickly. The temperature-controlled fan shall not be driven when the coolant temperature falls below the minimum level recommended by the engine manufacturer. |

5.2.2.1.2.3 Auto Shift Gearbox Cooling

The auto shift gearbox shall be cooled by a separate heat exchanger sized to maintain operating fluid within the gearbox manufacturer's recommended parameters of flow, pressure and temperature

###### 5.2.2.1.3 Auto Shift Gearbox

The proposed vehicle shall employ a two speed auto-shift gearbox capable of propelling the bus in all operating conditions as described in this specification. Shifting shall be electro-pneumatic. The auto shift gearbox must have a service life of 250,000 miles and be capable of operating in a 120 deg. F environment.

The auto-shift gearbox shall have an auto neutral feature that shall cause it to automatically and immediately shift to “Neutral” whenever the gearbox is left in gear and the parking brake is applied. This system shall also automatically shift the transmission to “Neutral,” after a 5-minute delay, whenever the exit door brake interlock is applied.

###### Regenerative Braking

The Drive Train shall be so designed so that when the foot is removed from the accelerator the drive motor is configured in such a manner electronically that current flow is reversed, thus converting the motor to a generator. As the brake pedal is applied the current demand from the motor/generator is increased. The generated electricity is then used to recharge the batteries in the same fashion that an engine generator operates. The system shall be so designed as to blend the regenerative braking with the service brake system so as to have an even blend of braking force without exceeding jerk requirements as defined in Section 5.2.2.1.5. Two yellow rear lights shall illuminate when the regenerative braking system is activated.

The regenerative braking shall become partially engaged (up to 2/3 of its total application torque, with a resulting deceleration of no greater than 0.03 g) when the throttle is completely released (e.g., zero throttle). Maximum regenerative braking shall be achieved when the brake pedal is depressed prior to significant engagement of the service brakes with a maximum resulting deceleration of approximately 0.13 g. The resulting decelerations specified include the effects of regenerative braking, wind resistance and rolling resistance. The energy storage system must be capable of accepting in excess of 75% of total available regenerative braking energy on the prescribed Duty Cycle.

###### 5.2.2.1.5 Jerk

Jerk, the rate of change of acceleration measured at the centerline, floor level of the bus shall be minimized throughout the shifting of each transmission range and retarder application and shall be no greater than 0.3 g/sec. for a duration of a quarter-second or more.

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##### MOUNTING

The drive motor and gearbox shall be mounted in a compartment in the rear of the bus. All drive system mounting shall be mechanically isolated to minimize transfer of vibration to the body structure as defined in Section 5.4.1.5. Mounts shall control movement of the drive train so as not to cause strain in piping and wiring connections to the drive system.

###### Service

The drive train shall be arranged so that accessibility for all routine maintenance is assured. No special tools, other than dollies and hoists, shall be required to remove the drive motor. Two 3M mechanics shall be able to remove and replace the drive motor and gearbox in 2 hours or less.

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

###### Accessories

All accessories shall be electrically driven. All accessories shall be mounted for quick removal and repair. .

###### Hydraulic Systems

The only system that shall be hydraulically driven is the electrohydraulic power steering system. Hydraulic system service tasks shall be minimized and scheduled no more frequently than those of other major bus systems. All elements of the hydraulic system shall be easily accessible for service or unit replacement. Critical points in the hydraulic system shall be fitted with service ports so that portable diagnostic equipment may be connected or sensors for an off-board diagnostic system permanently attached to monitor system operation. All hydraulic lines shall meet the requirements of Section 5.2.2.2.4, and all elements of the hydraulic system shall meet the noise limits defined in Section 5.1.6.6. All elements of the hydraulic system shall meet the accessibility loading requirements of Section 5.4.5.4.2.

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| 🞏 *Baseline: No requirement for hydraulic system sensors.*   * ***Alternative****: Hydraulic system sensors.*   Specific systems for which low hydraulic fluid level sensors are required are included in attachments to Part 5: Technical Specifications. |

###### Fluid Lines, Fittings and Clamps, and Charge Air Piping

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

All flexible lines shall be as short as practicable, no greater than 6 feet in length, unless demonstrated inappropriate for a given application, and shall be routed or shielded to deter spraying or draining onto any component operable above the auto-ignition temperature of the line's contents in case of line failure. Flexible hoses and fluid lines shall not touch one another, or any part of the bus.

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

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

Radiator Piping

Radiator piping shall be stainless steel, brass tubing or powder coated steel and, if practicable, hoses shall be eliminated. EPDM coolant hoses for heavy vehicle applications SAEJ20R3 specs, and silicone in limited areas as required.

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

Oil & Hydraulic Lines

Oil and hydraulic lines shall be compatible with the fluids they carry. The lines shall be designed and intended for use in the environment which they are installed, i.e., high temperatures, road salts, oils, etc. Lines shall be capable of withstanding maximum system pressures and operating temperatures. Lines within the engine compartment shall be composed of steel tubing where practicable except in locations where flexible lines are specifically required by customer in attachments to Part 5: Technical Specifications.

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

Operating Range

The operating range of the bus, when run on the transit Central Business District (CBD) duty cycle of the Design Operating Profile (as defined in 5.1.2), shall be at least 30 miles with full load and HVAC.

##### 5.2.2.4 FINAL DRIVE

The bus shall be driven by a single heavy-duty axle at the rear with a load rating sufficient for the bus loaded to GVWR. Transfer of gear noise to the bus interior shall be minimized. The drive axle shall be designed to operate for not less than 300,000 miles on the design operating profile without replacement or major repairs. The lubricant drain plug shall be magnetic type, external hex head. If a planetary gear design is employed, the oil level in the planetary gears shall be easily checked through the plug or sight gauge. The drive shaft shall be guarded to prevent it striking the floor of the bus or the ground in the event of a tube or universal joint failure.

The fill oil type used within the drive axle planetary gears shall be synthetic or semi-synthetic, with minimum 150,000-mile oil change interval.

The 3rd member (planetary gears, if so equipped) shall be removable without axle assembly removal.

The proposed vehicle shall be capable of operating continuously in a zero emissions mod

### CHASSIS

#### SUSPENSION

##### GENERAL REQUIREMENTS

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

No plumbing, hoses or lines shall be located below or on the top of the axles that would foul or cause interface to customer maintenance lifts.

Radius rod(s) shall have an expected life cycle of 100,000 miles minimum.

##### SPRINGS AND SHOCK ABSORBERS

###### Travel

The suspension system shall permit a minimum wheel travel of 3 inches jounce-upward travel of a wheel when the bus hits a bump (higher than street surface), and 3 inches rebound-downward travel when the bus comes off a bump and the wheels fall relative to the body. Elastomeric bumpers shall be provided at the limit of jounce travel. Rebound travel may be limited by elastomeric bumpers or hydraulically within the shock absorbers. Suspensions shall incorporate appropriate devices for automatic height control so that regardless of load the bus height relative to the centerline of the wheels does not change more than ± 1/2 inch at any point from the height required in Section 5.1.6.1.3.

###### 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 3 cycles or less after hitting road perturbations. Shock absorbers shall maintain their effectiveness for at least 50,000 miles of the service life of the bus. Each unit shall be replaceable by a 2M mechanic in less than 15 minutes. The shock absorber bushing shall be made of elastomeric or natural rubber material that will last the life of the shock absorber.

###### 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 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. Lubricant specified shall be standard for all elements on the bus serviced by standard fittings. Additional requirements for lubrication if any are contained in Attachments to Part 5: Technical Specifications.

###### Kneeling

A kneeling system shall lower the entrance(s) of the bus a minimum of 2.5 inches during loading or unloading operations regardless of load up to GVWR, measured at the longitudinal centerline of the entrance door(s), by the driver using a three position, spring loaded to center switch. Downward direction will lower the bus. Release of switch at any time will completely stop lowering motion and hold height of the bus at that position. Upward direction of the switch will allow the system to go to floor height without the driver having to hold the switch up.

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

An indicator visible to the driver shall be illuminated until the bus is raised to a height adequate for safe street travel. An audible warning alarm will sound simultaneously with the operation of the kneeler to alert passengers and bystanders. A warning light mounted near the curbside of the front door, minimum 2" diameter, amber lens shall be provided that will blink when the kneel feature is activated. Kneeling shall not be operational while the wheelchair ramp is deployed or in operation.

##### WHEELS AND TIRES

###### Wheels

Wheels and rims shall be hub-piloted one side polished aluminum. All wheels shall be interchangeable and shall be removable without a puller. Wheels shall be compatible with tires in size and load-carrying capacity. Front wheels and tires shall be balanced as an assembly per SAE J1986.

One (1) spare wheel shall be provided for each bus. They shall be shipped in bulk to customer.

###### Tires

Tires shall be suitable for the conditions of transit service and sustained operation at the maximum speed capability of the bus. Load on any tire at GVWR shall not exceed the tire supplier's rating. The tires may be provided under a lease agreement between customer and tire supplier. Standard tire size for specified bus is size: R22.5 305 R70.

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

#### STEERING

##### FRONT AXLE

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

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

##### STRENGTH

Fatigue life of all steering components shall exceed 1,000,000 miles. No element of the steering system shall sustain a Class I failure when one of the tires hits a curb or strikes a severe road hazard. Inadvertent alternations of steering as a result of striking road hazards are steering failures.

##### TURNING RADIUS

Outside body corner turning radius for a standard configuration 35-foot long bus shall not exceed 39 feet. A 40’ bus shall not exceed 44 feet.

##### STEERINGTURNING EFFORT

The steering wheel shall be removable with a standard or universal puller. The steering column shall have full tilt and telescoping capability allowing the operator to easily adjust the location of the steering wheel.

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. With the bus on dry, level, commercial asphalt pavement, and tires inflated to recommended pressure and the front wheels positioned straight ahead, the torquerequired to turn the steering wheel 10 degrees shall be no less than 5 foot pounds and no more than 10 foot pounds. Steering torque may increase to 70 foot pounds when the wheels are approaching the steering stops, as the reliefvalveactivates. Steering effort shall be measured with the bus at GVWR, stopped with the brakes released and the engine 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 wheels to the straight position with minimal assistance from the driver.

##### STEERING WHEEL - GENERAL

The tilt-and-telescoping steering wheel shall be **TRW.**

The steering wheel diameter shall be no less than 18" and no more than 20"; the rim diameter shall be 7/8" to 1 1/4" and shaped for firm grip with comfort for long periods of time.

The steering wheel shall be removable with a standard or universal puller. Steering wheel spokes and wheel thickness should be such as to insure that visibility is within the range of a 95-percentile range as described in SAE 1050a, section 4.2.2 and 4.2.3. Placement of steering column must be as far forward as possible, but either in-line or behind the instrument cluster.

##### STEERING WHEEL TILT

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

##### STEERING WHEEL TELESCOPIC ADJUSTMENT

Measurement - From the top of the rim of the steering wheel in the horizontal position to the cab floor at the heel point***.***

The steering wheel height shall adjust to accommodate a 5th percentile female to 95th percentile male as referenced below.

The following chart is acknowledged as the standard for measurements of thigh clearance, resting elbow height, the slope of the steering wheel, and the height of the wheel, and the relationship of one to another, to assist in determining the appropriate telescopic range***.***

***(Based on Drillis and Contini, 1966)***

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| --- | --- | --- |
|  | **Thigh Clearance** | **Resting Elbow Height** |
| **5 Percentile Female** | 19.1" | 22.1" |
| **95 Percentile Male** | 25.6" | 30.4" |

#### BRAKES

##### SERVICE BRAKE

###### Actuation

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

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| *Baseline: Air Brakes*  Service brakes shall be controlled and actuated by a compressed air system. Force to activate the brake pedal control shall be an essentially linear function of the bus deceleration rate and shall not exceed 70 pounds at a point 7 inches above the heel point of the pedal to achieve maximum braking. The heel point is the location of the driver’s heel when foot is rested flat on the pedal and the heel is touching the floor or heel pad of the pedal. A microprocessor controlled Automatic Braking System (ABS) shall be provided. The microprocessor for the ABS system shall be protected yet in an accessible location to allow for ease of service. Automatic slack adjusters are required.  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. Air Disc Brakes on all 4 wheels are required. |

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| * ***Baseline****:* No Automatic Traction Control (ATC) required*, unless ATC is integral to OEM design.* |

###### Anti-Lock Braking System (ABS)

The buses shall be equipped with ABS system. ABS shall control all wheels with dual controllers, (two (2) wheels at a time) and shall regulate the transmission retarder in avoidance of wheel slip. A warning light that would indicate to the operator that the ABS system malfunctioned shall be integrated within the telltale panel cluster.

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

###### Friction Material

The entire service brake system, including friction material, shall have a minimum overhaul or replacement life of 30,000 miles with a brake retarder on the design operating profile. Brakes shall be self-adjusting throughout this period. Visible stroke indicators (on drum brakes only) shall be provided to allow service personnel to easily identify when the brakes are not in correct adjustment. The brake linings shall be made of non-asbestos material. In order to aid maintenance personnel in determining extent of wear, a provision such as a scribe line or chamfer indicating the thickness at which replacement becomes necessary, shall be provided on each brake lining.

###### Hubs and Drums

Replaceable wheel bearing seals shall run on replaceable wear surfaces or be of an integral wear surface sealed design. Wheel bearing and hub seals shall not leak or weep lubricant for 100,000 miles when running on the design operating profile.

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| 🞏 ***Baseline****: Disc brakes front and rear*.  The bus shall be equipped with disc brakes on both the front and rear axles and the brake discs shall allow machining the surfaces up to ¼ inch each side to obtain smooth surfaces. |

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

##### PARKING /EMERGENCY BRAKE

The parking brake shall be a spring-operated system, actuated by a valve that exhausts compressed air to apply the brakes. The parking brake may be manually enabled when the air pressure is at the operating level per FMVSS 121. An emergency brake release shall be provided to release the brakes in the event of automatic emergency brake application. The parking brake valve button will pop out when air pressure drops below requirements of FMVSS 121. The driver shall be able to manually depress and hold down the emergency brake release valve to release the brakes and maneuver the bus to safety. Once the operator releases the emergency brake release valve, the brakes shall engage to hold the bus in place.

#### pneumatic system

##### GENERAL

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

Provision shall be made to apply shop air to the bus air systems using a quick-disconnect fitting, **Milton 777**. A quick disconnect fitting specified herein shall be easily accessible and located in the drive system compartment and near the front bumper area for towing. Retained caps shall be installed to protect fitting against dirt and moisture when not in use. A quarter (¼) turn manual shutoff valve shall be added behind the fitting. Air for the compressor shall be filtered separately and specifically for the air compressor/intake.

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

##### AIR COMPRESSOR

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

##### AIR LINES AND FITTINGS

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 J844 for nylon tubing if not subject to temperatures over 200 degrees F. Nylon tubing shall be installed in accordance with the following color-coding standards:

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|  | Green. | Indicates primary brakes and supply |
|  | Red. | Indicates secondary brakes |
|  | Brown. | Indicates parking brake |
|  | Yellow. | Indicates compressor governor signal |
|  | Black. | Indicates accessories |

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 practicable 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 no more than 5-foot intervals. Nylon lines may be grouped and shall be supported at 30-inchintervals or less.

The compressor discharge line between compressor 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 flexible Teflon hose with a braided stainless steel jacket. End fittings shall be standard SAE or JIC brass or steel, flanged, swivel type fittings. Flexible hoses shall be as short as practicable and individually supported. They shall not touch one another or any part of the bus except for the supporting grommets. Flexible lines shall be supported at 2.5-foot intervals or less.

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

##### AIR RESERVOIRS

All air reservoirs shall meet the requirements of FMVSS Standard 121 and SAE Standard J10 and shall be equipped with clean-out plugs *or* guarded flush type drain valves. If air reservoirs are located within the roof structure or any location not readily accessible, remote drain valves shall be provided in a convenient and accessible location. Major structural members shall protect these valves and any automatic moisture ejector valves from road hazards. Reservoirs shall be sloped toward the drain valve. All air reservoirs shall have brass drain valves which discharge below floor level with lines routed to eliminate the possibility of water traps and/or freezing in the drain line.

* *Baseline: Non-heated moisture ejector valves*

🞎 *Alternative: Heated moisture ejector valves*

Heated moisture ejector valves are only required when air reservoir installation location is likely to be exposed to temperatures at or below freezing.

##### AIR SYSTEM DRYER

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

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| 🞎 *Baseline: No requirements for additional oil separator provision.*   * *Alternative: Use for requiring additional oil separator provision.*   A provision shall be included to collect/remove oil from the air system to prevent affecting function and/or damaging pneumatic system components. **PuraGuard Coalescing Filter** may perform this function. |

### BODY

#### GENERAL

##### DESIGN

The bus shall have a clean, smooth, simple design, primarily derived from bus performance requirements and passenger service criteria established by Part 5: Technical Specifications. The exterior and body features, including grilles and louvers, shall be shaped to facilitate 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. The body and windows shall be sealed to prevent leaking of air, dust, or water under normal operating conditions and during cleaning in automatic bus washers for the service life of the bus. Exterior panels shall be sufficiently stiff to minimize vibration, drumming or flexing while the bus is in service. When panels are lapped, the upper and forward panels shall act as a watershed. However if entry of moisture into interior of vehicle is prevented by other means, then rear cap panels may be lapped otherwise. The windows, hatches, and doors shall be able to be sealed. Accumulation on any window of the bus of spray and splash generated by the bus' wheels on a wet road shall be minimized.

A complete water test of all bus exterior surfaces shall be accomplished on each vehicle to a customer approved test plan. The following are minimum requirements:

###### Exterior Water Test Requirements

Exterior Water Test Requirements- The finished bus body shall be constructed as to prevent an opening that would admit water, dust, cold drafts, exhaust fumes, and unwanted noise into the interior of a finished bus. This water test is also intended for use as a criterion for the bus body sealing by Contractor’s Design Engineers, as well as, an acceptance criteria for Quality Assurance, to assure a weather-tight product is delivered to CUSTOMER. A water test shall be conducted over the entire exterior surface of each bus. All Buses shall pass a full coverage water test before release for delivery. This test shall be conducted so that each area of the bus surface under test is subject to the water spray.

**(1)** Applicable Facility and Equipment requirements

**a.** The water test testing apparatus or cell shall be equipped with manifolding as required to adequately perform the specified testing. The facility shall be capable of testing buses as designated in this specification.

**b.** The nozzles that deliver the water shall provide conical spray pattern with 2.0 ± 0.2 gallons per minute with a minimum 20 psi measured at each nozzle tip throughout the duration of the test.

**c.** The spacing shall not exceed 14 to 48 inches from the nozzle tip to the body of the bus. Location of gauges shall be visible during the test.

**(2)** Test Procedure

**a.** Positioning vehicle in testing apparatus or cell:

In order to obtain spray coverage of the bus body as specified, the vehicle must be positioned accurately laterally and fore and aft within the test facility. Proper location of the vehicle is also required to assure that the adjustable manifolds for bus front and underside will adequately perform their specified task. Water shall be sprayed on the Bus at strategic locations to simulate road and bus washer conditions.

**b.** The bus engine shall be started prior to the start of water test. The air conditioning system and the lights shall be operating normally. Panels defined by Test Plan shall be removed for inspection for water leaks.

##### Crashworthiness

The bus body and roof structure shall withstand a static load equal to 150 percent 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. These requirements must be met without the roof mounted air conditioning systems installed.

The bus shall withstand a 25-mph impact by a 4,000-pound 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 below 35 inches from ground level shall withstand a static load of 2,000 pounds applied perpendicular to the bus by a pad no larger than 5 inches square. This load shall not result in deformation that prevents installation of new exterior panels to restore the original appearance of the bus.

In addition to the above requirements, NFPA-52 and local regulations must be met.

##### Materials

Body materials shall be selected and the body fabricated to reduce maintenance, extend durability, and provide consistency of appearance throughout the service life of the bus. Detailing shall be kept simple; add-on devices and trim, where necessary, shall be minimized and integrated into the basic design.

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| * ***Baseline****: No requirement for protection against graffiti/vandalism for body material surfaces.* * *Alternative: Additional requirements for protection against graffiti/vandalism for body material surfaces. Also see Sections 5.4.3 and 5.4.4.*   The body material surfaces shall be protected against graffiti and vandalism. The specific requirements for the treatment of exterior surfaces are defined in Section 5.4.3 and interior surfaces in Section 5.4.4. |

##### CORROSION

The bus flooring, sides, roof, understructure, axle suspension components shall resist corrosion or deterioration from atmospheric conditions and road salts for a period of 12 years or 500,000 miles whichever comes first. It shall maintain structural integrity and nearly maintain original appearance throughout its service life, provided that it is maintained by customer in accordance with the procedures specified in the Contractor’s service manual. With the exception of periodically inspecting the visible coatings applied to prevent corrosion and reapplying these coatings in limited spots, the Contractor shall not require the complete reapplication of corrosion compounds over the life of the bus.

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| 🞏 *Baseline: Use for corrosion resistance requirements for exposed surfaces and interior surfaces of tubing below lower window level.*  All exposed surfaces and the interior surfaces of tubing and other enclosed members below lower window line shall be corrosion resistant.   * + *Alternative: Use for corrosion resistance requirements for exposed surfaces and interior surfaces of tubing throughout entire vehicle.*   All exposed surfaces and the interior surfaces of tubing and other enclosed members shall be corrosion resistant.   * ***Option****: Use for additional corrosion resistance requirements. (Stainless steel option)*   The vehicle shall be constructed using only inherently corrosion-resistant materials and fasteners to minimize deterioration. The structure shall not require corrosion-preventive coatings or after-treatments either during construction or throughout the service life of the vehicle. |

All materials that are not inherently corrosion resistant shall be protected with corrosion-resistant coatings. All joints and connections of dissimilar metals shall be corrosion-resistant and shall be protected from galvanic corrosion. Representative samples of all materials and connections shall withstand a 2-week (336-hour) salt spray test in accordance with ASTM Procedure B-117 with no structural detrimental effects to normally visible surfaces, and no weight loss of over 1 percent.

The bus body shall be of composite construction, the composite bus body shall be manufactured from composite materials consisting of High Strength fiber Glass, Carbon Fiber and Resin with a Balsa Wood Core. As such, the body shall be corrosion resistant and need no undercoating material. All exposed metal surfaces are to be E coated and powder coated.

Additional requirements for corrosion protection are contained in attachments to Part 5: Technical Specifications.

##### RESONANCE AND VIBRATION

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.

##### FIRE PROTECTION

The passenger and engine compartments shall be separated by a bulkhead(s) that shall, by incorporation of fireproof materials in its construction, be a firewall. This firewall shall preclude or retard propagation of a drive system compartment fire into the passenger compartment and shall be in accordance with the Recommended Fire Safety Practices defined in FTA Docket 90, dated October 20, 1993. Only necessary openings shall be allowed in the firewall, and these shall be fireproofed. Any passageways for the climate control system air shall be separated from the drive motor compartment by fireproof material. Piping through the bulkhead shall have copper, brass, or fireproof fittings sealed at the firewall with copper or steel piping on the forward side. Wiring may pass through the bulkhead only if connectors or other means are provided to prevent or retard fire propagation through the firewall. Drive motor 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.

***Each bus will be subjected to the customer approved smoke bomb test.***

##### DISTORTION

The bus, loaded to GVWR and under static conditions, shall not exhibit deflection or deformation that impairs the operation of the steering mechanism, doors, windows, passenger escape mechanisms and service doors. Static conditions shall include the vehicle at rest with any one wheel or dual set of wheels on a 6-inch curb or in a 6-inch deep hole.

#### STRUCTURE

##### GENERAL

###### Design

The structure of the bus as defined in Section 5.1.2 (25), shall be designed to withstand the transit service conditions typical of an urban duty cycle throughout its service life. The Design Operating Profile defined in Section 5.1.2 shall be considered for this purpose. An option for stainless steel structure shall be submitted, if available.

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| * + ***Baseline****:* The vehicle structural frame shall be designed to operate with no maintenance throughout a minimum 12-years under the Design Operating Profile. The vehicle shall be constructed using only inherently corrosion-resistant materials and fasteners to minimize deterioration. The structure shall not require corrosion-preventive coatings or after-treatments either during construction or through the service life of the vehicle. |

###### Altoona Testing

Prior to acceptance of first bus, the structure of the bus shall have undergone appropriate structural testing and/or analysis, including FTA required Altoona testing, to ensure adequacy of design for the urban transit service. Any items that required repeated repairs or replacement must undergo the corrective action with supporting test and analysis. A report clearly describing and explaining the failures and corrective actions taken to ensure any and all such failures will not occur shall be submitted to customer. No vehicles used for completion of the Altoona testing are acceptable for delivery under this contract.

A manufacturer whose bus is involved in a structurally related fleet failure in any transit property in the U.S. or Canada in the last ten (10) years must have completed the detailed investigation of the failure and the detailed structural analysis of the complete bus structure to rule out any effect on any part of the structure.

All failures involving basic body, structure, axles, and suspension are considered structural related failures for purposes of this specification.

The investigation of failure and structural analysis of Class 1 or Class 2 failures must be carried out by a reputable, independent Transit Industry Consultant and shall not only be limited to finite element analysis but be confirmed by actual track test with suitable time concentration, to prove ability of modified structure to perform for the specified 500,000 miles in CUSTOMER’s operating conditions.

The Engineering Report submitted to CUSTOMER must be detailed and must include proof of accuracy of customer’s operational conditions.

If the apparent responsive manufacturer's bus has been involved in a structurally related fleet failure, that manufacturer shall submit the aforementioned report to CUSTOMER for review with the initial proposal.

##### TOWING

Towing devices shall be provided on each end of the bus. Towing devices should accommodate flat-bedding or flat-towing. Each towing device shall withstand, without permanent deformation, tension loads up to 1.2 times the curb weight of the bus within 20 degrees of the longitudinal axis of the bus. The rear towing device(s) shall not provide a toehold for unauthorized riders. Two rear recovery devices/tie downs shall permit lifting and towing of the bus for a short distance, such as in cases of an emergency, to allow access to provisions for front towing of bus.

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| * ***Baseline****: Front tow only.*   The front towing devices shall allow attachment of adapters for a rigid tow bar and shall permit lifting of bus until the front wheels are clear off the ground in order to position the bus on the towing equipment by the front wheels. Tow adapters shall permit the towing of buses without interfering with the bicycle rack assemblies, or removal of the bicycle racks.  🞏 *Alternative: Front lift and tow of bus required.*  The front towing devices shall allow attachment of adapters for a rigid tow bar and shall permit lifting and towing of the bus, at curb weight, until the front wheels are clear off the ground.   * + *Alternative: Rear Tow Eyes required.*   Tow eyes shall be required on the rear of the bus to allow attachment of a chain or hooks to pull a bus from the rear. |

The rear towing devices shall permit lifting and towing of the bus for a short distance, such as in cases of an emergency, to allow access to provisions for front towing of the bus. The method of attaching the tow bar or adapter shall require the specific approval of customer. Each towing device shall accommodate a crane hook with a 1-inch throat.

##### JACKING

It shall be possible to safely jack up the bus, at curb weight, with a common 10-ton floor jack with or without special adapter, when a tire or dual set is completely flat and the bus is on a level, hard surface, without crawling under any portion of the bus. 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 be easily identified and 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 mechanic helper in less than 30 minutes from the time the bus is approached. The bus shall withstand such jacking at any one or any combination of wheel locations without permanent deformation or damage.

Jacking pads or points shall be painted safety yellow or orange for ease of identification.

##### 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 designed 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.

Other pads [if used shall be of an eight inch (8") diameter] or the bus structure shall support the bus on jack stands independent of the hoist, and painted safety yellow***.***

##### FLOOR

###### Design

The floor shall be essentially a continuous flat plane, except at the wheel housings and platforms. The floor height shall be as specified in Section 5.1.6.1.3, to eliminate steps and facilitate boarding and de-boarding of passengers.

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| * ***Baseline****: Use for bi-level floor design.*   The floor design shall consist of two levels (bi-level construction). Aft of the rear door extending to the rear settee riser, the floor height may be raised to a height approximately 20 inches above the lower level. An increased slope shall be allowed on the upper level not to exceed 3½° off the horizontal. |

Where the floor meets the walls of the bus, as well as other vertical surfaces, the surface edges shall be blended with a circular section of radius not less than 1 inch. At other surfaces such as, platform risers, the surface edges shall be blended with a circular section of radius not less than ¼ inch. Similarly, a molding or cove shall prevent debris accumulation between the floor and wheel housings. The vehicle floor in the area of the entrance and exit doors shall have a lateral slope not exceeding 2o to allow for drainage. Exceptions to lateral slope for drainage to be determined after contract award. Stainless steel flashing shall be added between the wheel wells and the floor to isolate the floor to prevent water damage.

###### Strength

The floor deck may be integral with the basic structure or mounted on the structure securely to prevent chafing or horizontal movement and designed to last the life of the bus. Sheet metal screws shall not be used to retain the floor and all floor fasteners shall be serviceable from one side only. The use of adhesives to secure the floor to the structure shall be allowed only in combination with the use of bolt or screw fasteners and its effectiveness shall last throughout life of the bus. Tapping plates, if 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 inches from the normal plane. The floor shall withstand the application of 2.5 times gross load weight without permanent detrimental deformation. Floor, with coverings applied, shall withstand a static load of at least 150 pounds applied through the flat end of a ½-inch diameter rod, with 1/32-inch radius, without permanent visible deformation.

###### Construction

The floor shall consist of the subfloor and the floor covering (See 5.4.4.5 Floor Covering). The floor, as assembled, including the sealer, attachments and covering shall be waterproof, non-hygroscopic, and resistant to mold growth. The subfloor shall be resistant to the effects of moisture, including decay (dry rot). It shall be impervious to wood destroying insects such as termites.

The floor system shall be of composite fiber glass and resin construction and as such be non corrosive.

##### PLATFORMS

###### General

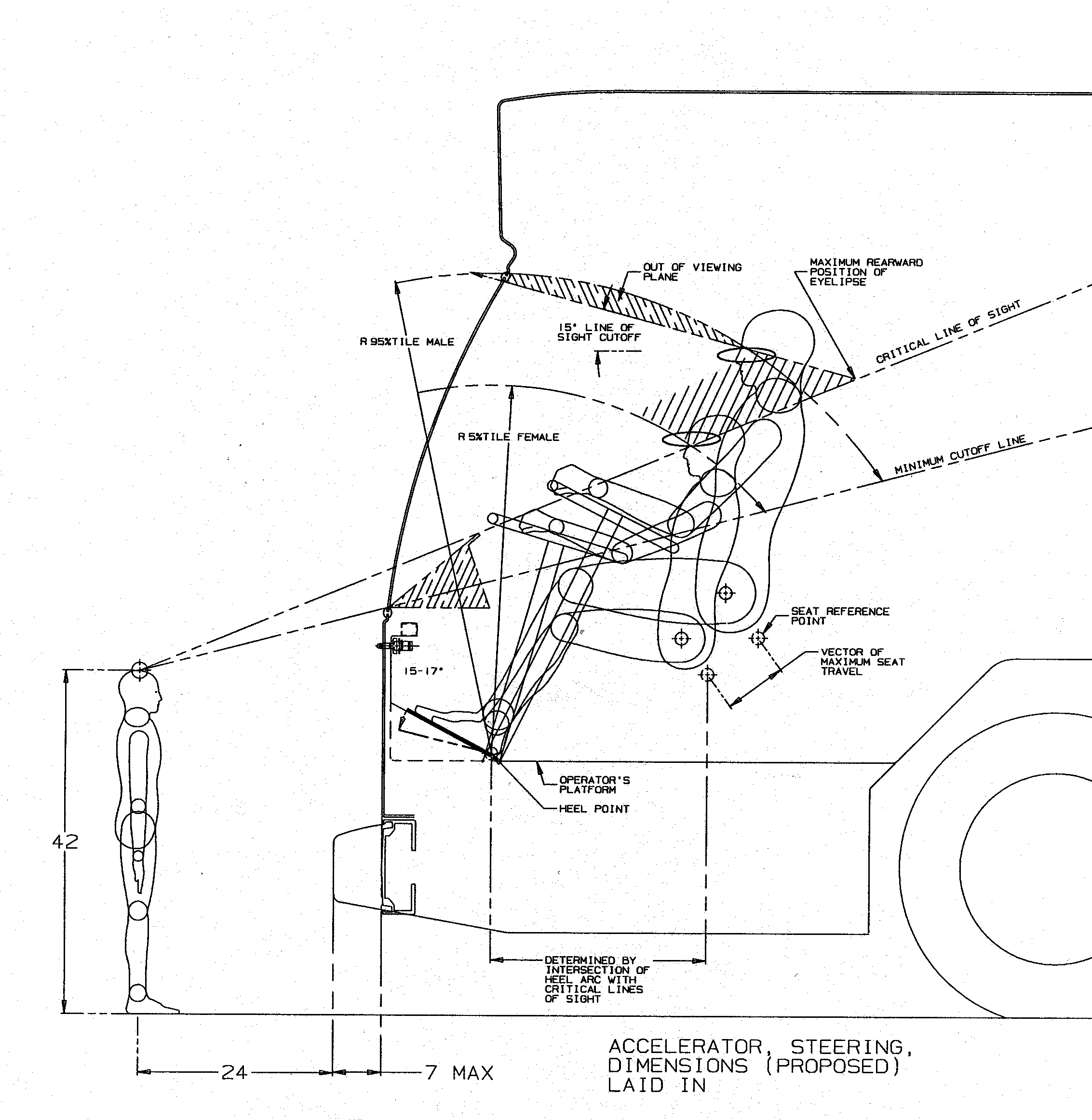
Platform height shall not exceed 17.5 inches. Any platform height in excess of 16 inches shall require an intermediate step. Trim shall be provided along top edges of platforms unless integral nosing is provided. Except where otherwise indicated, covering of platform surfaces and risers shall be same material as specified for floor covering.

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| * ***Baseline****: No trim material specified.*   □  *Alternative: Stainless steel trim.*  Trim installed along edges of platforms shall be constructed of stainless steel. |

Other raised areas such as for providing space for under-floor installation of components shall be limited. Such raised areas shall be constructed in accordance to these specifications.

###### Operator’s Platform

The operator's platform shall be of a height that, in a seated position,the operatorcan seean object located at an elevation of 42" above the road surface, 24" from the leading edge of the bumper. Notwithstanding this requirement, the platform height shall not position the operator such that the operator's vertical upward view is less than 15 degrees (seeStandard Bus Procurement Guidelines/Low Floor Specificationsection 5.4.7.2 ***-*WINDSHIELD).**  A warning decal or sign shall be provided to alert operator to the change in floor level. The following schematic diagram illustrates a means by which the platform height can be determined, using the Critical Line of Sight.



The Operator’s area shall meet all criteria with the 5th percentile female to 95th percentile male operator by demonstration on the 1st article vehicle.

###### Farebox

If the driver’s platform is higher than 12 inches, then the farebox is to be mounted on platform of suitable height to provide accessibility for operator without compromising passenger’s access.

###### Intermediate Platform

If the vehicle is of a bi-level floor design, an intermediate platform shall be provided along the center aisle of the bus to facilitate passenger traffic between the upper and lower floor levels. This intermediate platform shall be cut into the rear platform and shall be approximately the aisle width, 18 inches deep and approximately one half the height of the upper level relative to the lower level. The horizontal surface of this platform shall be covered with yellow Hypalon ribbed rubber or skid-resistant material and shall be sloped slightly for drainage. A warning decal or sign shall be provided at the immediate platform area to alert passengers to the change in floor level.

##### WHEEL HOUSING

###### Design

Sufficient clearance and air circulation shall be provided around the tires, wheels, and brakes to preclude overheating when the bus is operating on the CBD phase of the design operating profile. See Section 5.1.2(20).

Interference between the tires and any portion of the bus shall not be possible in maneuvers up to the limit of tire adhesion with weights from curb weight to GVWR. Wheel housings shall be adequately reinforced where seat pedestals are installed. Wheel housings shall have sufficient sound insulation to minimize tire and road noise and meet all requirements of Section 5.1.6.6, Noise.

Design and construction of front wheel housings shall allow for the installation of radio/electronic equipment storage compartment on interior top surface or its use as a luggage rack.

The exterior finish of the front and rear wheel housings shall be scratch-resistant, meeting requirements of Section 5.4.4.1, Interior Panels and Finishes, and complement interior finishes of the bus to minimize the visual impact of the wheel housing. If fiberglass wheel housings are provided, then they shall be color-impregnated to match interior finishes. The lower portion extending to approximately 12 inches above floor shall be equipped with additional more resistant coating or stainless steel trim.

###### Construction

Wheel housings shall be constructed of corrosion-resistant, fire-resistant fiber glass composite material. Wheel housings, as installed and trimmed, shall withstand impacts of a 2-inch steel ball with at least 200 foot-pounds of energy without penetration.

🞏 *Baseline: Material to be bus manufacturer’s choice.*

#### EXTERIOR PANELS AND FINISHES

##### PEDESTRIAN SAFETY

Exterior protrusions greater than 1/2 inch and within 80 inches of the ground shall have a radius no less than the amount of the protrusion. The exterior rearview mirrors and required lights and reflectors are exempt from the protrusion requirement. Advertising frames shall protrude no more than 7/8 inch from the body surface and shall have the exposed edges and corners rounded to the extent practicable. 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.

##### REPAIR AND REPLACEMENT

The bus body shall be of one piece monocoque composite construction and as such has no replaceable body panels other than access doors. Because of this construction the body shall be much more resilient to impact than conventional construction requiring only minor fiberglass body work in most cases.

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| * ***Baseline****: No requirement for anti-graffiti/vandalism surface treatments.* * *Alternative: Additional requirements for anti-graffiti/vandalism treatments for exterior surfaces.*   Additional requirements for anti-graffiti/vandalism treatments for exterior surfaces are contained in attachments to Part 5: Technical Specifications. |

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| * ***Baseline****: No requirements for easily replaceable, impact-resistant panels on lower exterior panels.* |

##### RAIN GUTTERS

Rain gutters shall be provided to prevent water flowing from the roof onto the passenger doors, operator’s side window, and exterior mirrors. When the bus is decelerated, the gutters shall not drain onto the windshield, or operator's side window, or into the door boarding area. Cross sections of the gutters shall be adequate for proper operation.

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| * + ***Baseline****: No requirements for rain gutter above passenger side windows.*   **Rain gutters may be provided over the passenger side windows at the discretion of the bus manufacturer, if they are integral to the body design.**   * + - A*lternative: Rain gutter above passenger side windows.*   Rain gutter shall also be provided above passenger side windows. |

##### LICENSE PLATE PROVISIONS

Provisions shall be made to mount standard size U.S. license plates per SAE J686 on the front and rear of the bus. These provisions shall direct mount or recess the license plates so that they can be cleaned by automatic bus washing equipment without being caught by the brushes. License plates shall be mounted at the lower center or lower street side of the bus and shall not allow a toehold or handhold for unauthorized riders.

##### RUBRAILS

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| * ***Baseline****: No requirement for rubrails* |

##### FENDER SKIRTS

Features to minimize water spray from the bus in wet conditions shall be included in wheel housing design. Any fender skirts shall be easily replaceable. They shall be flexible if they extend beyond the allowable body width. Wheels and tires shall be removable with the fender skirts in place.

The front and rear wheelwell housing design shall prevent exposure from water migration to the interior of the bus or floor plywood.

##### SPLASH APRONS

Splash aprons, composed of 1/4-inch minimum composition or rubberized fabric, shall be installed behind and/or in front of wheels as needed to reduce road splash and protect underfloor components. The splash aprons shall extend downward to within 4 to 6 inches of the road surface at static conditions. Apron widths shall be no less than tire widths. Splash aprons shall be bolted to the bus understructure. Splash aprons and their attachments shall be inherently weaker than the structure to which they are attached. The flexible portions of the splash aprons shall not be included in the road clearance measurements. Other splash aprons shall be installed where necessary to protect bus equipment.

##### SERVICE COMPARTMENTS AND ACCESS DOORS – EXTERIOR

###### Access Doors

Conventional or pantograph hinged doors shall be used for the drive system compartment and for all auxiliary equipment compartments including doors (if so equipped) for checking the quantity and adding to the drive system (motor and controller) coolant, power steering fluid, windshield washer fluid and transmission fluid. Access openings shall be sized for easy performance of tasks within the compartment including tool operating space. Access doors shall be of rugged construction and shall maintain mechanical integrity and function under normal operations throughout the service life of the bus. They shall close flush with the body surface. All doors shall be hinged at the top or on the forward edge, with the exception of the front defroster access panel, which is allowed to be hinged at the bottom, and shall be prevented from coming loose or opening during transit service or in bus washing operations. Doors with top hinges shall have safety props stored behind the door or on the doorframe or employ gas shocks of sufficient size to support the weight of the door when opened. All access doors shall be retained in the open position by props or counterbalancing with over-center or gas-filled springs and shall be easily operable by one person. 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. Access doors, when opened, shall not restrict access for servicing other components or systems.

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| * *Baseline: Requirement for locks on access doors. Also see Section 5.4.4.8.*   Access doors larger in area than 100 square inches shall be equipped with corrosion resistant flush-mounted locks. All such access door locks that require a tool to open shall be standardized throughout the vehicle and will require a nominal 5/16-inch square male tool to open or lock.   * *Alternative: Use for Agency defined locks for access doors. Also see Section 5.4.4.8.*   Access doors larger in area than 100 square inches shall be equipped with locks. The locks shall be standardized as defined by the Procuring Agency in the attachments to Part 5: Technical Specifications so that only one tool is required to open all major access doors on the bus.   * ***Alternative****: Deletion of the requirement for locking access doors. Also see Section 5.4.4.8.*   Access doors larger in area than 100 square inches shall be equipped with corrosion resistant, flush-mounted latches. The latches shall be standardized and shall be openable without the use of a key or tool. The latches shall be reviewed and approved by customer after contract award. |

###### Battery Compartment

The batteries shall be securely mounted on a stainless steel, powder coated steel or equivalent tray that can accommodate the size and weight of the batteries. The battery tray shall pull out easily and properly support the batteries while they are being serviced. The tray shall allow each battery cell to be easily serviced and filled. A locking device shall retain the battery tray in the stowed position. Battery trays shall be released with partial turn (no tools) retaining mechanism. All electrical components located and mounted within the battery compartment shall be subject to CUSTOMER approval after contract award.

The battery compartment or enclosure shall be vented and self-draining. It shall be accessible only from outside the bus. All components within the battery compartment, and the compartment itself, shall be protected from damage or corrosion from the electrolyte and gases emitted by the battery, and from snow, slush, salt spray, mud, etc. generated from environmental conditions outside the vehicle. The inside surface of the battery compartment's access door shall be electrically insulated, as required, to prevent the battery terminals from shorting on the door if the door is damaged in an accident or if a battery comes loose. The Master Battery Switch accessibility requirements are defined in Section 5.5.3.1.3.

A customer approved smoke bomb test shall be applied to this battery compartment to ensure that the passenger compartment is protected from intrusion of any battery fumes on each bus.

**5.4.3.8.2.1 Propulsion Battery Compartment**

The propulsion batteries shall be mounted within the floor cavity of the bus between the front and rear wheel wells to provide even weight distribution and a low center of gravity. Additional batteries may be located on the rooftop and/or rear motor compartment if additional range is necessary. The battery cases shall be so designed that they may be replaced using a standard hydraulic lifting table. The case shall be designed in such a fashion as to be self-aligning when inserted into the battery housing. The battery cases shall be fabricated of a non-corrosive material such as stainless steel, E-coated and powder coated steel or fiber glass.

###### Service Area Lighting

Lights shall be provided in the engine and all other compartments, where service may be required, to generally illuminate the area for night emergency repairs or adjustments. Sealed lamp assemblies shall be provided in the drive motor compartment and shall be controlled by a switch located near the rear control panel in the drive motor compartment. Necessary lights, located in other service compartments, shall be provided with switches on the light fixture or convenient to the light.

###### *Alternative: No requirement for engine compartment lighting.*

##### BUMPERS

###### Location

**Romeo Rim** bumpers shall provide impact protection for the front and rear of the bus with the top of the bumper being (26 +6/ -2) inches above the ground. Bumper height shall be such that when one bus is parked behind another, a portion of the bumper faces will contact each other.

###### Front Bumper

No part of the bus, including the bumper (excluding bike racks), 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' longitudinal centerline. The bumper shall return to its pre-impact shape within 10 minutes of the impact. The bumper shall protect the bus from damage as a result of 6.5 mph impacts at any point by the Common Carriage with Contoured Impact Surface defined in Figure 2 of FMVSS 301 loaded to 4,000 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 of the bus and shall not require service or maintenance in normal operation during the service life of the bus. The bumper may increase the overall bus length specified in Section 5.1.6.1.1 by no more than 7 inches.

###### Rear Bumper

No part of the bus, including the bumper, shall be damaged as a result of a 2-mph impact with a fixed, flat barrier perpendicular to the longitudinal centerline of the bus. The bumper shall return to its pre-impact shape within 10 minutes of the impact. When using a yard tug with a smooth, flat plate bumper 2 feet wide contacting the horizontal centerline of the rear bumper, the bumper shall provide protection at speeds up to 5 mph, over pavement discontinuities up to 1 inch high, and at accelerations up to 2 mph/sec. The rear bumper shall protect the bus, when impacted anywhere along its width by the Common Carriage with Contoured Impact Surface defined in Figure 2 of FMVSS 301 loaded to 4,000 pounds, at 4 mph parallel to, or up to a 30-degree angle to, the longitudinal centerline of the bus. The rear bumper shall be shaped to preclude unauthorized riders standing on the bumper. The bumper shall be independent of all power systems of the bus and shall not require service or maintenance in normal operation during the service life of the bus. The bumper may increase the overall bus length specified in Section 5.1.6.1.1 by no more than 7 inches.

###### Bumper Material

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

##### FINISH AND COLOR

(See Exhibit ‘P’ for sample PAINT SCHEME). All exterior surfaces shall be smooth and free of wrinkles and dents. Exterior coating shall be white gel-coat. Exterior surfaces to be gel-coated shall be properly prepared as required by the gel coat system supplier. Drilled holes and cutouts in exterior surfaces after body construction shall be coated with gel coating material. The bus shall be completely gel coated prior to installation of exterior lights, windows, mirrors and other items that are applied to the exterior of the bus. Body filler materials may be used for surface dressing, but not for repair of damaged or improperly fitted panels.

Gel-coat shall be applied smoothly and evenly with the finished surface free of dirt and the following other imperfections:

A. Blisters or bubbles appearing in the topcoat film.

B. Chips, scratches, or gouges of the surface finish.

C. Cracks in the paint film.

D. Craters where paint failed to cover due to surface contamination.

E. Overspray.

F. Peeling

G. Runs or sags from excessive flow and failure to adhere uniformly to the surface.

H. Chemical stains and water spots.

I. "Orange peel" finish.

To the degree consistent with industry standards for commercial vehicle finishes, gel-coated surfaces shall have gloss and orange peel shall be minimized. All exterior finished surfaces shall be impervious to diesel fuel, gasoline and commercial cleaning agents. Finished surfaces shall resist damage by controlled applications of commonly used graffiti-removing chemicals. Colors and paint schemes shall be in accordance with the attachments to Part 5: Technical Specifications.

Contractor shall use scratch and tape adhesion test (ASTM D3359, “Standard Test Method for Measuring Adhesion by Tape Test”) or customer-approved alternative test method for paint adhesion test on all vehicles.

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##### NUMBERING AND SIGNING

Monograms, numbers and other special signing specified by customer 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. Signs shall be provided in compliance with the ADA requirements defined in 49 CFR Part, Subpart B, 38.27. The exact wording, size, color, and locations for these signs shall be provided by after contract award.

1. Sample design is provided in Exhibit P. Final design shall be approved by CUSTOMER during first article review.
2. Interior passenger directions and/or decals shall be in English and Spanish.
3. All decals are the responsibility of the manufacturer to obtain and install.
4. CUSTOMER shall provide samples where required such as: “Children May Be Exiting”, U.S. America Flag (LH / RH), and No Smoking, Eating, Drinking, etc.

*Bus numbers series shall be forwarded to the Contractor after contract award. Quantities of buses per lot in the 30-foot and 40-foot configurations are listed in the Schedule.*

##### EXTERIOR LIGHTING

All exterior lights, including headlights, shall be designed to prevent entry and accumulation of moisture or dust, and each lamp shall be replaceable in less than 5 minutes by a 2M mechanic helper. Commercially available LED (Light Emitting Diode)-type lamps shall be used wherever possible, including applications where white lights are used, such as for headlights.

* *Baseline: Standard sealed-beam headlights*
* *Acceptable Alternative 1: High-intensity discharge (HID) headlights.*

**Hella** High-intensity discharge (HID) headlights, separate headlights for the low and high beam functions are permitted. Lights shall have the following characteristics:

> Low beam: 120 mm modular, DE projection technology, with H1 single bulb.

> High beam: 90 mm modular, DE projection technology with H9 single bulb.

> VPS 90mm high- and low-beam headlights with the H11LL (Long life) bulb is also permitted.

* *Acceptable Alternative 2: One-piece headlight assembly*

A one-piece headlight assembly may be used at the manufacturer's discretion with the following characteristics:

> Molded automotive type headlight assemblies manufactured by Automotive Lighting.

> Shall incorporate an Osram 9003L High/Low beam lamp

> Shall include a 64150D day run light

*🗹 Acceptable Alternative 3: Integrated LED headlight assembly*

A one-piece headlight assembly may be used at the manufacturer's discretion with the following characteristics:

> Low-beam lamp: LED headlights.

> High beam lamp: Incandescent light.

> Headlight assembly shall meet FMVSS 108 requirements.

Lights mounted on the engine compartment doors shall be protected from the impact shock of door opening and closing. Lamps, lenses and fixtures shall be interchangeable to the extent practicable. Two hazard lamps at the rear of the bus shall be visible from behind when the engine service doors are opened. Light lenses shall be designed and located to prevent damage when running the vehicle through an automatic bus washer. Lights located on the roof and sides (directionals) of the bus shall have protective shields and/or be of the low profile or flush mount type to protect the lens against minor impacts.

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 passenger doorways shall comply with ADA requirements and shall activate only when the doors open. These lamps shall illuminate the street surface to a level of no less than 1 foot-candle for a distance of 3 feet outward from the outboard edge of the door threshold. The lights may be positioned above or below the lower daylight opening of the windows and shall be shielded to protect passengers' eyes from glare.

Turn-signal lights shall be provided on both sides of the bus. Specific number and mounting requirements are defined in attachments to Part 5: Technical Specifications.

* *Baseline: No DRLs (Daytime Running Lights*
  + ***Alternative****: Daytime Running Lights required*
* ***Alternative****:* *Two (2) High-mounted Brake Lights*

In addition to the Federal and State DOT required operational brake lights, the Contractor shall also mount two (2) (approximately 10 to14½" center-to-center) additional stop lights on the upper panel, center and flush, located above the rear engine access door, on a horizontal axis as a means to reduce potential rear end collisions. Each added stop lamp lens (LED) shall be approximately 4" diameter and red in color.

Alternatively, two (2) 18-inch LED strip lights may be placed on the rear panel. The stop lamp assemblies shall be waterproof and shall be illuminated when the Operator's brake treadle is depressed and shall go off when the brake treadle is released. "Snap on" type/design retention of any lamp lens are not acceptable.

##### BICYCLE RACKS

The Contractor shall mount a bicycle rack, **Midwest Bus BykRak Narrow Profile (NP) or Sportworks DL2 NP,** to the front bumper of the bus. The bike rack shall be installed as per the manufacturer’s recommendations and shall not impact the bus approach angle. The bike rack shall be mounted to preclude damage to the windshield in the event of a frontal impact.

Appropriate decals shall be installed at the front of the bus to adequately describing the operation of the bicycle rack. Decals and decal location shall be approved by CUSTOMER during the Pilot Bus review.

The bicycle rack shall be designed to carry two bicycles. Each bike can be loaded/unloaded independently of the other. In the deployed position the bike rack shall latch automatically in position. When not in use the bike rack shall fold upward against the front of the bus and latch securely in place.

The bike rack shall not interfere with the operation of the windshield wipers, access panels, or front lift tow or flat tow adapters. The bike rack shall be easily removable for seasonal and emergency detachment from the bus. Detachment shall not require removal or disassembly of the front bumper or any other bus mounted parts.

**The bicycle rack shall be equipped with a Bike Rack Ad Sign with the minimum dimensions of 12” x 30”, aluminum powder-coated black.**

Approval of the mounting location and installation will be provided by CUSTOMER after contract award.

* ***Baseline****: No requirement for interior indicator lights or exterior markers.*
* *Alternative 1: Requirement for dash-mounted indicator light.*

A telltale panel integrated light shall warn the operator when the rack is not stowed.

* *Alternative 2: Requirement for bike rack mounted reflectors.*

Reflective markers, visible from a minimum distance of fifty (50) feet and a maximum distance of three hundred (300) feet, shall be mounted on the rack so that they are visible from the side.

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#### INTERIOR PANELS AND FINISHES

##### GENERAL

Materials shall be selected on the basis of maintenance, durability, appearance, safety, flammability, and tactile qualities. Trim and attachment details shall be kept simple and unobtrusive. Materials shall be strong enough to resist everyday abuse and vandalism; they shall be resistant to scratches and markings. Interior trim shall be secured to avoid resonant vibrations under normal operational conditions.

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. The entire interior shall be cleanable with a hose, using a liquid soap attachment. Water and soap should not normally be sprayed directly on the instrument and switch panels.

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| * *Baseline: No requirement for anti-graffiti/vandalism surface treatments.*   X ***Alternative:*** *Interior panels shall be of Kydex vacuum formed plastic to meet anti-graffiti/vandalism requirements.* |

Interior colors shall be color-coordinated bone, white, gray and black.

ABS Plastic may be used on the interior ceiling panels, provided the color matches other panels used in the interior or the bus.

##### FRONT END

The entire front end of the bus shall be sealed to prevent debris accumulation behind the dash and to prevent the operator's feet from kicking or fouling wiring and other equipment. The front end shall be free of protrusions that are hazardous to passengers standing or walking in the front of the bus during rapid decelerations. Paneling across the front of the bus and any trim around the operator's compartment shall be formed metal, fiberglass, or plastic material. Formed metal dash panels shall be painted and finished to the quality described in Section 5.4.3.10 or may be carpeted or vinyl covered. Fiberglass or plastic dash panels shall be reinforced, as necessary, vandal-resistant, and replaceable. All colored, painted, and plated parts forward of the operator's barrier shall be finished with a dull matte surface to reduce glare. (See Section 5.4.6.1.1)

##### REAR END

The rear bulkhead and rear interior surfaces shall be material suitable for exterior skin, painted and finished to exterior quality, or paneled with melamine-type material, plastic, or carpeting and trimmed with stainless steel, aluminum, or plastic. Colors, patterns, and materials are defined in attachments to Part 5: Technical Specifications.

##### INTERIOR PANELS

###### General

Interior side trim panels, modesty panels, and operator's barrier shall be textured stainless steel, anodized aluminum, plastic, melamine-type material, or carpeting. Panels shall be easily replaceable and tamper-resistant. They shall be reinforced, as necessary, to resist vandalism and other rigors of transit bus service. Individual trim panels and parts shall be interchangeable to the extent practicable. Untrimmed areas shall be painted and finished to the quality described in Section 5.4.3.10. All materials shall comply with the Recommended Fire Safety Practices defined in FTA Docket 90, dated October 20,1993.

Colors, patterns, and materials for the interior trim shall be approved by CUSTOMER.

Operator's Coat Hanger

A suitable hanger shall be installed in a convenient approved location for the operator's overcoat.

Operator's Drink Holder

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| * ***Baseline****: No Drink holder.* * *Alternative: Drink holder****.***   A rugged device shall be provided to securely hold the operator's drink container, which may vary widely in diameter. It must be mounted within easy reach of the operator and must have sufficient vertical clearance for easy removal of the container. When the container is in the device, the operator's view of the road must not be obstructed and leakage from the container must not fall on any switches, gauges or controls. |

###### Operator Barrier and Operator's Enclosure/Shield

A barrier or bulkhead between the operator and the street-side front passenger seat shall be provided. The barrier shall minimize glare and reflections in the windshield directly in front of the barrier from interior lighting during night operation.

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| * *Baseline: Standard configuration of operator’s barrier.*   The barrier shall extend from below the level of the passenger or operator's seat cushion, whichever is lower, to above the level of the seated operator's head and shall fit the bus side windows and wall to prevent passengers from reaching the operator or the operator’s personal effects.   * ***Alternative****: Full-height configuration of operator’s barrier*.   The operator’s barrier shall prevent passengers from reaching the operator or operator’s personal effects. Where the radio box doesn’t serve as a barrier, a full height tinted Lexan or melamine barrier is required. Operator’s barrier shall be integrated with the Radio and/or Communications compartment provided design meets the intent of the above requirements.  Operator's Barrier shall extend continually from floor to within 6" of the ceiling and from the bus wall to first stanchion immediately behind the Operator to provide security to the Operator and limit passenger conversation.   * Location and shape must permit full seat travel possibilities and accommodate the shoulders of a 95th percentile male * Partition shall have a side return and stanchion to prevent passenger from standing behindtheOperator'sseat; lower area between seat and panel must be accessible to theOperator***.*** * Partition must be strong enough in conjunction with entire partition assembly for mounting of such equipment as flare kits, fire extinguishers (1.2kg), microcomputer, public address amplifier, etc. * Partition shall start 25mm (1") above floor * CUSTOMER shall select panel choices * Panel should be attached with rubber grommets * *Alternative: Operator's Enclosure or Shield*.   A protective shield (**TCB Industries, Inc., Bus Solutions Co., LLC, or Bentech, Inc.**) for the operator shall be installed. The shield shall have the following characteristics:   * + - Panels should not interfere with the operation or maintenance of the farebox or operator's controls or restrict airflow to the operator.     - Shield panel(s) should allow for rapid egress of the operator in case of an emergency.     - Should be integrated into the Operator’s area and allow for necessary interaction between boarding passengers and operator     - Latch should allow the shield door to be latched in the fully opened or fully closed position.     - Edges of panels and attachment hardware and hinges should be rounded and polished to prevent snags.     - Material should resist graffiti and scratches.     - Shield panel material must be high-impact and anti-glare. |

Operator Storage Box

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| * *Baseline: No storage box*. * ***Alternative****: Storage box*.   An enclosed Operator Storage Area, minimum approximate size 355 mm x 355 mm x 355 mm (14" x 14" x 14") **or** 495 mm x 305 mm x 241 mm (19.5" x 12" x 9.5"), shall be provided, with a positive latching door and approved combination lock. |

###### Modesty Panels

Sturdy divider panels constructed of durable, unpainted, corrosion-resistant material complementing the interior trim shall be provided to act as both a physical and visual barrier for seated passengers. Modesty panels shall be located at doorways to protect passengers on adjacent seats, and along front edge of rear upper level (floor to ceiling). Design and installation of modesty panels located in front of forward facing seats shall include a handhold/grab-handle along its top edge*.* These dividers shall be mounted on the sidewall and shall project toward the aisle no farther than passenger knee projection in longitudinal seats or the aisle side of the transverse seats. Modesty panels shall extend no higher than 6 inches above than the lower daylight opening of the side windows and those forward of transverse seats shall extend downward to a level between 1-1/2 and 1 inches above the floor. Panels forward of longitudinal seats shall extend to below the level of the seat cushion. Dividers positioned at the doorways shall provide no less than a 2-1/2-inch clearance between the modesty panel and the opened door to protect passengers from being pinched. Modesty panels installed at doorways shall be equipped with grab rails (see Section 5.4.5.2). The modesty panel and its mounting shall withstand a static force of 250 pounds applied to a four-inch by four-inch area in the center of the panel without permanent visible deformation

###### Rear Bulkhead

The rear bulkhead paneling shall be contoured to fit the ceiling, side walls, and seat backs so that any litter, such as a cigarette package or newspaper, will tend to fall to the floor or seating surface when the bus is on a level surface. Any air vents in this area shall be louvered to reduce airflow noise and to reduce the probability of trash or litter being thrown or drawn through the grille. If it is necessary to remove the panel to service components located on the rear bulkhead, the panel shall be hinged or shall be able to be removed and replaced by a 3M mechanic in 5 minutes. Grilles where access to or adjustment of equipment is required shall be heavy duty and designed to minimize damage.

###### Headlining

Ceiling panels shall be textured stainless steel, anodized aluminum, melamine-type material, ABS plastic, carpeting, or material suitable for exterior skin painted and finished to exterior quality. Headlining shall be supported to prevent buckling, drumming, or flexing and shall be secured without loose edges. Headlining materials shall be treated or insulated to prevent marks due to condensation where panels are in contact with metal members. Moldings and trim strips, as required to make the edges tamperproof, shall be stainless steel, aluminum, or plastic, colored to complement the ceiling material. 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. Colors, patterns, and materials for the headlining shall be CUSTOMER's selection of presented options.

###### Fastening

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

###### Insulation

Any insulation material used between the inner and outer panels shall be sealed or self-sealing to minimize entry and/or retention of moisture. Insulation properties shall be unimpaired during the service life of the bus. Any insulation material used inside the drive system compartment shall not absorb or retain oils or water and shall be designed to prevent casual damage that may occur during maintenance operations. All insulation materials shall comply with the Recommended Fire Safety Practices defined in FTA Docket 90, dated October 20, 1993. Exceptions to Docket 90 will be considered during the solicitation questions and answers (Request for Approved Equal) process.

The combination of inner and outer panels on the sides, roof, wheel wells and ends of the bus, and any material used between these panels shall provide a thermal insulation sufficient to meet the interior temperature requirements of Part 5: Technical Specifications. The bus body shall be thoroughly sealed so that the operator or passengers cannot feel drafts during normal operations with the passenger doors closed. Engine access panel and rear seat access material design shall be a robust closed cell insulation material appropriate for the application.

##### FLOOR COVERING

The floor covering shall be **Altro Transflor Meta Storm, TFM 27903 ([Gray], 2.7 mm) or** **RCA Rubber Company,** and shall have a non-skid walking surface that remains effective in all weather conditions and complies with all ADA requirements. The floor covering, as well as transitions of flooring material to the main floor and to the entrance and exit area, shall be smooth and present no tripping hazards. The standee line shall be at least 2 inches wide and shall extend across the bus aisle. This line shall be the same color as the outboard edge of the entrance/exit areas. Color/pattern shall be consistent throughout the floor covering.

The area of the front ramp platform as well as the floor area under and around the ramp in the vestibule area may be LineX sprayed-on polyurethane, non-skid surface. The step edge shall be LineX yellow.

Any areas on floor, which are not intended for standees, such as areas “swept” during passenger door operation, shall be clearly and permanently marked.

The floor in the operator's compartment shall be easily cleaned and shall be arranged to minimize debris accumulation.

A one-piece 3/16th inch minimum thickness center strip shall extend from the vertical wall of the rear settee between the aisle sides of transverse seats to the standee line. If the floor is of a bi-level construction, then center strip shall be one-piece at each level. The covering between the center strip and the wheel housings may be separate pieces, but be 1/8th inch minimum thickness smooth finish to top of cove with 1 to 2 inch radius. Exceptions allowed for the 1 to 2 inch radius on welded joint floor systems only. At the rear door, however, a separate strip as wide as the door shall extend from the center strip to the outboard edge of the rear/exit area.

The floor under the seats shall be covered with smooth surface flooring material. The floor covering shall closely fit the sidewall cove or extend to the top of the cove.

##### PASSENGER INTERIOR LIGHTING

The interior lighting system shall provide a minimum 15 foot-candle illumination on a 1 square foot plane at an angle of 45 degrees from horizontal, centered 33 inches above the floor and 24 inches in front of the seat back at each seat position. Allowable average light level for the rear bench seats shall be 7 foot-candles. Floor surface in the aisles shall be a minimum of 10 foot-candles, vestibule area a minimum of 4 foot-candles with the front doors open and a minimum of 2 foot-candles with the front doors closed. The front entrance area and curb lights shall illuminate when the front door is open and master run switch is in the “Lights” positions. Rear exit area and curb lights shall illuminate when rear door is unlocked.

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| 🗹 **Alternative**:  Two (2) LED strip lights may be installed at the front and rear doors. The strip lights shall illuminate the door opening to the ground. Curb lights are not required if strip lights illuminate ground area. |

Step lighting for the intermediate platform between lower and upper floor levels shall be provided and shall illuminate in all motor run positions. The step lighting shall be low-profile to minimize tripping and snagging hazard for passengers and shall be shielded as necessary to protect passengers’ eyes from glare.

The light source shall be located to minimize windshield glare with distribution of the light focused primarily on the passengers' reading plane while casting sufficient light onto the advertising display. Fluorescent tubes shall be a maximum 6-foot length, single-pin, T‑12 type, with exception granted for extinguishing or dimming fixtures as noted below.

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| * *Baseline: LED lights for passenger interior lighting*. LED lights shall be indirect type for maximum dispersion and coverage. **Hadley** |

Lens material for LED lighting shall be frosted polycarbonate. Lens shall be sealed to inhibit incursion of dust and insects yet are easily removable for service. If threaded fasteners are used they must be held captive in the lens. Access panels shall be provided to allow servicing of components located behind light panels. If necessary, the entire light fixture shall be hinged.

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| 🗹 *Baseline: Use for first light modules dim/extinguish when front door opens.*  When the master switch is in the RUN or NITE/RUN mode, the first light module on each side of the bus shall automatically extinguish or dim when the front door is in the closed position and illuminate when the door is opened.   * *Alternative: Use for no dimming/extinguishing of first light modules when front door opens.*   No dimming/extinguishing feature of first light modules is required and shall not be provided. |

The light system may be designed to form part or the entire air distribution duct.

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| * *Baseline: Farebox light*   A light fixture shall be mounted in the ceiling above the farebox location. The fixture shall be capable of projecting a concentrated beam of light on the farebox. This light will automatically come on whenever the front doors are opened and the run switch is in the “night run” or “night park” position.  🗹 ***Alternative****: No farebox light* |

##### FARE COLLECTION

Space, as far forward as practicable, and structural provisions shall be made for installation of a **GFI CENTSaBILL w/TriM** fare collection device(s). Location of the fare collection device shall not restrict traffic in the vestibule, including wheelchairs if a front door loading device is used, and shall allow the operator to easily reach the farebox controls and to view the fare register. The farebox shall not restrict access to the operator area, shall not restrict operation of operator controls and shall not, either by itself or in combination with stanchions, transfer mounting, cutting, and punching equipment and route destination signs, restrict operator’s field of view per SAE Recommended Practice J1050 (See Section 5.4.7.2.) Location and mounting of the fare collection device shall allow use, without restriction, by passengers. Farebox location shall permit accessibility to the vault for easy manual removal or attachment of suction devices. Meters and counters on the farebox shall be readable on a daily basis. The floor under the fare box shall be reinforced, as necessary, to provide a sturdy mounting platform and to prevent shaking of the fare box. The fare collection device shall be protected by a 20-amp minimum, 12- or 24- volt, DC, protected circuit shall be available to power the farebox. This power service shall include power and grounded leads with both wires enclosed in a flexible conduit or through the floor base of the farebox, with a minimum 36” length cable relief tied off to the stanchion. Also included with the power wires, shall be cabling from the Radio system. The Radio system shall provide conditioned AVL output for GFI Farebox Positional Data communication and provisions for providing a communications path from the GPS/AVL system to the GFI Farebox shall be accomplished via a three (3) conductor cable, terminated on a six (6) circuit connector.

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| * *Alternative: Provision shall be made for a Smart Media (Smart Card) Processor.* |

The electric and electronic requirements of the fare box and Smart Media processor are described in Section 5.5.5.4.3.12.

A GFI CENTSaBILL w/TRiM farebox mock up shall be provided by CUSTOMER for first article bus and used for a fit check on each production bus. A typical GFI GenFare, CENTSaBILL electronic farebox is used and weighs approximately 113 lbs (full).

Transfer mounting, cutting, and punching equipment are not required.

##### ACCESS PANELS AND DOORS - 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. Access doors shall be hinged with gas props or over-center springs, where practical, to hold the doors out of the mechanic's way.Panel fasteners shall be standardized so that only one tool is required to service all special fasteners within the bus.

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| 🗹 ***Baseline****: Door actuator access doors that do not require tools or keys to open.*  Access doors for the door actuator compartments shall be secured with 1/4 turn 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.   * *Alternative: Requirement for locking access doors. Also see Section 5.4.3.8.1*   Access doors for the door actuator compartments shall be secured with locks, and shall prevent entry of mechanism lubricant into the bus interior. The locks shall be standardized so that only one tool, as required in Section 5.4.3.8.1, is required to open access doors on the bus. All fasteners that retain access panels shall be captive in the cover. |

Access openings in the floor shall be sealed to prevent entry of fumes and water into the bus interior. Flooring material shall be flush with the floor and shall be edge-bound with stainless steel, or other material that is acceptable to CUSTOMER, to prevent the edges from coming loose. Access openings shall be asymmetrical so that reinstalled flooring shall be properly aligned. Fasteners shall tighten flush with the floor.

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#### PASSENGER ACCOMMODATIONS

##### PASSENGER SEATING

###### Arrangements and Seat Style

The passenger seating arrangement in the bus shall be a cantilevered support and arrangement in the bus shall be such that seating capacity is maximized and in compliance to the following requirements. CUSTOMER recognizes that ramp location, foot room, hip-to-knee room, doorway type and width, seat construction, floor level type, seat spacing requirements, etc. ultimately affect seating capacity and layout.

. 35 and 40-foot buses require front and rear doors.

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| * *Baseline: Forward facing seat configuration*   Passenger seats shall be arranged in a transverse, forward facing configuration, except at the wheel housings where aisle-facing seats may be arranged as appropriate with due regard for passenger access and comfort. Other areas where aisle-facing seats may be provided are at wheelchair securement areas and platforms (such as for fuel tank storage space). Passenger seating capacity with this arrangement shall be submitted for approval in the Approved Equals process.  Passenger seating capacity with this arrangement shall be no less than **37** not including the operator, with the specified seating arrangement.  🗹 ***Alternative****: Any combination of forward-facing and perimeter seating arrangement.*  Passenger seats shall be arranged in a transverse, two-position forward facing configuration at the front section of the bus, and in longitudinal rows facing the centerline of the bus with one row of transverse, forward facing seats provided at the rear of the bus. The number of forward facing seats shall be maximized. Longitudinal seating shall meet the requirements in Section 5.4.5.1.3 except that armrest shall be provided between every other seating position at the same location as vertical passenger assists defined in Section 5.4.5.2.6. Each seat shall have a minimum width of 17 inches, not including the armrest. No closeouts or covers under seats.  The proposed seat layout consistent with these specifications shall depict the hip-to-knee and foot room dimensions, stanchion layout and wheelchair maneuverability layout and included with technical proposal submittals for CUSTOMER review and approval. The Offeror shall also indicate on this layout the Free Floor Space available to standees and include the calculation of the Free Floor Space area.   * NOTE: Specified seating arrangement(s) does not including the operator. * *Alternative: Perimeter seating arrangement.*   Passenger seats shall be arranged in longitudinal rows facing the centerline of the bus. One row of transverse, forward facing seats shall be provided at the rear of the bus. Longitudinal seating shall meet the requirements in Section 5.4.5.1.3 except that armrest shall be provided between every other seating position at the same location as vertical passenger assists defined in Section 5.4.5.2.6. Each seat shall have a minimum width of 17 inches, not including the armrest.  Seating capacity with this arrangement shall be no less than  *[CUSTOMER to fill-in]* seated passengers, not including the operator, with the specified seating arrangement. |

Note: This minimum capacity may be reduced when accommodations for more than two wheelchairs are required in Section 5.4.5.4

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| **□ *Baseline****: No bid evaluation factor for maximized seating capacity.*   * ***Alternative****: Use for inclusion of bid evaluation factor for maximized seating capacity.*   A bid evaluation factor for maximized seating capacity is included Exhibit A. |

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| * ***Baseline****: Rearward facing seats not allowed* * *Alternative: Allow minimum rearward facing seats*   A limited number of rearward facing seats will be allowed, with the expressed approval of CUSTOMER. *[Note that hip-to-knee and foot room requirements may also need to be addressed for this.]* |

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| * *Baseline: Non-padded inserts*   The passenger seats shall be equipped with non-padded inserts throughout the bus.   * ***Alternative****: Padded inserts*   The passenger seats shall be equipped with vandal-resistant padded inserts throughout the bus. Note that all applicable seat dimensions specified below shall be measured with pad fully depressed. **The passenger seats shall be Freedman CitiPro or American Seating Model Insight- (1)** with the following characteristics:   * Seat backs shall have a padded insert (onsert), one-half inch (1/2") thick. * Seat bottoms shall have a padded insert (onsert), one inch (1") thick. * Passenger handholds shall be integral with the seat frame. * Upholstery shall meet the requirements in Section 5.4.5.1.4. * Moisture barrier protection shall be provided between the fabric and the pad. * *Alternative: Fully cushioned seats*   The passenger seats shall be fully cushioned throughout the bus. Note that all applicable seat dimensions specified below shall be measured with cushion fully depressed.   * *Alternative: Combination padded and non-padded inserts*   The passenger seats in the front section shall be equipped with padded inserts and those in the rear (aft of the rear/exit door) shall be equipped with non-padded inserts. Note that all applicable seat dimensions specified below shall be measured with pad fully depressed. |

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| 🗹 *Baseline: No requirements for drain hole/provision in seat inserts.*   * + *Alternative: Requirement for drain hole/provision in seat inserts*   Provision, such as a small grommeted hole, to allow drainage shall be incorporated into seat insert. |

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| * *Baseline: Hip-to-knee room.*Hip-to-knee room measured from the front of one seat back horizontally across the highest part of the seat to the seat or panel immediately in front, shall be no less than 26 inches. At all seating positions in paired transverse seats immediately behind other seating positions hip-to-knee room shall be no less than 26.5 inches. * *Alternative: Increased hip-to-knee room.*   Hip-to-knee room measured from the front of one seat back horizontally across the highest part of the seat to the seat or panel immediately in front, may be a minimum of 27.5 inches in no more than six (6) seated positions. All other seated positions shall be no less than 29 inches. At all seating positions in paired transverse seats immediately behind other seating positions hip-to-knee room shall be no less than 28 inches. |

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| 🗹 *Alternative: Allow variations in limited areas*  In order to maximize seating capacity without unduly affecting passenger comfort, minor variations in the required hip-to-knee room will be allowed in limited areas. All such areas shall be identified to CUSTOMER prior to bid for approval. *Refer to allowed variations stated above*. |

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| 🗹 *Baseline: 14 inch foot room*  Foot room, measured at the floor forward from a point vertically below the front of the seat cushion, shall be no less than 14 inches. Seats immediately behind the wheel housings and modesty panels may have foot room reduced, provided the wheelhouse is shaped so that it may be used as a footrest or the design of modesty panel effectively allows for foot room.   * *Alternative: Reduced foot room*.   Foot room, measured at the floor forward from a point vertically below the front of the seat cushion, shall be no less than 10 inches. Seats immediately behind the wheel housings and modesty panels may have foot room reduced, provided the wheelhouse panel is shaped so that it may be used as a footrest or design of modesty panel effectively allows for foot room. |

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| * *Alternative: Hip-to-knee and foot room for rearward facing seats*   At seating positions with rearward facing seats, the distance as measured from the front edge of the rearward facing seat to the front edge of the immediately opposite forward facing seat shall be no less than 24 inches. |

Thickness of the transverse seat backs shall be minimized at the bottom to increase passenger knee room and passenger capacity. The area between the longitudinal seat backs and the attachment to the bus sidewalls shall be designed to prevent debris accumulation.

The aisle between the seats shall be no less than 20 inches wide at seated passenger hip height. Seat backs shall be shaped to increase this dimension to no less than 24 inches at standing passenger hip height.

Raised platforms for passenger seats shall not be allowed without CUSTOMER’s approval. If vehicle is of a sloped floor design, then raised platforms for passenger seats may be provided in the rear sloped section.

All bidder(s) shall submit in accordance to requirements within Exhibit "B" a copy of the proposed seat layout consistent with these specifications showing hip-to-knee and foot room dimensions, stanchion layout and wheelchair maneuverability layout prior to bid for CUSTOMER review and approval. The bidders shall also indicate on this layout the Free Floor Space available to standees as defined in Section 5.1.2 and include the calculation of the Free Floor Space area.

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###### Dimensions

Seat dimensions for the various seating arrangements shall have the dimensions as follows (refer to the figure above):

1. The width, W, of the seat shall be 35 inches.
2. The length, L, shall be 17 ±1 inches.
3. The seat back height, B, shall be a minimum of 15 inches.
4. The seat height, H, shall be 17 ± 1 inches. For the rear lounge (or settee) and longitudinal seats, and seats located above raised areas for storage of under floor components, a cushion height of up to 22 inches will be allowed. This shall also be allowed for limited transverse seats, but only with expressed approval of CUSTOMER.
5. The foot room, F, shall be specified in 5.4.5.1.1.
6. The seat cushion slope, S, shall be between 5° to 11°.
7. The seat back slope, C, shall be between 8° to 17°.
8. The hip to knee room, K, shall be no less than 29 inches or as further specified in 5.4.5.1.1.
9. The pitch, P, is shown as reference only.

###### Structure and Design

The passenger seat frame and its supporting structure shall be constructed and mounted so that space under the seat is maximized to increase wheelchair maneuvering room and is completely free of obstructions to facilitate cleaning.

The transverse seat structure shall be fully cantilevered from the sidewall 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. Folding seats used in wheelchair securement areas, as well as, transverse seats mounted in locations at which cantilevered installation is precluded by design and/or structure, need not be cantilevered.

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| * ***Alternative****: Allow use of Pedestal-mounted seats.*   In order to reduce cost and/or maximize seating capacity, CUSTOMER will allow pedestal mounted transverse seats. For these type seats, the structure shall be attached to the sidewall and supported by a pedestal attached to the floor. The lowest part of the seat assembly that is within 12 inches of the aisle, excluding the pedestal, shall be at least 10 inches above the floor. |

The underside of the seat and the sidewall shall be configured to prevent debris accumulation and the transition from the seat underside to the bus sidewall to the floor cove radius shall be smooth. All transverse objects, including seat backs, modesty panels, and longitudinal seats, in front of forward facing seats shall not impart a compressive load in excess of 1,000 pounds onto the femur of passengers ranging in size from a 5th-percentile female to a 95th-percentile male during a 10g deceleration of the bus. This deceleration shall peak at .05 ± .015 seconds from initiation. Permanent deformation of the seat resulting from two 95th-percentile males striking the seat back during this 10g deceleration shall not exceed 2 inches, measured at the aisle side of the seat frame at height H. Seat back should not deflect more than 14 inches, measured at the top of the seat back, in a controlled manner to minimize passenger injury. Structural failure of any part of the seat or sidewall shall not introduce a laceration hazard.

The seat assembly shall withstand static vertical forces of 500 pounds applied to the top of the seat cushion in each seating position with less than 1/4-inch permanent deformation in the seat or its mountings. The seat assembly shall withstand static horizontal forces of 500 pounds evenly distributed along the top of the seat back with less than 1/4-inch permanent deformation in the seat or its mountings. The seat backs at the aisle position and at the window position shall withstand repeated impacts of two 40-pound sandbags without visible deterioration. One sandbag shall strike the front 40,000 times and the other sandbag shall strike the rear 40,000 times. Each sandbag shall be suspended on a 36-inch pendulum and shall strike the seat back 10,000 times each from distances of 6, 8, 10, and 12 inches. Seats at both seating positions shall withstand 4,000 vertical drops of a 40-pound sandbag without visible deterioration. The sandbag shall be dropped 1,000 times each from heights of 6, 8, 10, and 12 inches. Seat cushions shall withstand 100,000 randomly positioned 3-1/2-inch drops of a squirming, 150-pound, smooth-surfaced, buttocks-shape striker with only minimal wear on the seat covering and no failures to seat structure or cushion suspension components.

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 usable by a 5th-percentile female, as well as by larger passengers, to assist with seat access/egress for either transverse seating position. The upper rear portion of the seat back and the seat back handhold immediately forward of transverse seats shall be padded and/or constructed of energy absorbing materials. During a 10g deceleration of the bus, the HIC number (as defined by SAE Standard J211a) shall not exceed 400 for passengers ranging in size from a 5th percentile female through a 95th percentile male. 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 5.4.5.2. Armrests shall not be included in the design of transverse seats.

Longitudinal seats shall be the same general design as transverse seats but without seat back handholds. Longitudinal seats may be mounted on the wheelhouses. 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 operator'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 1-1/2 to 3-1/2 inches of the end of the seat cushion. Armrests shall be located from 7 to 9 inches above the seat cushion surface. The area between the armrest and the seat cushion shall be closed by a barrier or panel. The top and sides of the armrests shall have a minimum width of 1 inch and shallbe free from sharp protrusions that form a safety hazard.

Seat back handhold and armrests shall withstand static horizontal and vertical forces of 250 pounds applied anywhere along their length with less than 1/4-inch permanent deformation. Seat back handhold and armrests shall withstand 25,000 impacts in each direction of a horizontal force of 125 pounds with less than 1/4-inch permanent deformation and without visible deterioration.

At CUSTOMER’s request, a test report shall be provided by the Contractor, fully documenting compliance with all the requirements defined above upon request. The test report shall contain a record of all testing activities, test diagrams, testing equipment, as well as test data related to loads, deflections and permanent deformation of the seat assembly. The report shall include a statement of compliance with the requirements of this section of Part 5: Technical Specifications.

###### Construction and Materials

Seat shall be constructed with materials that comply with the physical test. Selected materials shall minimize damage from vandalism and shall reduce cleaning time. The seats shall be attached to the frame with tamperproof fasteners. Coloring shall be consistent throughout the seat material, with no visually exposed portion painted. All visually exposed metal of the standard seat structure including mounting brackets and other components shall be aluminum or stainless steel. The seat, pads and cushions shall be contoured for individuality, lateral support, and maximum comfort and shall fit the framework to reduce exposed edges.

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| * *Baseline: Non-padded seat configuration*   The seat back thickness shall not exceed 1/2 inch in the knee room area.  🗹 ***Alternative****: Padded insert configuration. Also see Section 5.4.5.1.1.*  Seating and interior trim shall have features to improve passenger comfort. The seat assembly shall be supported by a suspension system. The seat cushion and back shall be padded with a cellular foam product that complies with the physical test requirements cited in this document and is no less than one (1)-inch thick in areas contacted and loaded by passengers in the normal seated position and shall be covered with vinyl and/or fabric material.  Fabric upholstery materials meeting CUSTOMER's design requirements shall be **Holdsworth #A657DD or BusTex Corp., Description:**  Seat fabric shall be treated with an anti-bacterial, anti-fungal, anti-viral coating **(Holdsworth Fiber Pro-Tector**), and integral to the fiber. Treatments applied after the seats have been fabricated are not permitted.  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 removable by the maintenance staff but not by the passengers. To the extent practicable, seat cushions and pads shall be interchangeable throughout the bus. Materials shall have high resistance to tearing, flexing, and wetting.   * *Alternative: Cushioned seat configuration. Also see Section 5.4.5.1.1.*   Seating and interior trim shall have features to maximize passenger comfort. The seat cushion shall be supported by springs. The seat cushion and back shall be padded with, a cellular foam product that complies with the physical test requirements cited in this document and is no less than 2 inches thick in areas contacted and loaded by passengers in the normal seated position and shall be upholstered with vinyl and/or fabric materials.  Armrests shall be padded with material that is the same as, or similar to, the seat back padding and handhold. 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 removable by maintenance personnel but not by passengers. To the extent practicable, seat cushions and pads shall be interchangeable throughout the bus. Materials shall have high resistance to tearing, flexing, and wetting. |

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. Seat covering materials shall be selected on the basis of durability, ease of maintenance, and pleasing texture and appearance. The seat back and seat back handhold immediately forward of transverse seats shall be constructed of energy absorbing materials to provide passenger protection and, in a severe crash, allow the passenger to deform the seating materials in the impact areas in accordance with the Knee Impact and Head Impact Criteria requirements of Section 5.4.5.1.3. Complete seat assemblies shall be interchangeable to the extent practicable. Additional construction details, color of the seat material and optional safety padding are defined in attachments to Part 5: Technical Specifications.

##### PASSENGER ASSISTS

###### General

Passenger assists in the form of full grip, vertical stanchions or handholds shall be provided for the safety of standees and for ingress/egress. Passenger assists shall be convenient in location, shape, and size for both the 95th-percentile male and the 5th-percentile female standee. Starting from the entrance door 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 (see Section 5.4.5.1.3) 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. All handholds and stanchions at front doorway, around farebox, and at interior steps for bi-level designs shall be plain stainless steel to match the rest of the vehicle. The forward-most vertical stanchions on either side of the aisle immediately behind the operator's area, shall be:

🞏 Powder-coated black

🞏 Powder-coated yellow

* Plain stainless steel finish to match the rest of vehicle

Excluding those mounted on the seats and doors, the assists shall have a cross-sectional diameter between 1-1/4 and 1-1/2 inches or shall provide an equivalent gripping surface with no corner radii less than 1/4 inch. All passenger assists shall permit a full hand grip with no less than 1-1/2 inches of knuckle clearance around the assist. Passenger assists shall be designed to minimize catching or snagging of clothes or personal items and shall be capable of passing the NHTSA Drawstring Test.

Any joints in the assist structure shall be underneath supporting brackets and securely clamped to prevent passengers from moving or twisting the assists. Passenger assists shall be designed to minimize glare in the Operator’s area to the extent possible (see Section 5.4.6.1.1). With the exception of seat and door handholds, all areas of the passenger assists that are handled by passengers including functional components used as passenger assists shall be of anodized aluminum or stainless steel. Seat handholds may be of the same construction and finish as the seat frame. Door mounted passenger assists shall be of anodized aluminum, stainless steel, or powder coated metal. Connecting tees and angles may be powder coated metal castings. Assists shall withstand a force of 300 pounds applied over a 12-inch lineal dimension in any direction normal to the assist without permanent visible deformation. All passenger assist components, including brackets, clamps, screw heads, and other fasteners used on the passenger assists shall be designed to eliminate pinching, snagging and cutting hazards and shall be free from burrs or rough edges.

###### Front Doorway

Front doors, or the entry area, shall be fitted with ADA compliant assists. Assists shall be as far outward as practicable, but shall be located no farther inboard than 6 inches from the outside edge of the entrance step and shall be easily grasped by a 5th-percentile female boarding from street level. Door assists shall be functionally continuous with the horizontal front passenger assist and the vertical assist and the assists on the wheel housing or on the front modesty panel.

###### Vestibule

The aisle side of the operator's barrier, the wheel housings, and when applicable the modesty panels shall be fitted with vertical passenger assists that are functionally continuous with the overhead assist and that extend to within 36 inches of the floor. 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 on the fare collection device or windshield in the event of a sudden deceleration. Without restricting the vestibule space, the assist shall provide support for 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. The assists at the front of the bus 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 operator's barrier, wheel housings, or front modesty panel.

###### 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(s). Passenger assists shall be provided on modesty panels that are functionally continuous with the rear door assists. Rear doors, or the exit area, shall be fitted with assists no less than 3/4 inch in width and shall provide at least 1-1/2 inches of knuckle clearance between the assists and their mounting. The assists shall be designed to permit a 5th-percentile female to easily move from one assist to another during the entire exiting process. The assists shall be located no farther inboard than 6 inches from the outside edge of the rear doorway.

###### 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.

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| 🗹 *Baseline: No requirements for overhead grab straps/extensions.*   * *Alternative: Requirement for overhead grab straps/extensions.* Straps or other extensions as necessary shall be provided for sections where vertical assists are not available and for the use by passengers that cannot reach to 70 inches. CUSTOMER shall provide details of type and locations at which such extensions are to be located. |

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.

###### Longitudinal Seats

Longitudinal seats shall have vertical assists located between every other designated seating position, except for seats that fold/flip up to accommodate wheelchair securement. 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 practicable and shall be no more than 52 inches apart or functionally continuous for a 5th percentile female passenger.

###### Wheel Housing Barriers/Assists

Unless passenger seating is provided on top of wheel housing, passenger assists shall be mounted around the exposed sides of the wheel housings (and propulsion compartments if applicable) which shall also be designed to prevent passengers from sitting on wheel housings. Such passenger assists shall also effectively retain items, such as bags and luggage, placed on top of wheel housing.

##### PASSENGER DOORS

###### General

Passenger doors and doorways shall comply with ADA requirements.

The door style for the front door shall be a bi-parting Slide-Glide type driven by a single electric motor. This door motor shall be controlled by two push buttons (open & close). Main door bearings shall be of the “maintenance free, shielded ball bearing type” and shall support the weight of the door system.

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| 🗹 ***Baseline****: One front and one rear door doorway.*  One front doorway shall be provided in the curbside of the bus forward of front axle for passenger ingress and egress. The front doorway shall be located so that the operator will be able to collect or monitor the collection of fares. The rear doorway centerline shall be rearward of the point midway between the front door centerline and the rear most seat back forward of front axle shall be presented to reflect any optimization available for seats and hip-to- knee room. The vehicle shall be equipped with a slide-glide front door.  The rear door shall be configured with a two panel electrically driven plug door assembly. |

###### Materials and Construction

Structure of the doors, their attachments, inside and outside trim panels, and any mechanism exposed to the elements shall be corrosion-resistant. Door panel construction shall be of corrosion-resistant metal or reinforced non-metallic composite materials. The doors, when fully opened, shall provide a firm support and shall not be damaged if used as an assist by passengers during ingress or egress. Doors, when closed, shall be non-rattling and effectively sealed to preclude entry of water, dirt and debris under normal operating conditions. Center door seals shall be of resilient rubber. The front leaves of the passenger doors shall overlap the rear leaves.

###### Dimensions



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| 🗹 ***Baseline****: Use with 31-inch doorway clear width.*  Front door clear width shall be no less than 31 inches with the doors fully opened.  Rear door opening clear width shall be no less than 23.75 inches with the doors fully opened. If a rear door ramp is provided, then the clear door opening width shall be no less than 31 inches with door fully opened.  The front door clear width shall be as wide as possible, must accommodate ADA minimum wheelchair ramp free space, but no less than 31 inches with the doors fully opened.   * *Alternative: Use for doorway clear width greater than 31.75 inches. Also see Sections 5.1.6.3 and 5.4.5.1.1*   The front door clear width shall be no less than inches with the doors fully opened. *(CUSTOMER insert dimension)*  The rear door clear width shall be no less than inches with the doors fully opened. *(CUSTOMER insert dimension)*  *Note: Either or both doorways may be specified to have a clear width greater than 31.75 inches. CUSTOMER should note that increased doorway width might result in a reduction of seating capacity.* |

When open, the doors shall leave an opening no less than 75 inches in height.

###### Door Glazing

The upper section of both front and rear doors shall be glazed for no less than 45 percent of the respective door opening area of each section. The lower section of the front door shall be glazed for no less than 25 percent of the door opening area of the section.

The front door panel glazing material shall have a nominal ¼ inch or 6 mm thick laminated safety glass conforming to the requirements of ANSI Z26.1 Test Grouping 2 and the Recommended Practices defined in SAE J673.

Glazing material in the rear doorway door panels shall be the same material, thickness and color as the side windows defined in Section 5.4.7.4.2.

###### Door Projection

The exterior projection of the frontdoors beyond the side of the busshall be minimized and shall not blockthe line of sight of the rear exit door via the curbside mirror when the doors are fully open. The exterior projection of both doors shall be minimized andshall not exceed 16.5 inches during the opening or closing cycles or when doors are fully opened. Projection inside the bus shall not exceed 21 inches. The closing edge of each door panel shall have no less than 2 inches of soft weather stripping. The doors, when closed, shall be effectively sealed and the hard surfaces of the doors shall be at least 4 inches apart. The combined weather seal andwindow glazing elements of the front door shall not exceed 10 degrees of binocular obstruction of the operator's view through the closed door***.*** Requirements for sensitive door edges are defined in Section 5.4.5.3.7.

###### Door Height above Pavement

It shall be possible to open and close either passenger door when the bus loaded to GVWR is not knelt and parked with the tires touching an 8-inch-high curb on a street sloping toward the curb so that the street side wheels are 5 inches higher than the right side wheels.

###### Closing Force

Closing door edge speed shall not exceed 19 inches per second. Power close rear doors shall be equipped with a sensitive edge or other obstruction sensing system such that if an obstruction is struck by a closing door edge, the doors will stop and/or reverse direction prior to imparting a 10-pound force on 1 square inch of that obstruction. Doors closed by return spring or counterweight-type device need not be equipped with an obstruction sensing device but shall be capable of being pushed to the point where the door starts to open with a force not to exceed 20 pounds applied to the center edge of the forward door panel. Whether or not the obstruction sensing system is present or functional it shall be possible to withdraw a 1-1/2 inch diameter cylinder from between the center edges of a closed and locked door with an outward force not greater than 35 pounds.

Front door only, shall have accelerator interlock; Rear door (if equipped) shall have accelerator and brake interlock, with manual over-ride.

**b. Exit Door Operation**

Rear doors shall be operator-controlled. The rear door control shall be limited to unlocking and enabling the opening mechanism, which shall be signaled by illumination of a green light near the door, operator-controlled. The door shall be opened when the operator enables the door controller. This action by the operator when the door is enabled will signal the door actuator to open. The doors shall begin to close after the operator initiates the door close button. The door closing speed shall be adjustable and not exceed 12 inches per second for closing. A separate switch, convenient to the driver, shall convert the rear door to a power door with both opening and closing controlled by the operator.

A door master switch, which is not within the reach of a seated driver, shall be provided to release the interlocks and disconnect electrical power from the rear door, allowing only manual operation of the door.

###### Actuators

Door actuators shall be adjustable so that the door opening and closing speeds can be independently adjustable to satisfy the requirements of Section 5.4.5.3.7. Actuators and the complex door mechanism shall be concealed from passengers but shall be easily accessible for servicing. The door actuators shall be rebuildable. If powered by compressed air, exhaust from the door system shall be routed below the floor of the bus to prevent accumulation of any oil that may be present in air system and to muffle sound.

Single motor is required (on Front and Rear doors, as applicable).

###### 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 respective door emergency unlocking device shall be accessible from the entrance and exit areas. When the rear door emergency device is actuated, the door interlock throttle system shall return the engine to idle and the door interlock brake system shall apply to stop the bus. When the front door emergency device is actuated, only the door interlock throttle system shall be actuated. 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.

##### ACCESSIBILITY PROVISIONS

###### General

The design and construction of the bus shall be in accordance with all requirements defined in 49 CFR, Part 38, Subpart B: ADA Accessibility Specifications for Transportation Vehicles - Buses, Vans and Systems. Space and body structural provisions shall be provided at the front or rear door of the bus to accommodate the wheelchair loading system. Specific requirements, including the number of wheelchairs to be accommodated, the tiedown and securement devices, and fold-down seats, are provided in attachments to Part 5: Technical Specifications. Prior to submission of bid, the Contractor shall provide a plan, including layout drawings for entry, maneuvering, parking, and exiting of wheelchair passengers, to show compliance with ADA regulations.

###### Loading System

An automatically-controlled, power-operated ramp system compliant to requirements defined in 49 CFR Part 38, Subpart B, §38.23c shall provide ingress and egress quickly, safely, and comfortably, both in forward and rearward directions, for a passenger in a wheelchair from a level street or curb.

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| **🗹 Alternative Operation**:***The rear run sign shall display a wheelchair ramp “ in use” signal when the wheelchair ramp has been activated.*** *Please see Section 5.5.5.4.3.5 for additional details.* |

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| 🗹 *Baseline: Front door location of loading system.*  The wheelchair loading system shall be located at the front door. |
| 🗹 *Baseline: Flip-out design ramp*  The ramp shall be of a simple hinged, flip-out type power-operated (Electric only) ramp design, **Lift-U LU-11 or Ricon Foldover ER6 1:6**. Ramp shall be minimum 30" wide and 2" high guide rails above platform. No deformation of the ramp shall be allowed. Maximum ramp slope shall be 1:6 (9.46 degrees). |

When the system is not in use, the passageway shall appear normal. In the stored position of the ramp, no tripping hazards shall be presented and any resulting gaps shall be minimized. The controls shall be simple to operate with no complex phasing operations required, and the loading system operation shall be under the surveillance and complete control of the operator. If the loading system and controls are at the rear doors, a switch shall be provided in the operator's area to disable the loading system. The bus shall be prevented from moving during the loading or unloading cycleby a throttle and brake interlock system. The wheelchair loading system shall not present a hazard, nor inconvenience any passenger. The loading system shall be inhibited from retracting or folding when a passenger is on the ramp/platform. A passenger departing or boarding via the ramp shall be able to easily obtain support by grasping the passenger assist located on the doors or other assists provided for this purpose. The platform shall be designed to protect the ramp from damage and persons on the sidewalk from injury during the extension/retraction or lowering/raising phases of operation. The loading platform shall be covered with a replaceable or renewable, nonskid material and shall be fitted with devices to prevent the wheelchair from rolling off the sides during loading or unloading. Deployment or storage of the ramp shall require no more than 15 seconds. The device shall function without failure or adjustment for 500 cycles or 6000 miles in all weather conditions on the design operating profile when activated once during the idle phase. A manual override system shall permit unloading a wheelchair and storing the device in the event of a primary power failure. The manual operation of the ramp shall not require more than 35 lbs. of force. Hydraulic systems incorporated in the loading system mechanism shall comply with the requirements defined in Section 5.2.2.2.3 of Part 5: Technical Specifications. The ramp assembly components shall be replaceable within 30 minutes by 3M mechanic.

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###### Wheelchair Accommodations

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| 🗹 ***Baseline****: Two forward facing wheelchair securement locations*  Two forward-facing locations, of the following dimensions: 30" x 48" and 30" x 60" as close to the wheelchair loading system as practical, shall provide parking space and securement system compliant with ADA requirements for a passenger in a wheelchair. The securement locations shall be located opposing each other across the aisle.  Wheelchair restraint system shall be **Q'Straint - Q'Pod modular system** with belts integrated into the attachment fixtures. Telescoping or folding attachment fixtures are required to maximize free floor space and reduce trip hazards when not being used. Signage at each location under seat shall be visible to user and explain operation in English and Spanish. Securement ends shall be hook design.  The Q-Pod System has the following characteristics:   1. Front Tie Down System    1. Automatic retractor tightening device mechanism to secure chair to bumper to eliminate chair tipping    2. Ratchet handle for both tightening and releasing front retractor belt 2. Integrated Rear Barrier    1. Locates the rear-integrated shoulder belt.    2. Express paddle handle for quick release of rear retractor belt with solenoid that returns the retractors to automatic retracting mode after 15 seconds.    3. Includes rear tie down restraint retractors with automatic self-tensioning and locking mechanism for slack adjustment. Eliminates tripping hazard associated with belt slack.    4. Retractors are enclosed and protected to eliminate tripping hazards and belt soiling. 3. Passenger Stop Request touch tape shall be integrated into the module. 4. Q-Pod System envelope is approximately: 63 ¾ L X 34 ¼ W X 48 ½ H.   The Q'Pod Wheelchair Restraint System may not interfere with the minimum 60-inch wheelchair turning diameter, when one passenger is already occupying one wheelchair station.   * *Alternative: Greater number of wheelchair securement locations*   \_\_\_\_\_ *[Procurement Agency shall fill in quantity]* forward-facing location(s), as close to the wheelchair loading system as practical, shall provide parking space and securement system compliant with ADA requirements for a passenger in a wheelchair. |

Additional equipment, including passenger restraint seat belts, shoulder harnesses and wheelchair securement devices shall be provided for each wheelchair passenger. All belt assemblies must stow up and out of the way when not in use.

###### Interior Circulation

Maneuvering room inside the bus shall accommodate easy travel for a passenger in a wheelchair from the loading device through the bus to the designated parking area, and back out. No portion of the wheelchair or its occupant shall protrude into the normal aisle of the bus when parked in the designated parking space(s). As a guide, no width dimension should be less than 34inches. Areas requiring 90-degree turns of wheelchairs should have a clearance arc dimension no less than 45 inches and in the parking area where 180-degree turns are expected, space should be clear in a full 60-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.

The Contractor shall demonstrate that the configuration meets the box test. The defined box test utilizes a box with the dimensions of 48”'L x 30"W x 30"H (+ or - 0.25”) to maneuver this box inside the bus to demonstrate travel for a passenger in a wheelchair from the loading device to the designated parking area, and back out. This box maneuverability shall be accomplished without any structural interference throughout the path to the parking (securement position).

###### Passenger Information

ADA priority seating signs as required and defined by 49 CFR, Part 38.27 shall be provided to identify the seats designated for passengers with disabilities.

Requirements for a public information system in accordance with 49 CFR, Part 38.35 shall be provided as required in Section 5.4.9.2 of Part 5: Technical Specifications.

Requirements for a stop-request passenger signal in accordance with 49 CFR, Part 38.37 shall be provided as required in Section 5.4.9.3 of Part 5: Technical Specifications.

Requirements for exterior destination signs in accordance with 49 CFR, Part 38.39 shall be provided as required in Section 5.4.9.1 of Part 5: Technical Specifications.

#### OPERATOR PROVISIONS

##### OPERATOR’S AREA

###### General

The operator’s work area shall be designed to minimize glare to the extent possible. Objects within and adjacent to this area shall be matte black or dark gray in color wherever possible to reduce the reflection of light onto the windshield. The use of polished metal and light-colored surfaces within and adjacent to the operator’s area shall be avoided. Such objects include dash panels, switches and controls, cowlings, windshield wipers and arms, barriers and modesty panels, fare stanchions, access panels and doors, fasteners, flooring, ventilation and heating ducting, window and door frames, and visors. The operator shall control interior lighting located ahead of the standee line. Additional provisions for operator’s area are included in attachments to Part 5: Technical Specifications.

CUSTOMER shall arrange for an operator review of the operator area to be performed prior to completing construction on the 1st article vehicle. Layout of operator’s controls shall provide an operator area that closely mirrors existing CUSTOMER fleet functional logic and controls for a 5th percentile female to 95th percentile male. Contractor shall submit dash panel controls layout, after contract award, and prior to 1st article for CUSTOMER’s review and approval.

###### Visors

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| * *Baseline: Requirements for sun visors.*   Adjustable sun visor(s) shall be provided for the 🞎 windshield and the 🞎 operator's side window. *[to choose one or both]* Visors shall be shaped to minimize light leakage between the visor and windshield pillars. Visors shall store out of the way and shall not obstruct airflow from the climate control system or interfere with other equipment such as the radio handset or the destination control. Deployment of the visors shall not restrict vision of the rearview mirrors. Visor adjustments shall be made easily by hand with positive locking and releasing devices and shall not be subject to damage by over-tightening. Sun visor construction and materials shall be strong enough to resist breakage during adjustments. Visors may be transparent, but shall not allow a visible light transmittance in excess of 10 percent. Visors, when deployed, shall be effective in the operator's field of view at angles more than 5 degrees above the horizontal.  🗹 ***Alternative****: Use for operator’s window sunscreens.*  An adjustable roller type sunscreen shall be provided over the operator’s windshield and the operator’s side window. The sunscreen shall be capable of being lowered to the midpoint of the operator’s window. When deployed, the screen shall be secure, stable and shall not rattle, sway or intrude into the operator's field of view due to the motion of the bus or as a result of air movement.Once lowered, the screen shall remain in the lowered position until returned to the stowed position by the operator. Up to 10 inches shall be solid. |

###### Operator's Controls

All switches and controls necessary for the safeoperation of the bus shall be conveniently located in the operator's area and shall provide for ease of operation. Switches and controls shall be divided into basic groups and assigned to specific areas, in conformance with SAE Recommended Practice J680, Revised 1988, Location and Operation of Instruments and Controls in Motor Truck Cabs, and be essentially within the hand reach envelope described in SAE Recommended Practice, J287, Driver Hand Control Reach. Operational controls, instrumentation, switches, and other system controls shall not be mixed with ventilation diffusers and non-operational controls or readouts.Controls shall be located so that boarding passengers may not easily tamper with control settings.

The door control, kneel control, windshield wiper/washer controls, and run switch shall be in the most convenient operator locations. They shall be identifiable by shape, touch, and permanent markings. Doors shall be operated by two push buttons conveniently located and operable in a horizontal plane by the operator's left hand.

All panel-mounted switches and controls shall be marked with easily read identifiers. Text designating position (on/off) shall be a minimum of 9 points, identifying legends shall be a minimum of 11 points. Extremely condensed or italic type fonts shall not be used. Graphical symbols shall conform to SAE Recommended Practice J2402, Road Vehicles - symbols ForControls, Indicators, and Tell Tales, where available and applicable. Color of switches and controls shall be dark with contrasting typography or symbols. Red type on a black or gray field shall *not* be used. Mechanical switches and controlsshall be replaceable, and the wiring at these controls shall be serviceable from the vestibule or the operator's seat. Switches, controls, and instruments shall be dust and water-resistant consistent with the bus washing practice described in Section 5.4.4.1.

Contractor shall submit Operator’s Hand controls layout, after contract award, and prior to 1st article design and build for CUSTOMER’s review and approval.

Normal Bus Operation

Operator Controls - The following list for Normal Bus Operation identifies bus controls used to operate the bus safely and efficiently. These controls are frequently used or they are critical to the operation of the bus. They should be located within easy reach of the operator. The operator should not be required to stand or turn his/her body to view or to actuate these controls that include:

Start Switch or Button Four Position Master Run Switch

Transmission Shift Select Parking Brake

Door High Beam

Turn Signals Hazard Lights

Defroster Ramp Control

KneelControl Instrument Panel Lighting Intensity

Windshield Wiper

Accelerator and brake pedals shall be designed for ankle motion. Foot surfaces of the pedals shall be faced with wear-resistant, nonskid, replaceable material.

Master Run Switch

The run switch shall be a four-position rotary switch with the following functions**:**

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| **ENGINE STOP or**  **OFF**  **or**  **STOP ENGINE** | All electrical systems off, except power available for the hazard lights, radio, silent alarm, , fare box, fire detection equipment, drive compartment lights, if provided and electronic equipment that require continuous energizing. If the bus is not operated for a period of 12 hours the total electric load due to devices that require continuous energizing shall not cause the battery to be discharged below the level necessary to start the vehicle. Electrical loads resulting from the Procurement Agency’s devices, such as, fare box, GPS, radio, etc., shall not exceed 1.5 amps with the master run switch in the OFF position. |
| **CL LPS or CL/ID or NIGHT PARK** | All electrical systems ON, interior lights and marker lights ON. Vehicle will automatically select transmission Neutral and not be allowed to select Drive or Reverse. Headlights will be OFF. |
| **RUN or DAY RUN** | All electrical systems on, HV ON. except the headlights, parking lights and marker lights. Daytime running lights (DRL), if provided, shall be on. |
| **LIGHTS or NIGHT RUN** | All electrical systems on with HV ON. |

Door Control

Doors shall open or close completely in not more than 3.5 seconds from the time of control actuation and shall be subject to the closing force requirements of Section 5.4.5.3.7 and the adjustment requirements of Section  5.4.5.3.8. The door control shall be located on the street side of the operator’s area within the hand reach envelope described in SAE Recommended Practice, J287, Driver’s Hand Control Reach.The front door shall remain in commanded state position even if power is removed or lost.

Operation of, and power to, the passenger doors shall be completely controlled by the operator.

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| 🗹 ***Baseline****: No requirements for accelerator interlock whenever front doors are open****, if bus is equipped with a front and rear door design****.*  🗹 ***Alternative****: Use for requiring accelerator interlock whenever front door (if designed with Single Front Door ONLY) are open.*  An accelerator interlock shall lock the accelerator in the closed position whenever front doors are open. |

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| * ***Baseline****: Use for operator- controlled front and rear doors.*   Operation of, and power to, the passenger doors shall be completely controlled by the operator.   * *Alternative: Use for operator-controlled front and passenger-controlled rear doors.*   Operation of, and power to, the front passenger doors shall be completely controlled by the operator. Power to rear doors shall be controlled by the operator. The opening of rear doors shall be controlled by passenger via touch-bars. An alarm shall sound whenever the rear door is opened or attempted to be opened when rear doors are not powered. Doors shall automatically close when touch-bars are released. |

A control or valve in the operator'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 operator when set in the "Off" position shall close the doors, deactivate the door control system, release the interlocks, and permit only manual operation of the doors.

Operator Interior Lights

The operator's area shall have a light to provide general illumination and it shall illuminate the half of the steering wheel nearest the operator to a level of 10 to 15 foot-candles. This light shall be operator controlled by a toggleswitch or a high quality rocker switch located on the operator's control panel or other approved location.

(1) A three-position toggle switch or high-quality rocker switch, labeled "Interior Lights" shall control the lights.

* + - "Bright"" turns interior lights to bright depending on the Master Switch position and passenger door position.
    - "Off" turns off lights except as noted in (2) and (3)
    - "Dim" turns interior lights to dim depending on the Master Switch position and passenger door position except as noted in (2).

(2) The first light modules on each side (behind the Operator and the front door) is normally turned on only when the front or rear door is opened, in "Night Run" As soon as the door closes, these lights shall go extinguish. (If non-extinguishing light modules are in effect as per Section 5.4.4.6, this requirement shall not apply.)

(4) All interior lighting shall be turned off whenever the transmission selector is in the reverse and engine run switch is in the "On" position. The interior lighting design shall require the approval of CUSTOMER***.***

Special Controls

Operator Controls - The following list of Special bus controls identifiesthe controls to initiate system diagnostics, aid the physically handicapped passenger, and control mirrors and speakers, etc. They are less often used than those in Normal Bus Operation. These controls should be within easy reach for viewing and actuation by the operator:

ABS Diagnostics Test Drive System Diagnostic Test

Override Chime

Driver's Fan Public Address System

Mirror Heater Diagnostic Light Panel Test (automatically occurs at

Driver's HVAC startup)

Emergency Radio Alarm (side console)

Remote Mirror Control

Adjustable Brake/Accelerator Pedal System Switch

Foot-Controlled Emergency Switch

Passenger Comfort Controls

Operator Controls - The following list of Passenger Comfort Controls identifies the bus controls for the interior bus temperature, lighting, air circulation, etc. The settings of thesecontrols are changed infrequently. The operator should be able to see and actuate these controls with minimal effort.

Climate Control

Interior HVAC-On/Off/Vent Blower

Interior Lights Operator's Lights

Controls Location

Figure 1 below is provided as an illustrative guide to instrument and control grouping:

**Area 1**: Operational gauges - speedometer, air pressure voltmeter(s), and diagnostics shall be located immediately in front of the operator's field of view.

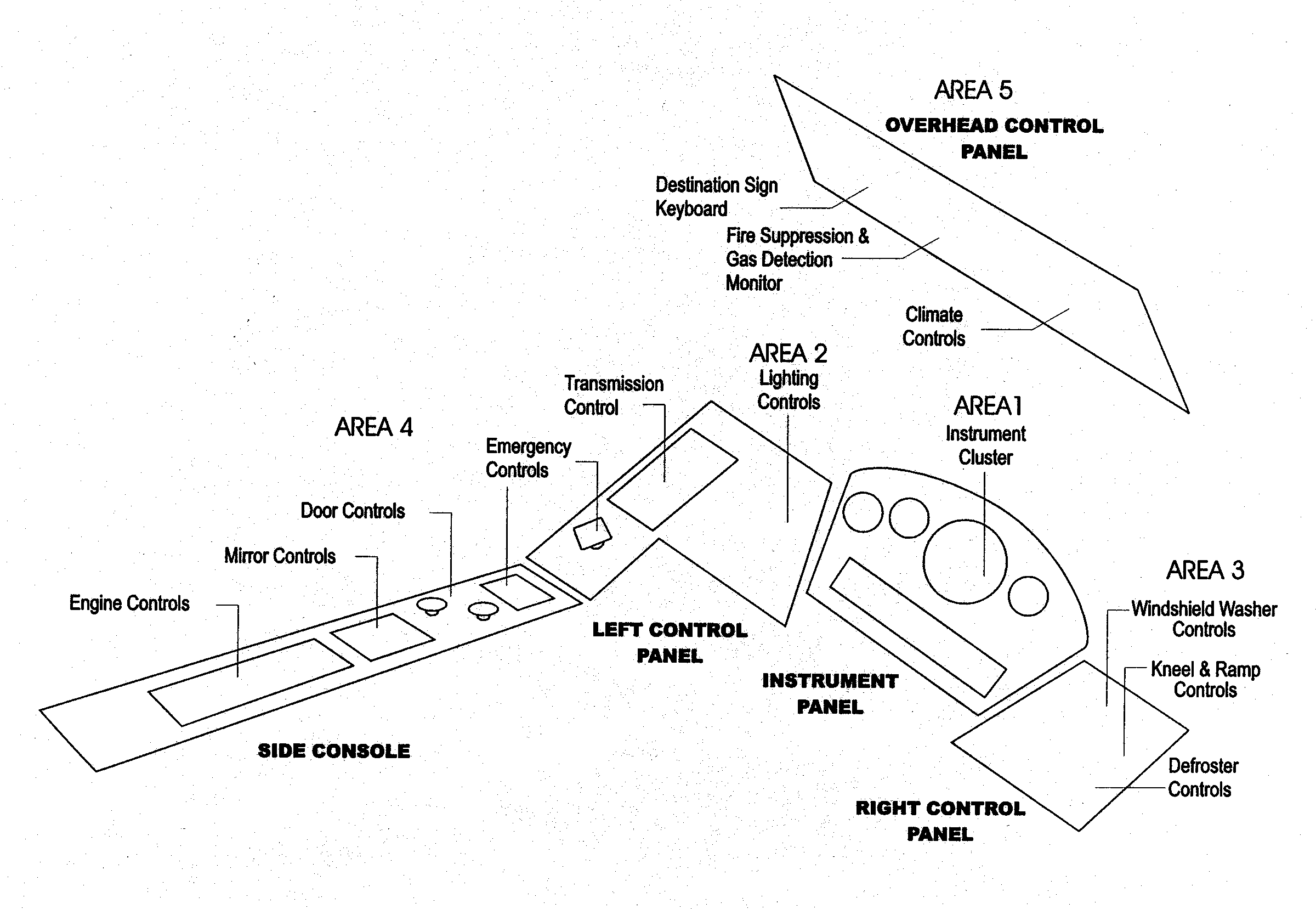
**Area 2**: Operational controls and switches, located adjacent the left side of the instruments.

**Area 3**: Operational controls and switches, including but not limited to washer controls, kneel and ramp switches, operator's climate controls, emergency controls and flashers located adjacent the right side of the instruments.

**Area 4**: Secondary operating controls including door, mirror, transmission, cabin climate controls (on side console) and lighting controls, located to the left of the operator ahead of the Seat Reference Point (SRP) of the 5 percentile female. Console shall be sealed to prevent water intrusion into electronics areas. Circuit cards located in this area require conformal coating.

**Area 5**: System function controls, including destination sign keypad, , fire suppression, located on the operator's centerline, above the operator's upper sight cutoff line.

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###### Operator Foot Controls

Standard foot controls shall be Kongsberg control pedal

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| * + *Option*: *A Kongsberg floor-mounted adjustable brake and accelerator pedal system shall be provided.*   1. Travel range (linear motion): 0″ to 3″   2. Travel time: Less than 6 seconds   3. Operating Voltage range: 9-16 VDC   4. Protection: Thermal overload |

Accelerator

Accelerator Pedal Angle

The angle of the acceleratorpedal shall be determined from a horizontal plane regardless of the slope of the cab floor.

The accelerator pedal shall be positioned at an angle of 40 - 45 degrees at the point of initiation of contact, and extend downward to an angle of 20-25 degrees at full throttle. Final accelerator pedal angle to be determined after contract award.

Accelerator Pedal Dimensions

The floor mounted accelerator pedal shall be 10" - 12" long and 3" - 4" wide.

Accelerator Pedal Force

The force to depress the accelerator pedal shall be measured at the midpoint of the accelerator. The accelerator force shall be no less than 7 foot-pounds and no more than 9 foot-pounds***.***

Accelerator Interlock

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 when the rear door control is activated and/or when the wheelchair ramp is deployed or bus is kneeled. The braking effort shall be non-adjustable. Rear doors shall not open until bus speed is below 2 m.p.h.

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| 🞏 *Baseline: No requirements for accelerator interlock whenever front doors are open.*   * *Alternative: Use for requiring accelerator interlock whenever front doors are open.*   An accelerator interlock shall lock the accelerator in the closed position whenever front doors are open. |

Brake

Brake Pedal Angle

The angle of the brakepedalshall be determined from a horizontal plane regardless of the slope of the cab floor. The brake pedal shall be positioned at an angle of 45 - 50 degreesatthe point of initiation of contact, and extend downward to an angle of 20-28 degrees at full depression. Final brake pedal angles to be determined after contract award.

Brake Pedal Dimensions

The floor mounted brakepedalshall be 10" - 12" long and 3" - 4" wide.

Brake Force

The force to depress the brake pedal shall be measured at the midpoint of the brake pedal. The brake pedal force shall be no less than 10 foot-pounds and no more than 50 foot-pounds.

Relative Position between Accelerator Pedal and Brake Pedal

The accelerator and brakepedalsshall be positioned such that the spacing between them, measured at the heel of the pedals, is between 1" and 2"*.*

Accelerator and Brake Pedal Location and Lateral Angle

The location of the brake and accelerator pedals shall be determined by the manufacturer, based on space needs, visibility, lower edge of windshield, and vertical H-point. The brake pedal shall have a 0-degree lateral angle, and the accelerator shall have a 9 to 12-degree lateral angle to coincide with the position of the operator's leg as it moves outward to operate the accelerator pedal.

Operator Foot Switches

Turn Signal Platform

The angle of the turn signal platform shall be determined from a horizontal plane, regardless of the slope of the cab floor. The turn signal platform shall be angled at a minimum of 10 degrees and a maximum of 37 degrees. It shall be located no closer to the seat-front than the heel point of the accelerator pedal.

Turn Signal Controls

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| * + - ***Baseline****: Foot Switches*   Turn signal controls shall be floor mounted, foot-controlled, waterproof, heavy duty, momentary contact switches. |

High Beam, Hazard, and PA Controls

May be floor mounted (Optional) with the same requirements as the Turn Signal controls.

Manual "Emergency" Switch

A manual "Emergency" indicator switch shall be located on the driver floor between the natural driver heel locations. A visual alert shall be provided on the front exterior sign and the rear exterior sign.

###### Instrumentation

The speedometer, air pressure gauge(s), and certain indicator lights shall be located in Area 1 Instrument Panelimmediately ahead of the steering wheel. The steering wheel spokes or rim shall not obstruct the operator'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 from the windshield, side window, or front door windows from the instruments, indicators, or other controls shall be minimized. Instruments shall be easily readable in direct sunlight or shielded in such a manner that sunlight does not adversely affect legibility. Instrument covers shall be non-reflective, without electrostatic qualities that attract and hold dust, and shall be resistant to scratching or hazing as a result of cleaning. Text shall be a minimum of 11 points. Extremely condensed or italic type fonts shall not be used. The color of the display field shall be dark with contrasting typography***.*** Indicator lights or illuminated symbols or typography immediately in front of the operator shall be restricted to those concerned with the operation of the vehicle, asidentified in the following table.

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| **Visual Indicator** | **Audible Alarm** | **Condition** |
| Back-Up | Backup Alarm | Reverse gear is selected |
| Hazard | Tone | Four-way flashers activated |
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| High Beam | None | Headlamp high beams activated |
| Kneel | Kneel Horn | Suspension kneeling system activated |
| Left Turn Signal | Tone | Left turn signal activated |
| Parking Brake | None | Parking brake is activated |
| Doors | None | Lighted control actuation button |
| Rear Door | None | Rear passenger door is not closed and locked |
| Right Turn Signal | Tone | Right turn signal activated |
| Stop Request | Chime | Passenger stop request has been activated |
| Wheelchair Request | Double Chime | Passenger wheelchair stop request has been activated |
| Wheelchair Ramp | Beeper | Wheelchair ramp during deploy/stow operations |

The instrument panel shall include an electronic speedometer indicating no more than 80 mph and calibrated in maximum increments of 5 mph. The speedometer shall be a rotating pointer type, with a dial deflection of 220 to 270 degrees and 40 mph near the top of the dial. The speedometer shall be sized and accurate in accordance with SAE Recommended Practice J678.

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| * ***Baseline****: Speedometer with no odometer*. * *Alternative: Use for speedometer with integrated odometer.*   The speedometer shall be equipped with an odometer with a capacity reading no less than 999,999 miles. |

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| * *Baseline: Use for hubodometer.*   The bus shall be equipped with a hubodometer mounted at the curbside of the rear axle. The hubodometer shall have a capacity reading no less than 999,999 miles.   * *Alternative: No hubodometer required.* |

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 operator's seat or top of the panel. The diagnostic panel shall be separately removable and replaceable without damaging the instrument panel or gauges.Wiring shall have sufficient length and be routed to permit service without stretching or chafing the wires.

###### Visual and Audible Alarms

The bus shall be equipped with visual and audible alarms linked to an on-board diagnostic system that will indicate conditions that require immediate action by the operator to avoid an unsafe condition or prevent further damage to the bus. The indicator panel shall be located in Area 1 of the Instrument Panel or in an overhead console, readily visible to the operator. The intensity of visual indicators shall permit easy determination of on/off status in bright sunlight or shielded in such a manner that sunlight does not adversely affect legibility. Indicator illumination shall not cause a visibility problem at night. All indicators shall have a method of momentarily testing their operation. The audible alarm shall be tamper resistant and shall have an outlet level between 80 and 83 dBA when measured at the location of the operator's ear. Wherever possible, sensors shall be of the closed circuit type, so that failure of the circuit and/or sensor shall activate the malfunction indicator.

To avoid unnecessary confusion and anxiety on the part of the operator, on-board displays visible to the operator should be limited to indicating the status of those functions described herein that are necessary for the safe operation of the bus and protection of assets. All other indicators needed for diagnostics and their related interface hardware shall be concealed and protected from unauthorized access. Data communications requirements for Drivetrain diagnostics are identified in Section 5.5.5.2.2.

Malfunction and other indicators listed in the following table shall be supplied on all buses.

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| **Visual Indicator (Color)** | **Audible Alarm** | **Condition or Malfunction** |
| ABS (Y) | None | ABS System Malfunction |
| A/C Stop or Check A/C (Y) | None | Compressor stopped due to high/low pressure or loss of refrigerant |
| Stop Engine (R) | Alarm | Motor shut down in |
| Check EDrive System | None | Drive system |
| Check Transmission (Y) | None | Transmission Electronic Control Unit detects a malfunction |
| Fire (R) | Bell or Buzzer | Over-temperature condition in engine/battery compartment |
| DC/DC Converter Fail (Y) | None | Loss of DC/DC Converter output |
| Low Air (R) | Buzzer | Insufficient air pressure in either primary or secondary reservoirs |
|  |  |  |
| \*Low Coolant (Y) | None | Insufficient drive system coolant level |
| Wheelchair Ramp (R) | Beeper | Wheelchair ramp in operation |
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| \* Required to be monitored by Engine Manufacturer Indicator (i.e., Check Engine/Stop Engine)  R – Red  Y - Yellow | | |

##### WINDSHIELD WIPERS

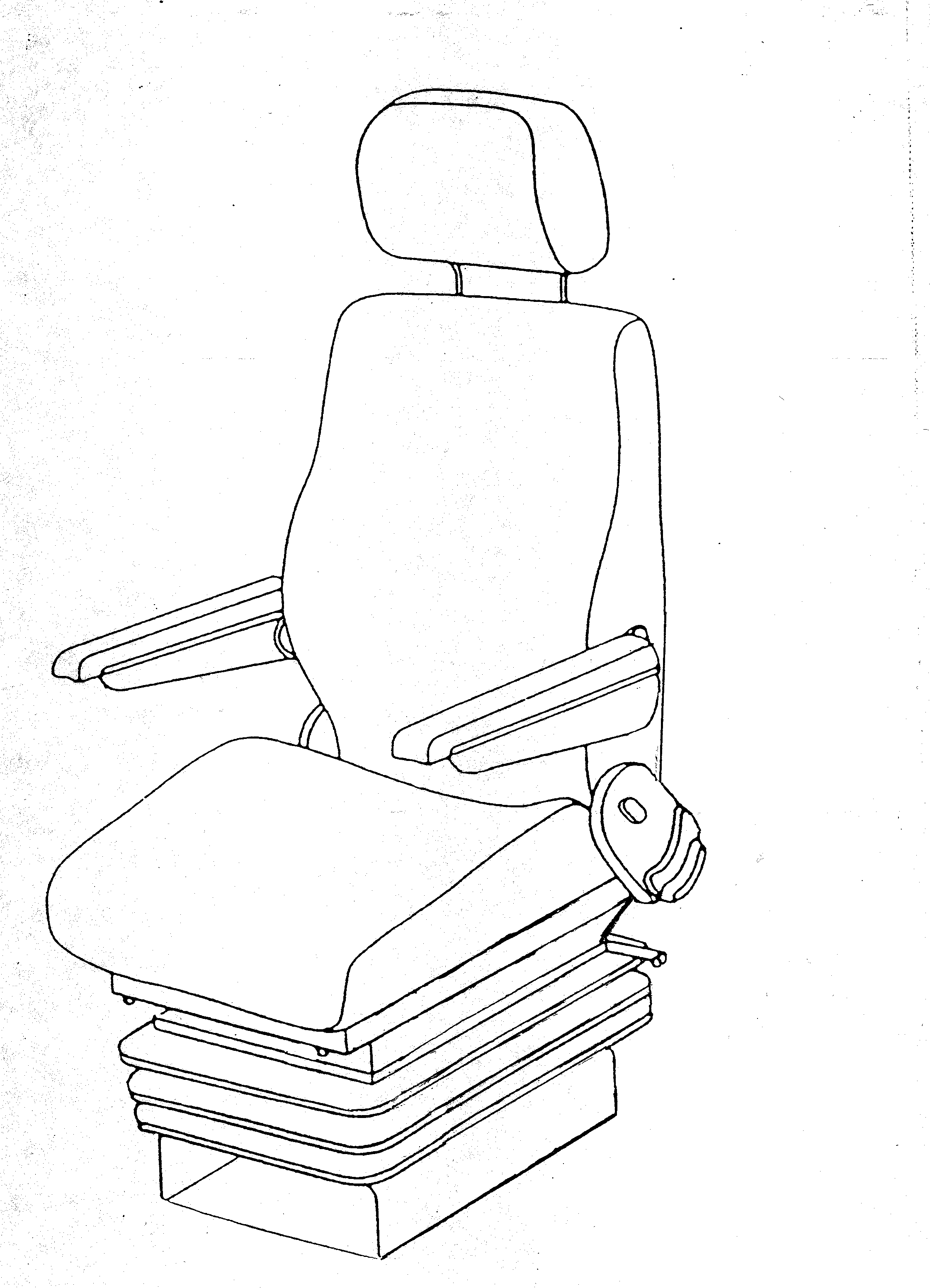
The bus shall be equipped with a variable speed electric windshield wiper for each half of the windshield. For non-synchronized wipers, separate controls for each side shall be supplied. A variable intermittent feature shall be provided to allow adjustment of wiper speed for each side, or a synchronized pair, ranging between approximately 5 to 25 cycles per minute. If powered by compressed air, exhaust from the wiper motors shall be muffled or piped under the floor of the bus. No part of the windshield wiper mechanism shall be damaged by manual manipulation of the arms. At 60 mph, no more than 10 percent 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 and shall be removable as complete units. The fastener that secures the wiper arm to the drive mechanism shall be corrosion resistant.

##### WINDSHIELD 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. If powered by compressed air, all fluid shall be purged from the lines after each use of the washers.

The windshield washer system shall have a minimum 2 -gallon reservoir, located for easy refilling from outside of the bus and protected from freezing. Reservoir pumps, lines, and fittings shall be corrosion-resistant, and the reservoir itself shall be translucent for easy determination of fluid level.

##### OPERATOR’S SEAT



Seat Base

Seat Pan Cushion

Seat Belt

Seat Back Lumbar Support

Arm Rest

Seat Back

Head Rest

###### Dimensions

The operator's seat shall be a **Recaro Ergo Metro or USSC 9100 ALX series.** The seatshall be comfortable and adjustable so that persons ranging in size from the 95th-percentile male to the 5th-percentile female may operate the bus. While seated, the operator shall be able to make seat adjustments by hand without complexity, excessive effort, or being pinched. Adjustment mechanisms shall hold the adjustments and shall not be subject to inadvertent changes. Graphical symbols shall conform to SAE Recommended Practice (Proposed) J1458, Universal Symbols for Seat and Suspension Adjustments***.*** CUSTOMER's salient characteristics for the operator's seat are described below:

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| --- | --- | --- | --- |
| **A.** | | Lifting Capacity: | Minimum 400 pounds |
| **B.** | | Suspension: | Pneumatic |
| **C.** | | Dampening: | Dampening as required to support up to 400 pounds |
| **D.** | | Back Rest: | Multiple chamber air adjustable lumbar support.  Full-length plastic back protector.  High – density polyurethane foam. |
| **E.** | | Back Rest Recline: | Maximum twelve (12°) degrees [plus or minus one (+/-1°) degree] recline. |
| **F.** | | Seat Travel: | Eleven inches (11”) fore and aft (minimum without contacting bus structure).  Air track seat release – Manufacturer’s standard. |
| **G.** | | Recliner Gears: | Dual interlocking |
| **H.** | | Seat Belt: | Minimum seventy-eight inches (78”) with top release button. Release shall be on the right hand side of the driver’s seat.  Shall meet FMVSS 209 and 302 |
| **I.** | | Height Adjustment: | Minimum six inches(6.0”) |
| **J.** | | Seat Tracks: | Reinforced steel double locking seat tracks |
| **K.** | | Rake Adjustment: | Minimum fifteen (15) degrees |
| **L.** | | Federal Standards: | Driver’s seat shall meet FMVSS: 207, 210, and 302. |
| **M.** | | Seat Cushion: | As required to meet APTA Standard Bus Procurement Guidelines |
| **N.** | | Seat Fabric and Color: | Manufacturer’s standard black Naugahyde fabric OR manufacturer's standard black fabric, FR treated. Fabric shall be treated with anti-microbial coating to inhibit the growth of fungi and bacteria. Fiber treatment shall be integral to the fiber. Coating sprayed on after fabric has been woven is not acceptable |
| **O.** | Seat Riser: | | Manufacturer’s standard and suitable to meet 5th to 95th percentile operator’s ergonomic evaluation and seat motion adjustability. |
| **P.** | Testing: | | Final seat selection must meet installed 5th to 95th percentile operator’s ergonomic evaluation, ride quality and seat motion adjustability (SAE J833 and 941). |
| **Q.** | Experience: | | Contractor must demonstrate that they have manufactured bus operator seats for the transit industry for at least three (3) years. Seats must have been proven in transit service operation for at least three (3) years. |

Seat Pan Cushion Length

Measurement shall befrom the front edge of the seat pan to the rear at its intersection with the seat back. The adjustment of the seat pan length shall be no more than 16.5***"*** at its minimum length and no less than 20.5***"*** at its maximum length.

Seat Pan Cushion Height

* *Baseline*:Measurementshall befrom the cab floor to the top of the level seat at its center midpoint. The seat shall adjust in height from a minimum of14***"*** toa maximum of 20", witha minimumofa 6" range of adjustment.
* *Alternative Measurement:*The reference point for seat height shall be determined by establishing the H-point.
* *Alternative Specification:*The seat shall have a minimum height adjustment range of 6*"****.***

Seat Pan Cushion Slope

Measurement is the slope of the plane created by connecting the two high points of the seat, one at the rear of the seat at its intersection with the seat back and the other at the front of the seat just before it waterfalls downward at the edge. The slope can be measured using an inclinometer and shall be stated in degrees of incline relative to the horizontal plane (0 degrees). The seat pan shall adjust in its slope from no less than plus 12 degrees (rearward "bucket seat" incline), to no less than minus 5 degrees (forward slope).

Seat Base Fore/Aft Adjustment

Measurement is the horizontal distance from the heel-point to the front edge of the seat. The minimum and maximum distances shall be measured from the front edge of the seat when it is adjusted to its minimum seat pan depth (approximately 15"). On all low-floor buses, the seat-base shall travel horizontally a minimum of 11". It shall adjust no closerto the heel-point than6".

Seat Pan Cushion Width

Measurement is the horizontal distanceacross the seat cushion. The seat pan cushion shall be 17" - 21" across at the front edge of the seat cushion and 20" - 23" across at the side bolsters.

Seat Suspension

The operator's seat shall be appropriately dampenedto support a minimum weight of 380 pounds. The suspension shall be capable of dampening adjustment***.***

Operator Area Depth

The measurement is the horizontal distance from the heel-point to the barrier at the height at which the top of the seat back reclines. For all low-floor buses, theoperator areadepth shall be a minimum of 45" and be able to accommodate the full range of seat adjustment and travel (for a seat with the specifications as described in these guidelines).

Seat Back Width

Measurement is the distance between the outer-most points of the front of the seat back, at or near its midpoint in height. The seat back width shall be no less than 19".

Seat Back Lumbar Support

Measurement is from the bottom of the seat back at its intersection with the seat pan, to the top of the lumbar cushioning. The seat back shall provide adjustable depth lumbar back support in at least two locations,within aminimum range of 7" - 11".

Seat Back Angle Adjustment

The seat back angle shall be measured relative to a level seat pan, whereas 90 degrees is the upright position and 90 degrees-plus represents the amount of recline. The angle can be measured using a protractor (or its equivalent) with the X-axis being the horizontal plane of a level seat pan, and the Y-axis the upright plane of the seat back. The angle is created by the intersection of the two planes, with the upright plane parallel to the frame of the seat back.

The seat back shall adjust in angle from a minimum of no more than 90 degrees (upright) to at least 102 degrees (reclined), with infinite adjustment in between.

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Seat Belt Adjustment

The Type I seat belt shall attach at a point that moves with the assembly.

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| ***🗹 Baseline****: Standard (lap only) seat belt.*  Required Type I seat belts shall be fastened to the seat so that the operator may adjust the seat without resetting the seat belt. Seat belts shall be stored in automatic retractors. Latch on right hand side.  *🞎* ***Alternative****: Three-point (lap and shoulder) seat belt.*  Seat belts shall be provided across the operator’s lap and diagonally across the operator’s chest. The operator shall be able to use both belts by connecting a single buckle on the right side of the seat cushion. The belts shall be fastened to the seat and/or the bus structure so that the operator may adjust the seat without resetting the seat belt. Seat belts shall be stored in automatic retractors. |

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| * *Baseline: No requirement for extended length seat belts.*   + *Alternative: Requirement for extended length seat belts.*   Seat belts shall be extended length to accommodate operators of all sizes. |

###### Seat Structure and Materials

The operator's seat shall be contoured to provide maximum comfort for extended period of time. Cushions shall be fully padded with at least 3 inches of closed-cellpolyurethane foam or material with equal properties, in the seating areas at the bottom and back. Upholstery shall be ventilated, transportation grade material. Seat Cushions must have moisture resistant barrier foam and meet Docket 90 foam smoke retardant.

All visually exposed metal on the operator's seat, including the pedestal, shall be unpainted aluminum or stainless steel.

The seat and seatbelt assemblies as installed in the bus shall withstand static horizontal forces as required in FMVSS 207 and 210. The seat shall withstand 10,000 impacts of a 40-pound sandbag dropped from a height of 12 inches without visible deterioration. The seat shall be tested in the lowest vertical position and repeated with the seat in the top vertical position.

The 40-pound sandbag shall be suspended on a 36-inch pendulum and shall strike the seat back 10,000 times from distances of 6, 8, 10, and 12 inches. Seat cushion shall withstand 100,000 randomly positioned 3-1/2-inch drops of a squirming, 150-pound, smooth-surfaced, buttocks-shape striker with only minimal wear on the seat covering and no failures to seat structure or cushion suspension components.

At the request of CUSTOMER, the Bus Manufacturer shall provide a certified test report fully documenting compliance with all the requirements defined above after contract award. The test report shall contain a record of all testing activities, test diagrams, testing equipment, as well as test data related to loads, deflections and permanent deformation of the seat assembly. The report shall include a statement of compliance with the requirements of this section of Part 5: Technical Specifications.

Color and material of the operator's seat are defined in the table below:

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| * ***Alternative****:* Color of fabric of the operator's seat upholstery shall be black Naugahyde with the following characteristics:   Color:Black  Material:Shall simulate smooth black leather  Average Thickness:Fifty (50) mils, plus or minus three (3) mils  Average Top Skin Thickness:8.7 mils  Tensile Strength:Warp: 136.3 pounds (minimum)  Fill: 119.3 pounds (minimum)  Elongation at Fifteen (15) Lbs:Warp: 5% maximum  Fill: 25% maximum  Trap Tear Strength:Warp: 29.4 pounds minimum  Fill: 42.7 pounds minimum  Adhesion of coating:Warp: 3.0 pounds per inch (minimum)  Fill: 3.0 pounds per inch (minimum)  Tack Strength (Stitch):Warp: 69.1 pounds (minimum)  Fill: 43.9 pounds (minimum)  Surface Abrasion:No appreciable color change after 6000 cycles (minimum) with wire screen  Colorfastness to Ultraviolet Light:72 hours, minimum under xenon ultraviolet lamp |

##### MIRRORS

###### Exterior Mirrors

The bus shall be equipped with a corrosion-resistant, **Hadley (B&R Manufacturing)** outside rearview mirror on each side of the bus. Mirrors shall permit the operator to view the roadway along both sides of the bus, including the rear wheels. The curbside rearview mirror shall be mounted so that its lower edge is no less than 78 inches above the street surface.

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| ***Baseline****: Use for mirrors on both sides*  The bus shall be equipped with 2 outside mirrors with a split surface. The top surface shall have unit magnification (flat), with not less than 50 sq. in. of reflective surface per top section of mirror. The bottom mirror shall have a convex surface to eliminate blind spots as much as possible, no less than four (4) inches tall. The mirrors shall be corrosion-resistant and be installed with stable supports on each side of the bus. The mirrors shall be located so as to provide the operator a view to the rear along both sides of the bus and shall be adjustable both in the horizontal and vertical directions to view the rearward scene. The curbside rearview mirror shall be mounted so that its lower edge is no less than 78 inches above the street surface. The roadside rearview mirror shall be mounted lower (not less than 54 inches above the street surface) on the bus body so that the operator's line of sight is not obstructed. Mirror glass shall be secured by method other than Velcro, hang vertically from mount fixture, have a field replaceable harness without mirror removal and be foldable without a detent.  *Alternative: Use of a**closed circuit television**camera and monitor in addition to required mirrors.*  In addition to the required mirrors, a video camera shall be mounted on the curbside of the bus and connected to a monitor visible to the operator. The monitor image shall be not less than 8 inches when measured diagonally. The video system shall permit the operator to view to the rear along curb side of the bus. The location of the video camera and monitor shall be approved by CUSTOMER. |

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| * *Baseline: Standard curb-side mirror (without remote adjustment)*      * + ***Alternative****: Remote adjustment of curbside mirror.*   The operator shall be able to adjust the curbside mirror remotely while seated in the driving position. The control for remote positioning of the mirror shall be a single switch or device or a set of dual switches that control the curbside and streetside mirrors individually. |

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| * *Baseline: Non-heated exterior mirrors.*   + ***Alternative****: Heated exterior mirrors.*   All exterior mirrors shall be electrically heated and controlled by a timer and switch. The timer shall be programmed for a 10-minute shut-off after activation. The heaters shall be energized whenever the operator’s heater and/or defroster is activated. |

Mirrors shall be firmly attached to the bus to minimize vibration and prevent 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 shall retract or fold sufficiently to allow bus washing operations. Additional details on external mirrors, including size, location and mounting, are contained in Attachments to Part 5: Technical Specifications.

###### Interior Mirrors

Mirrors shall be provided for the operator to observe passengers throughout the bus without leaving his seat and without shoulder movement. The operator shall be able to observe passengers in the front/entrance and rear/exit areas, anywhere in the aisle, and in the rear seats.

Additional details on external mirrors, including size, location and mounting, are contained in Attachments to Part 5: Technical Specifications.

#### WINDOWS

##### GENERAL

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| * + ***Baseline****: Use with 35-ft bus*   A minimum of 8,000 square inches of window area, including operator and door windows, shall be required on each side of the standard configuration bus.  ***Baseline:*** *Use with 40-ft bus*  A minimum of 10,000 square inches of window area, including operator and door windows, shall be required on each side of the standard configuration bus. |

##### WINDSHIELD

The one-piece windshield shall permit an operator's field of view as referenced in SAE Recommended Practice J1050. The vertically upward view shall be a minimum of 15 degrees, measured above the horizontal and excluding any shaded band. The vertically downward view shall permit detection of an object 3-1/2 feet high no more than 2 feet in front of the bus. The horizontal view shall be a minimum of 90 degrees above the line of sight. Any binocular obscuration due to a center divider may be ignored when determining the 90-degree requirement, provided that the divider does not exceed a 3-degree angle in the operator's field of view. Windshield pillars shall not exceed 10 degrees of binocular obscuration. The windshield shall be designed and installed to minimize external glare as well as reflections from inside the bus. Windshield shall be capable of being removed and replaced by one (1) 3M mechanic in 150 minutes.

The windshield shall be easily replaceable by removing zip-locks from the windshield retaining moldings. Bonded-in-place windshield shall not be used. The windshield glazing material shall have a 1/4-inch or 6-mm nominal thickness laminated safety glass conforming to the requirements of ANSI Z26.1 Test Grouping 1A and the Recommended Practices defined in SAE J673. The glazing material shall have single density tint.

##### OPERATOR’S SIDE WINDOW

The operator's side window shall be the sliding type, requiring only the front half of sash tolatchuponclosing andshall open sufficiently to permit the seated operator to easily adjust the street side outside rearview mirror. When in an open position, the window shall not rattle or close during braking. The window opening shall be sufficiently large for Emergency Egress.This window section shall slide in tracks or channels designed to last the service life of the bus. The operator's side window shall not be bonded in place and shall be easily replaceable. The glazing material shall have a single density tint.

* *Baseline:*Design must prevent sections from freezing closed in the winter. Light transmittance shall be 75% on the glass area below 53" from the operator platform floor.
  + ***Alternative***:*The**glazed area above 53" may have maximum 5% light transmittance or maximum as allowed by State of Texas regulations.*
* ***Baseline****: Emergency Egress Operator side window not required.*
  + *Alternative: Emergency Egress Operator side window required*

*The entire assembly shall be hinged and have a single release for Emergency Egress.*

The operator's view, perpendicular through operator's side window glazing, should extend a minimum of 840 mm (33 inches) to the rear of the Heel Point on the accelerator, and in any case must accommodate a 95th percentile male operator. The view through the glazing at the front of the assembly should begin not more than 560 mm (26 inches) above the operator's floor to ensure visibility of an under-mounted convex mirror.

The operator’s side window glazing material shall have a 1/4 inch nominal thickness laminated safety glass conforming with the requirements of ANSI Z26.1 Test Grouping 2 and the Recommended Practices defined in SAE J673.

##### SIDE WINDOWS

###### Configuration

All side windows shall be fixed in position, except as necessary to meet the emergency escape requirements.

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| 🞏 *Baseline: Fixed side windows.*  All side windows shall be fixed in position, except as necessary to meet the emergency escape requirements.   * + *Openable windows with inward-opening transom panels*:   Each openable side window shall incorporate an upper transom portion. The transom shall be between 25 and 35 percent of the total window area. The lower portion of the window shall be fixed. The transom portion shall be hinged along the lower edge and open inward*.* All passenger windows shall be top hopper (inward-opening transom) window assemblies with the exception of the driver window and destination window assemblies. All aluminum and steel material will be black anodized to prevent corrosion.  . |

All side windows shall be easily replaceable without disturbing adjacent windows and shall be mounted so that flexing or vibration from engine operation or normal road excitation is not apparent.

* ***Baseline****: Conventional glazing retention*
* *Alternative: Quick change glazing retention*

The windows shall be designed and constructed to enable a 3M mechanic to remove and replace two windows in less than 10 minutes.

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| * ***Baseline****: No requirements for cyclone cleaner.*   🞏 *Alternative: Requirement for cyclone cleaner.*  An opening in the rear of the bus shall be provided to accommodate a cyclone cleaner. An openable rear window may be used if the window cannot be accidentally closed during the cleaning operation. Minimum size of this opening is defined in attachment to Part 5: Technical Specifications. |

###### Materials

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| * *Baseline: Use for safety glass glazing panels.*   Side windows glazing material shall have a 1/4-inch nominal thickness tempered safety glass. The material shall conform to the requirements of ANSI Z26.1 Test Grouping 2 and the Recommended Practices defined in SAE J673.  🞏 *Alternative: Use for polycarbonate glazing panels*    Side window glazing material shall have a 1/4‑inch nominal thickness. The material shall conform to 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 per cent. Windows shall be polycarbonate sheet with an abrasion resistant coating on both sides of the window  🞏 *Alternative: Use for acrylic glazing panels.*  Side window glazing material shall have a 1/2‑inch nominal thickness. The material shall conform to 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 per cent. Windows shall be cell cast acrylic sheet with an abrasion resistant coating on both sides of the window.   * ***Alternative****: Use for laminated glazing panels.*   Side windows glazing material shall have ¼-inch nominal thickness laminated safety glass. The material shall conform to applicable requirements of ANSI Z26.1 and the Recommended Practices defined in SAE J673. Frames shall be anodized black and conform to FMVSS 217 for emergency egress.   * *Alternative: Use for laminated and tempered safety glazing with anti-vandalism polyester sacrificial film*.   All glazing material that is aft of the standee line shall be equipped with multi-layer(s) laminated polyester film. This material shall be easily installed and removed without the use of specialized tools. Polyester film shall adhere to the window and be resistant to peeling, curling and discoloration by ultra violet rays. The film shall withstand normal cleaning operations.   * *Alternative: Use for Anti-vandalism sacrificial liner (“storm window type”).*   All glazing material aft of the standee line shall be equipped with necessary bracketry, fasteners and clear acrylic liner that shall be easily removable in the event of vandalism. The acrylic material shall be clear and shall have minimal effect the transmittance of the underlying glazing. This material shall not be adversely affected by ultra-violet rays and shall withstand normal cleaning practices. The installation of the liner shall prevent clouding or fogging. A mechanic without the use of any specialized tools shall be able to easily remove and replace the acrylic liner in 5 minutes or less. |

Windows on the bus sides and in the rear door shall be tinted a neutral color, complementary to the bus exterior. For tinted windows, a reference standard for light transmission is approximately 28percent (which is approximately equal to the light transmission of dark sunglasses).

For tinted windows on the new CUSTOMER buses procured under this contract, the windows shall be tinted to a luminous transmittance of 28 percent nominally as measured by ASTM D-1003. Maximum tinting shall be determined by CUSTOMER after contract award. The maximum solar energy transmittance shall not exceed 37 percent, as measured by ASTM E-424, and the luminous transmittance shall be no less than 28 percent as measured by ASTM D-1003. Windows over the destination signs shall not be tinted.

##### REAR WINDOW

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| * ***Baseline****: No requirement for rear window.* * *Alternative: Use for Rear Window requirement. Note that requirement for a rear-mounted HVAC unit will preclude a rear window.*   A rear window shall be provided. The rear window shall be glazed with same material (including anti-vandalism provision if required) and tint as side windows. The glazing shall be set in rubber channels or be push-out type to meet FMVSS 217. If push-out type, it shall be one-piece, rugged sash design, meeting specifications for side windows. |

#### HEATING VENTILATING AND AIR CONDITIONING

##### CAPACITY AND PERFORMANCE

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

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| * + ***Baseline****: HVAC equipped. (See below for configuration)* * *Alternative: No requirements for cooling. All requirements relevant to the HVAC cooling mode contained in this section as well as throughout this Specification need not apply.* |

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| * + ***Baseline****: Allow either roof or rear-mounted HVAC unit. Note that a rear-mounted unit will preclude a rear window and that the term “roof-mounted unit” includes units mounted on top of beneath the roof surface.*   The HVAC unit shall be roof or rear-mounted.   * The AC will be an Eberspaecher AC-136 AE G3 unit which is a fully electric production HVAC unit that is industry leading in performance and weight. The unit utilizes an electric driven, two pole motor compressor assembly that can provide 28 kW of ARI cooling capacity with a maximum cooling capacity of 37 kW. Additional refrigerant to liquid exchanger cooling plate capacity enables a fully integrated system that provides 5kW of cooling capacity for the vehicle battery cooling loop. 3kW of cooling capacity is available for the integrated inverter unit with 400v AC output. An electric saloon heating capacity of 16 kW is provided. CAN bus interface is used to control power management, battery cooling coordination, and 5-100% fresh air intake. The unit weighs 575 lbs.   The Eberspaecher unit utilizes R134a refrigerant, which is a non-blended homogenous refrigerant that improves performance and enhances serviceability. This refrigerant allows for lower system pressures and temperatures, has a higher coefficient of performance than other blended refrigerants, and reduces the propensity for temperature glide and performance issues due to the lack of blended constituents with varying boiling points. For serviceability, R134a allows for easy filling and replacement because mix ratios/compositions do not have to be restored in instances of leaks. This refrigerant is also better for the environment than other mixed refrigerants, and exhibits a lower GWP (Global Warming Potential) value. |

Accessibility and serviceability of components shall be provided without requiring maintenance personnel to climb-up on the roof of the bus.

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

When the bus is operated in outside ambient temperatures of 95o to 115oF, the interior temperature of the bus shall be permitted to rise one degree for each degree of exterior temperature in excess of 95oF.

When bus is operated in outside ambient temperatures in the range of -10o to +10oF, the interior temperature of the bus shall not fall below 55oF while bus is running on the Design Operating Profile.

System capacity testing, including pulldown/warm-up, stabilization and profile, shall be conducted in accordance to the APTA Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System. Temperature measurements shall be made in accordance to this document with the following modifications:

The four primary locations used for temperature probes are:

(1) 6 inches aft of front wheel housing,

(2) Centered between the two axles

(3) 6 inches aft of rear wheel housing, and

(4) In the Operator's area.

At each primary location, the ten (10) temperature sensing devices shall be:

(A) 72 inches above floor level,

(B) 6 inches above top surface of seat cushion, and

(C) 6 inches above floor.

The recommended locations of temperature probes are only guidelines and may require slight modifications to address actual bus design. Care must be taken to avoid placement of sensing devices in immediate path of air duct outlet. In general, the locations are intended to accurately represent the interior passenger area.

Additional testing shall be performed as necessary to ensure compliance to performance requirements stated herein.

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| * *Baseline: Capacity and performance requirements*   The air conditioning portion of the HVAC system shall be capable of reducing the passenger compartment temperature from 110o to 90oF in less than 20 minutes after engine start-up. Engine temperature shall be within the normal operating range at the time of start-up of the cool-down test and the engine speed shall be limited to fast idle that may be activated by an operator-controlled device. During the cool-down period the refrigerant pressure shall not exceed safe high-side pressures and the condenser discharge air temperature, measured 6 inches from the surface of the coil, shall be less than 45oF above the condenser inlet air temperature. The appropriate solar load as recommended in the APTA “Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System,” representing 4 P.M. on August 21, shall be used. There shall be no passengers on board, and the doors and windows shall be closed.   * + ***Alternative****: For hotter ambient conditions*   The test procedure as described in Section 8 of the APTA document, “Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System,” shall be used for the purposes of the following pulldown requirements. The air conditioning portion of the HVAC system shall be capable of reducing the passenger compartment temperature as defined in the referenced test procedure from 110oF heat soak after 2 hours to 75°F ± 3oF in less than 30 minutes after start-up of A/C system and when run at 3/4 of maximum engine RPM. System performance shall be met for an additional 30 minutes after reaching the 75°F ± 3°F requirement for the A/C system stabilization of climate control demonstration. A greater variance may be allowed for the sensor closest to the return air vent.  During the cool-down period the refrigerant pressure shall not exceed safe high-side pressures and the condenser discharge air temperature, measured 6 inches from the surface of the coil, shall be less than 45oF above the condenser inlet air temperature. There shall be no passengers on board, and the doors and windows shall be closed.   * + ***Performance requirements*** *for CUSTOMER's heating mode conditions*   The heating mode "pull-up" requirements for the heating system shall be in accordance with Section 9 of APTA’s “Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning.” With ambient temperature at +10°F, and vehicle cold soaked at that temperature, the bus heating system shall warm the interior passenger compartment to an average temperature of 70o ±2oF within 70 minutes. |

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| * + **Baseline***: No requirement for an auxiliary heater.* * *Alternative: Auxiliary heater.* |

Additional HVAC system and performance requirements are contained in Attachments to Part 5: Technical Specification. The air conditioning system shall meet these performance requirements using:

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| * HFC R22 | * + HFC R134a | * HFC R407c | * Other (Specify)\_\_\_\_\_\_\_\_\_\_\_\_ |

The climate control blower motors and fan shall be designed such that their operation complies with the interior noise level requirements as specified in Section 5.1.6.6.1.

##### CONTROLS AND TEMPERATURE UNIFORMITY

The HVAC system excluding the operator's heater/defroster shall be centrally controlled with an advanced electronic/diagnostic control system with provisions for extracting/reading data.

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| *xAlternative: Use for fully automatic climate control system.*  The climate control system shall be fully automatic and control the interior average temperature to within ±2oF of specified temperature control set-point. |

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| * ***Baseline****: Use for single control set point at 72oF*The temperature control set-point for the system shall be 72oF. * *Alternative: Use for dual temperature control set-point*The temperature control set-point for the system in the cooling mode shall be \_\_oF [*Procuring Agency to fill-in]* and \_\_\_oF *[Procuring Agency to fill-in]* in the heating mode. * *Alternative: Manually adjustable temperature control set-point*   The climate control system shall have the provision to allow operator to adjust the temperature control set-point at a minimum of between 68o and 72oF. From then on, all interior climate control system requirements shall be attained automatically, unless re-adjusted by operator*.* |

The operator shall have full control overthe defroster and operator's heater. The operator shall be able to adjust the temperature in the operator's area through air distribution and fans. The interior climate control system shall switch automatically to the ventilating mode if the refrigerant compressor or condenser fan fails.

Interior temperature distribution shall be uniform to the extent practicable to prevent hot and/or cold spots. After stabilization with doors closed, the temperatures between any two points in the passenger compartment in the same vertical plane, and 6 inches to 72 inches above the floor, shall not vary by more than 5oF with doors closed. The interior temperatures, measured at the same height above the floor, shall not vary more than ± 5oF, from the front to the rear, from the average temperature determined in accordance to APTA Recommended Instrumentation and Performance Testing for Transit Bus Air Conditioning System. Variations of greater than ± 5oF will be allowed for limited, localized areas provided the majority of the measured temperatures fall within the specified requirement.

##### 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 (cfm) per passenger based on the standard configuration bus carrying a number of passengers equal to 150 percent of the seated load. Airflow shall be evenly distributed throughout the bus with air velocity not exceeding 100 feet per minute on any passenger. The ventilating mode shall provide air at a minimum flow rate of 20 cfm per passenger.

Airflow may be reduced to 15 cfm per passenger (150 percent of seated load) when operating in the heating mode. The fans shall not activate until the heating element has warmed sufficiently to assure at least 70oF air outlet temperature. The heating air outlet temperature shall not exceed 120oF under any normal operating conditions.

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| * + *Baseline: No “fresh air” requirements. Procuring Agencies who have type of operating profile where door opening cycle results in effectively providing an adequate “fresh air” mixture.* * *Alternative: Requirement for 20% “fresh air” mixture.*   The air shall be composed of no less than 20 percent outside air. |

###### Operator's Area

The bus interior climate control system shall deliver at least 100 cfm of air to the operator's area when operating in the ventilating and cooling modes. Adjustable nozzles shall permit variable distribution or shutdown of the airflow. Airflow in the heating mode shall be reduced proportionally to the reduction of airflow into the passenger area. The windshield defroster unit shall meet the requirements of SAE Recommended Practice J382, Windshield Defrosting Systems Performance Requirements, and shall have the capability of diverting heated air to the operator's feet and legs. The defroster or interior climate control system shall maintain visibility through the operator's side window.

Controls for the Climate Control System (CCS)

The controls for theoperator'scompartment for heating, ventilation, and cooling systems shall be integrated and shall meet the following requirements***.***

1. The heat/defrost system fan shall be controlled by a separate switch that has an "Off" position and *at least two positions for speed control*. All switches and controls shall preclude the possibility of clothing becoming entangled and shields shall be provided, if required. If the fans are approved by CUSTOMER, an "On-Off" switch shall be located to the right of or near the main Defroster switch.

Heating is resistive electric and as such shall be electronically controlled..

Operator's Compartment Requirements

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

1. The heater and defroster system shall provide heating for the operator and heated air to

completely defrost and defog the windshield, operator's side window, and the front door glasses in all operating conditions. Fan(s) shall be able to draw air from the bus body interior and/or the exterior through a control device or by design and pass it through the heating element to the defroster system and to the operator's area. A minimum capacity of 100cfm shall be provided. The operator shall have complete control of the heat and fresh airflow for their area***.***

(2) The defroster supply outlets shall be located at the lower edge of the windshield. These outlets shall be unbreakable and shall be free of sharp edges that can catch clothes during normal daily cleaning. The system shall be such that foreign objects such as coins or tickets cannot fall into the defroster air outlets. Adjustable ball vents shall be provided at the left of the operator's position to allow direction of air onto the side windows. Two additional vents shall be located on the vertical or horizontal front dash panel adjacent to the front door to allow direction of air onto the door windows and/or entrance area. Adjustable ball vents shall not be located where the operator’s foot or knee can dislodge them.

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

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Operator's Cooling

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| * + ***Baseline****: Requirements for operator's cooling shall be consistent with specifications noted in section 5.4.8.1* * *Alternative: Separate Dedicated Evaporator*   Using a separate, dedicated evaporator, the CCS shall be designed to maintain the operator's compartment temperatures within the range specified for the passenger compartment. The unit shall operate when the Climate Control switch is in the "Cool" position. It shall have a separate thermostatic control. A separate fan unit shall provide 100cfm of air to the operator's area through directionally adjustable nozzles and an infinitely variable fan control, both of which shall be located above and ahead of the operator***.*** |

##### AIR FILTRATION

Air shall be filtered before discharge into the passenger compartment. The filter shall meet the ANSI/ASHRAE 52.1 requirement for 5 percent 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 easily removable for service.

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| * *Baseline: Requirement for cleanable filters.*   Air filters shall be cleanable.   * + ***Alternative****: Disposable type filters.*   Air filters shall be of disposable type. |

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##### ROOF VENTILATORS

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| * + *Baseline: Two roof ventilators required*   Two roof ventilators shall be provided in the roof of the bus, one approximately over or just forward of the front axle and the other, forward of the rear axle. |

Each ventilator shall be easily opened and closed manually by a 50th percentile female. If roof ventilator(s) cannot be reached by a 50th percentile female, then a tool shall be provided to allow this. When open with the bus in motion, this ventilator shall provide fresh air inside the bus. 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 open no less than 4 inches, or with all four edges raised simultaneously to a height of no less than 3-1/2 inches. Anescape hatch shall be incorporated into the roof ventilator. Roof ventilator(s) shall be sealed to prevent entry of water when closed. A bilingual (English/Spanish) decal giving operating instructions shall be affixed to the interior of the hatch and emergency instructions for opening from the exterior shall be affixed to the outside of the hatch.

##### MAINTAINABILITY

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

Note: CUSTOMER may include the following sections if Alternative for colder ambient performance is specified above.

##### ENTRANCE/EXIT AREA HEATING

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| * *Baseline: No requirements for entrance/exit area heating.* * *Alternative: Entrance/exit area heating.*   Heat shall be supplied to the entrance and exit areas to prevent accumulation of snow, ice, or slush with bus operating under design operating profile and corresponding door opening cycle. |

##### FLOOR LEVEL HEATING

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| * *Baseline: No requirements for floor level heating.* * *Alternative: Floor level heating.*   Sufficient floor level heaters shall be provided that evenly supply heated forced air through floor ducts across the length of 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. |

#### SIGNAGE AND COMMUNICATION

##### DESTINATION SIGNS

If selected in section 5.5.5.4.3, a destination sign system (**Luminator Spectrum LED**) shall be furnished on the front, on the right side near the front door, and on the rear of the vehicle. The sign shall have a single color block with 256 true color design.

It is CUSTOMER’s intent to describe a requirement for a full color sign display on the Front, Side and Dash signs, and amber ONLY on rear route sign.

The sign located near the front door shall not block the operator’s critical horizontal line of sight. Display areas of destination signs shall be clearly visible in direct sunlight and/or at night. Signs shall be installed to allow replacement by a 3M mechanic within 30 minutes. Parts shall be commercially available.

External passenger information signs shall provide capabilities for front, side, and rear signs, and will meet all applicable Federal ADA requirements.

All signs shall be controlled via a single Human Machine Interface (HMI). In the absence of a single Mobile Data Terminal (MDT), the HMI shall be conveniently located for the bus operator in Area 5 of the Operator’s Workstation Control and Instrument Array, mounted in such a manner that will not pose any safety hazard.

The destination sign compartments shall be designed to meet the following minimum requirements:

1. Prevent condensation and entry of moisture and dirt.
2. Prevent fogging of both compartment window and glazing on unit itself.
3. Access shall be provided to allow cleaning of inside compartment window and unit glazing.
4. Front window shall have an exterior display area of no less than 8.5”h by 56”w.

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| * + ***Baseline****: Electronic Destination Signs.* See Section 5.5.5.4.3.5   Electronic signs shall be controlled via a single Human Machine Interface (HMI), furnished by CUSTOMER. In the absence of a single Central Control Unit, the HMI shall be conveniently located for the bus operator in Area 5 of the Operator’s Workstation Control and Instrument Array, mounted in such a manner that will not pose any safety hazard. System shall be subject to CUSTOMER approval on 1st article. Preferred in the overhead access if it can be reached by 5th percentile female operator. System shall allow single destination sign entry to control both destination sign and internal announcements. Internal announcement system shall be driven through the Integrated Radio System, Vehicle Logic Unit (VLU) with all current software, programming and databases. The front bus block number sign shall be a **Luminator** **Spectrum LED** 256 true color design LED electronic and capable of displaying 5 alphanumeric characters (1 through 9 and A through Z) with a display area of not less than 4 inches high by 13 inches wide.   * *Alternative: Mechanical Curtain Signs.*   If curtain signs are selected, selections for front and side signs shall be powered and controlled with a switch conveniently located near the inspection window of each sign or shall be manually operated. The switch on the side sign shall be capable of being deactivated from the operator’s compartment. Each sign box or housing shall have an inspection window for the operator to monitor sign selection.   * + ***Alternative****: Electronic* ***Multi-Color*** *Destination Signs.*   The multi-color Sign shall be a **Luminator Spectrum**, single panel color Front sign, Dash-mounted Block/Run Number Sign, and Side destination sign, solid-state, all-LED product. The sign shall have a single color block with 256 true color design. The Rear route sign shall be amber ONLY. |

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##### PASSENGER INFORMATION AND ADVERTISING

###### Interior Displays

Provisions shall be made on the rear of the operator's barrier and electronics area to mount an information sign holder for items such as routes and schedules, that is sized 21"l x 3"w x 24"h. Advertising media 11 inches high and 0.09 inches thick shall be retained near the juncture of the bus ceiling and sidewall. The retainers may be concave and shall support the media without adhesives. The media shall be illuminated by the interior light system.

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| * **Option**: **Luminator INFOtainment System**. System should include a 15" diagonal LCD display screen, with a 4:3 aspect ratio, VGA resolution of 1024 x 768, contrast of 700:1, and a minimum brightness of 350 cd/m2 |

Additional requirements for interior advertising and passenger information displays are defined in the Attachments to Part 5: Technical Specifications.

###### Exterior Displays

Provisions shall be made to integrate advertising, which may be specified by CUSTOMER, into the exterior design of the bus. Advertising media, frames, or supporting structures shall not detract from the readability of destination signs and signal lights, and shall not compromise passenger visibility. Advertising provisions shall not cause pedestrian hazards or foul automatic bus washing equipment, and shall not cover or interfere with doors, air passages, vehicle fittings, or in any other manner restrict the operation or serviceability of the bus.

No frames are required; only space shall be optimized.

Advertising Space:

The bus exterior shall have unrestricted smooth areas, as follows, suitable for installation of CUSTOMER’s pressure sensitive advertising signs:

* + 1. Each exterior side below the passenger window level an area 30″ tall x the maximum width available (*as near to 144″ as possible*) on the curbside between the entrance and exit doors and on the street side between the front and rear wheel axles.
    2. At the rear back of the bus, above the motor compartment door, an area 34″ tall x 64.5″ wide or 21″ x 70″ minimum, unless louvered engine and HVAC compartment doors are integral to the design of the bus, which preclude the inclusion of rear advertising space.

##### PASSENGER STOP REQUEST/EXIT SIGNAL

A passenger "Stop Requested" signal system that complies with applicable ADA requirements defined in 49 CFR, Part 38.37 shall be provided. It shall be easily accessible to all passengers, seated or standing.

For additional Passenger Stop Request sign information See Section 5.5.5.4.3.7

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| * + ***Baseline****: Use for touch tape passenger signal.*   A passenger "Stop Requested" signal system that complies with applicable ADA requirements defined in 49 CFR, Part 38.37 shall be provided. The system shall consist of a touch tape, chime, and interior sign message. It shall be easily accessible to all passengers, seated or standing. Vertical touch tape shall be provided at each window mullion and adjacent to each wheelchair parking position and priority seating positions.   * + *Alternative: Use for pull cord passenger signal.*   A passenger "Stop Requested" signal system that complies with applicable ADA requirements defined in 49 CFR, Part 38.37 shall be provided. The system shall consist of a heavy-duty pull cable, chime, and interior sign message. The pull cable shall be located the full length of the bus on the sidewalls at the level where the transom is located. If no transom window is required, height of pull cable shall approximate this transom level and shall be no greater than 63 inches as measured from floor surface. It shall be easily accessible to all passengers, seated or standing. Pull cable(s) shall activate a solid state or magnetic proximity switch(es). At each wheelchair parking position and priority seating positions additional provisions shall be included to allow a passenger in a mobility aid to easily activate “Stop Requested” signal.  Exception: Guarded yellow touch tape passenger signal under flip seat at Wheelchair stations, and a minimum 15" above the floor. |

**Luminator LED** interior sign with red letters, or, optionally, LCD sign (WVGA x 4, 250:1 contrast, 400 cd/m2) controlled through the Radio VLU (CUSTOMER-provided).

An auxiliary passenger “Stop Requested” signal shall be installed at the rear door to provide passengers standing in the rear door/exit area convenient means of activating the signal system. The signal shall be a heavy-duty push button type located above rear door on the rear door actuator compartment access panel or on stanchion near the exit door. Button shall be clearly identified as “Passenger Signal.”

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| * + ***Baseline****: No requirements for additional Stop Request button on rear door stanchion.* * *Alternative: Use for requirements for additional Stop Request button on rear door stanchion.*   A heavy-duty “Stop Request” signal button shall be installed on modesty panel stanchion adjacent to the rear door and clearly identified as “Passenger Signal.” |

A single "Stop Requested" chime shall sound when the system is first activated. A double chime shall sound when the system is first activated from wheelchair passenger areas. Neither shall repeat until the door is cycled.

Exit signals located in the wheelchair parking area shall be no higher than 4 feet above the floor. Instructions shall be provided to clearly indicate function and operation of these signals.

#### FIRE DETECTION / Fire suppression system

No fire suppression system shall be provided so long as the battery management system is capable of thermally monitoring by redundant sensors internal to the modules the internal temperature. If the temperatures became high enough to effect performance, the Battery Management System shall de-rate power until the temperature is reduced. If the temperatures continue rising the control system shall disable the vehicle. The internal temperature at which the vehicle is disabled shall be approximately 50°C realizing that in general, Lithium Titinate batteries reach thermal instability around 200°C.

### ELECTRICAL, ELECTRONIC AND DATA COMMUNICATION SYSTEMS

#### GENERAL REQUIREMENTS

This section encompasses electrical, electronic and data communication systems installed on-board the vehicle.

General requirements for the electrical system shall be as specified in Subsection 5.5.3. The Electrical System consists of the vehicle batteries and all other equipment that generate, distribute and use battery power throughout the vehicle (e.g., drive system batteries, inverters, motor drives, contactors, high voltage fuses, high voltage switches, wiring, relays, and connectors).

General requirements for electronics shall be as specified in Subsection 5.5.4. Electronics are those components of the electrical system made up of discrete solid-state devices such as transistors, resistors, capacitors and diodes that are part of individual vehicle systems. Electronics also include the integrated circuits that are part of microprocessors that allow individual vehicle systems to process and store data.

Data Communication Systems shall be as specified in Subsection 5.5.5. These systems consist of the bi-directional communications networks that electronic devices use to share data with other electronic devices and systems. Communication networks are essential to integrating electronic functions both onboard the vehicle and off.

Data Communications Systems are divided into three levels to reflect the use of multiple data networks.

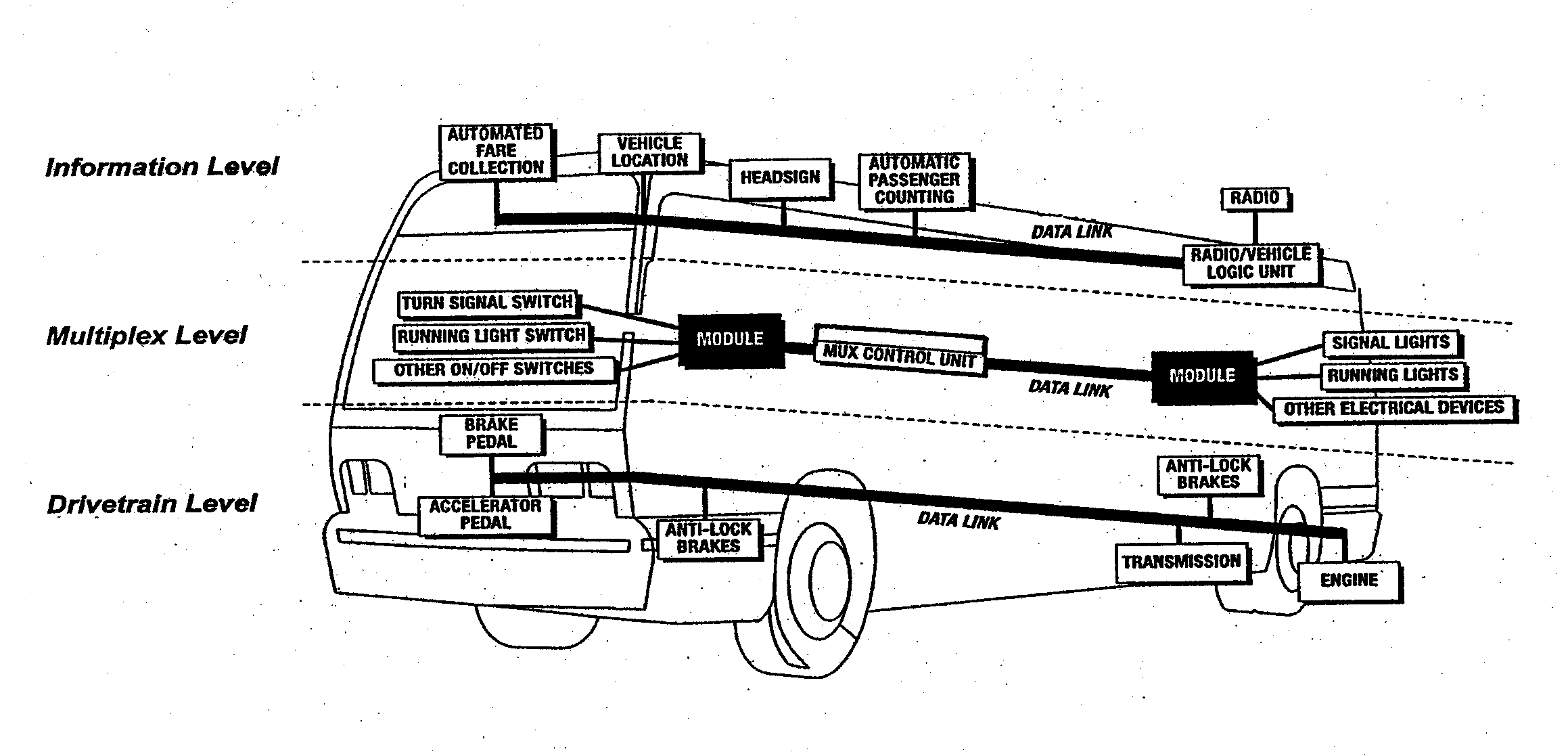
**1)** Information Level – Components whose primary function is the collection, control or display of data that is not necessary to the safe drivability of the vehicle (i.e., those functions, that when inoperable, will still allow the vehicle to operate). These components typically consist of those required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

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

**3)** Drivetrain Level – Components related to the drivetrain including the drive motor , transmission, and anti-lock braking system (ABS), which may include traction control.

Central Data Access, a concept where all on-board data is made available at one location, is detailed in Subsection 5.5.6.

Responsibilities for system integration and testing by CUSTOMER, vehicle manufacturer, and the sub-system supplier or other third party integrator shall be as specified in Subsection 5.5.7.



* + - 1. Provisions for up to 3 GPS/ WiFi antennas on the operator’s side.
      2. All Radio interfaces shall be integrated through the Radio Vehicle Logic Unit (VLU).

Additional information and guidance concerning the application and integration of advanced electronics can be found in the Appendix.

##### MODULAR DESIGN

Design of the electrical, electronic and data communication systems shall be modular so that each major component, apparatus panel, or wiring bundle is easily separable with standard hand tools or by means of connectors. Each module, except the main body wiring harness, shall be removable and replaceable in less than 1 hour by a 3M mechanic. Power plant wiring shall be an independent wiring module. Replacement of the drive system compartment wiring module(s) shall not require pulling wires through any bulkhead or removing any terminals from the wires.

#### 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, except as modified by the temperature requirements provided in the table “Temperature Extreme Summary Heavy-Duty Transit Bus” and figure “Heavy-Duty Transit Bus,” found in the Appendix A.

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. No vehicle component shall generate, or be affected by, electromagnetic interference or radio frequency interference (EMI/RFI) that can disturb the performance of electrical/electronic equipment as defined in SAE J1113.

CUSTOMER shall follow recommendations from bus manufacturers and subsystem suppliers regarding methods to prevent damage from voltage spikes generated from welding, jump starts, shorts, etc.

##### MOUNTING

All electrical/electronic hardware shall be accessible and replaced by a 3M mechanic in 30 minutes. It shall be mounted on an insulating panel to facilitate replacement. The mounting of the hardware shall not be used to provide the sole source ground, and all hardware shall be isolated from potential EMI/RFI.

All electrical/electronic hardware mounted in the interior of the vehicle shall be inaccessible to passengers and hidden from view unless intended to be viewed. The hardware shall be mounted in such a manner as to protect it from splash or spray.

All electrical/electronic hardware mounted on the exterior of the vehicle, that is not designed to be installed in an exposed environment, shall be mounted in a sealed enclosure.

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

#### GENERAL ELECTRICAL REQUIREMENTS

##### BATTERIES

###### Main Power Supply

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

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| * *Baseline: Two 8D Battery Units*   Two 8D battery units conforming to SAE Standard J537 shall be provided. Each battery shall have a minimum of 1150 cold cranking amps. Each battery shall have a purchase date no more than 120 days from date of release, and shall be fully maintained prior to shipment to CUSTOMER.   * ***Alternative****: Two Group 31 Sealed Lead Acid Maintenance-Free Batteries*, with permanently-sealed servicing ports.   Two (2) Group 31 Series deep cycling maintenance free battery units shall be provided. Each battery shall have a minimum of 700 cold cranking amps. Each battery shall have a purchase date no more than one year from date of release for shipment to CUSTOMER.    *Battery shall be*  ***BCI Group 31M Deep Cycle (P/N: SLI31AGMDPM)*** |

The positive and negative battery terminal ends and cables shall be color-coded with red for the primary positive, black for negative, and another color for any intermediate voltage cables. Heat shrink at the terminal ends of the aforementioned colors may be used on battery cables with black insulation. Battery cables shall be flexible and sufficiently long to reach the batteries with tray in the extended position without stretching or pulling on any connection and shall not lie directly on top of the batteries. Except as interrupted by the master battery switch(s), battery wiring shall be continuous cables with connections secured by bolted terminals; and shall conform to specification requirements of SAE J1127 –Type SGT or SGX and SAE Recommended Practice J541.

**Sure Power or Vanner, 12 volt** min. 200-amp charging system shall be provided. The DC-DC Converter shall provide 24 V with 300A of capacity.

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| * *Baseline: No requirements for jump-start connector.* * **Alternative***: Use for requirements for jump-start connector.*   Jump-start connector shall be provided in the Drive system compartment equipped with dust cap and adequately protected from moisture, dirt and debris. See Attachments to Section 5 for details on type of connector required.   * *Alternative: Use for requirements for jump-start connector.*   Jump-start connector shall be provided as close, electrically speaking, to the batteries as possible. The jump-start connector shall be equipped with dust cap and adequately protected from moisture, dirt and debris. See Attachments to Section 5 for details on type of connector required. |

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###### Dedicated Electronic Power Supply

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

###### Master Battery Switch

A single master switch shall be provided near the battery compartment for the disconnecting of all battery positives (12V & 24V) except for safety devices such as fire suppression system and other systems as specified. The location of the master battery switch shall be clearly identified on the exterior access panel, be accessible in less than 10 seconds for de-activation, and prevent corrosion from fumes and battery acid when the batteries are washed off or are in normal service.

Turning the master switch “OFF”, with the power plant operating, shall not damage any component of the electrical system. The master switch shall be capable of carrying and interrupting the total circuit load. Any equipment that requires power with the master battery switch “OFF” shall be listed in attachments to Part 5: Technical Specifications.

* **Baseline***: Single battery disconnect switch*

The batteries shall be equipped with a single switch for disconnecting both 12V & 24V power.

* *Alternative: Separate switches*

The batteries shall be equipped with separate switches for disconnecting 12V & 24V power.

* *Alternative: Remote Power Contactor*

The batteries shall be equipped with a single power contactor (normally open) solenoid that is controlled by a dash-mounted switch.

##### Power generation and distribution

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

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

The vehicle manufacturer shall provide to CUSTOMER both at time of bid and actual production an analysis of the estimated electrical load for each system.

TABLE 20 – REPRESENTATIVE EXAMPLES OF STATIC ELECTRICAL LOADS

(With batteries fully charged)

|  |  |  |  |
| --- | --- | --- | --- |
| Footnote | Components | 24V Load  Amps | 12V Load  Amps |
| 1 | Interior Lights (all) | 22.8 | 8.5 |
| 1 | Intercom (inside and outside) | 8.5 | 6.6 |
| 1 | Turn Signal (right) | 10.6 | 10.4 |
| 1 | All Hazard Flashers | 12.7 | 12.9 |
| 2 | Radio, Farebox, Destination Signs, Rear Camera, and Step Well Lights | 26.1 | 11.8 |
| 3 | HVAC and all applicable devices | 150.0 | N/A |

FOOTNOTE Legend:

1 - High Voltage off and Master Run Switch in the “day run” position

2 - High Voltage off and Master Run Switch in the “night run” position

3 - High Voltage enabled and Master Run Switch in the “day run” or “night run” position

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

###### PROPULSION BATTERY SYSTEM

The energy management system design shall be a holistic integrated system with safety set as the absolute top priority. There are to be three main sections to this system: 1) the mechanical design 2) the electrical design and 3) the control system interacting with the battery system.

The mechanical aspect shall start with the vehicle body structure surrounding the battery packs, then continue through to the enclosure structure encasing the battery modules and works its way down into the actual module designs and inherent properties of the chemistry. On the electrical front, the high voltage cabling for the system shall be safely enclosed by both the vehicle body structure and steel access panels. These cables shall utilize industry standard shielding and insulation as well as a low voltage interlock circuit that provides an automatic de-energizing feature that will enact if a high voltage box is opened. The controls system shall be designed to optimize safety and performance by monitoring interactions of all of the sensors and vehicle information. The controls system shall incorporate major components inside each battery as well as an overall battery system controller and an overall bus system controller.

**Mechanical Design:**

The complete battery pack system shall reside under the bus within the vehicle wheel base (between front and rear axles). The body design shall be a fully composite structure that has several advantages over other materials in terms of corrosion, strength, weight, and reactivity. An additional major safety feature of this design shall be that it is a natural electric insulator. The body will incorporate four primary composite stringers that run the length of the body, surrounding the battery boxes between the front and rear axles. Each of these four stringers shall incorporate full-length, pultruded carbon fiber stringers that maximize strength to weight ratio and add stiffness and rigidity to the battery box surround. This positioning will provide two external cavities where battery packs can be secured away from the passenger compartment, and protected by the most robust beam structure of the composite body. The vertical location of the battery boxes behind these beams is also to be located below bumper height of most vehicles to protect from direct side impact. This location shall provide for an extremely low center of gravity as well as an ideal weight distribution. The chemistry portion of the battery system is comprised of 8 packs. These packs are to be configured in a parallel architecture with four resting in each body cavity. The packs are mounted with ten fasteners per pack in a two planes, and are to be easily accessible for service. Each pack shall be approximately 515 pounds, so that managing the weight is very reasonable with access to a small lift or jack.

Each pack shall be a composite structure in and of itself that lends individual protection to that subcomponent. The laminate schedule for the pack shall include features including a Kevlar layer to protect for road hazards that may pose a penetration risk. The pack shall be designed to be sealed to IP66/7 and ANSI/ISE 60529-2004 standards. The pack shall also contain electrolyte should a cell leak (pursuant to SAE J1766) and meet 1,000 hours salt spray per ASTM B 117 testing. The packs shall be designed to handle 5g half-sine peak shock accelerations. The modules, and therefore cells, internal to the packs are to be cooled via a recirculating air system. This air is to be reconditioned and cooled by a small radiator in each pack that uses a vehicle-based water/glycol cooling system. The vehicle-based system shall include a chiller integrated with the HVAC system that runs as needed if the ambient environment is too warm for the cell manufacturer desired system set-points. The recirculated air system in the battery packs shall allow the pack to be sealed, so there is no concern regarding debris or contaminant ingestion. Using an internal air-cooled system should also allow for more uniform cooling as well as reducing potential failure modes associated with leaks inside of the pack. Should the cooling system fail, the controls shall monitor and limit operation as a function of temperature, so that the vehicle will function and de-rate performance safely while indicating a fault to the operator. In this way, a cooling system failure should not result in a hard and immediate stop in operation.

Each module shall be designed and delivered by the module supplier, Toshiba. These modules shall provide robust industry-standard cell-level safety. The pack and module system should be designed such that a single cell failure doesn’t propagate to nearby cells.

**Electrical Design:**

The battery system shall be comprised of eight individual battery packs and a battery management system. The wiring from each pack is to be insulated and shielded to industry standards and pass into the third, center cavity formed between the stringers under the vehicle. The center cavity shall provide a protected route the length of the bus back to the high voltage junction box in the rear compartment of the vehicle. This is where the individual batteries shall all be bussed together to provide for one high voltage electrical system. Running along this route, with the high voltage cables shall be the high voltage interlock circuit and control wires for the battery system.

Each pack shall have a high-speed fused safety disconnect as well as an internal set of contactors. The contactors shall be near the pack outputs while the safety disconnect is to be in the center of the battery’s series stack of cells. This design should not only provides a physical disconnect to provide more certainty of safety, but it also divides the internal pack voltage by two reducing the voltage potential technicians could be exposed too. Removing the safety disconnect should also open the high voltage interlock loop (HVIL) and serve as the individual pack fuse holder.

Internal to each pack shall be an individual pack controller. This shall serve as a central hub to gather and report information specific to that pack. Each module shall have a monitoring board that measures voltage of each cell and performs cell balancing. This information is to be communicated to the pack controller via serial communication.

**Control System:**

The battery control system shall be a hierarchical control with the energy storage module (ESM) acting as the interface and lead controller to the rest of the battery system and to the rest of the vehicle system. This module shall communicate on the main vehicle CAN bus to interface with the cooling, powertrain, charge and other systems. This module shall also communicate on the separate battery CAN bus with all of the individual packs. The main controller interface shall exchange information about battery input and output capability as well as cooling needs and diagnostic information.

The pack controllers shall control fan speed internal to the pack as well as the contactors. They shall also gather the current information as well as pack voltage, cell voltage, and temperature information. This data is be provided back to the master controller as well as being selectively captured for battery warranty information. The master controller shall use this information to compute system limits, determine health, and ultimately apply system-wide boundaries on use. All of the contactors in the system shall have feedback to allow the system to know if there is a potential for high voltage to be present when it shouldn’t be. The temperature measurements in the pack are to be redundant. There shall also be sensors to detect moisture as well as monitoring to ensure that the current distribution between the pack is within an acceptable range. Should loss of communication occur with a pack or module, the system shall gracefully handle this with independent default actions.

The battery control system shall provide system discharge limits to ensure that the lowest cell never goes below its minimum and the system charge limit to ensure that the highest cell never goes above its maximum. The system shall also comprehend current imbalance between the packs, temperatures throughout all of the packs, moisture, and isolation detection.

The control system shall provide fidelity that meets or exceeds all requirements established by CUSTOMER.

Charge control shall be performed through a separate slave controller that obeys all power limits communicated by the ESM. This operation shall be audited by a third controller that has the ability to terminate the charge operation. The actual charge handshake shall be very similar to SAE J1772. The power levels at which the charge process utilizes shall require a different message structure to handle the current commands. This is because the J1772 protocol does not reach the power levels that the charges at.

##### circuit protection

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

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

Circuit breakers or fuses shall be sized to a minimum of 15 percent larger than the total circuit load current. The current rating for the wire used for each circuit must exceed the size of the circuit protection being used. Wire and cable ampacity for wire sizes 18 AWG and larger shall be in accordance with the Wire Ampacity Chart found in Appendix B.

##### GROUNDS

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

##### WIRING AND TERMINALS

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

Wiring shall be grouped, permanently numbered, and color-coded. Wiring harnesses shall not contain wires of different voltage classes unless all wires within the harness are insulated for the highest voltage present in the harness. Kinking, grounding at multiple points, stretching, and exceeding minimum bend radius shall be prevented. All wiring shall be labeled where it is terminated at fuse blocks, circuit breakers, and load devices, e.g. heater water pump, tail lights etc. The labels shall be affixed in a manner where they will not be easily removed or made illegible by dirt, grease or oil. All connectors shall be marked in the same manner as the wiring. The provided wiring schematics shall give locations of the connectors on the bus as built, not generic.

Wiring harnesses are to be properly routed and supported using TYRAPS.

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

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

All wiring harnesses over five feet long and containing at least five wires shall include 10 percent (minimum one [1]) excess wires for spares. This requirement for spare wires does not apply to data links and/or communication cables. Wiring length shall allow end terminals to be replaced twice without pulling, stretching, or replacing the wire. Except for large wires such as battery cables, terminals shall be crimped according to connector manufacturer’s recommendations for techniques and tools 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. Battery cable connectors shall be crimped and soldered or machine-crimped and bonded in place with adhesive heat shrink. Adhesive heat shrink should cover the crimped portion of the terminal and the cable insulation.

Terminals shall be crimped, corrosion-resistant and full ring type or interlocking lugs with insulating ferrules. When using pressure type screw terminal strips, stranded wire only shall be used. Insulation clearance shall ensure wires have a minimum of “visible clearance” and a maximum of two (2) times the conductor diameter or 1/16 “, whichever is less. When using shielded or coaxial cable, upon stripping of the insulation, the metallic braid shall be free from frayed strands that can penetrate the insulation of the inner wires.

For shielding and coaxial requirements refer to Section 5.5.4.1.2.

Ultra-sonic and T-splices may be used with 7 AWG or smaller wire, and power cables on limited applications (as approved by CUSTOMER). When a T-splice is used it shall meet these additional requirements: include a mechanical clamp 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.

For wiring harness connectors, pins shall be removable, crimp contact type of the correct size, and rated for the wire being terminated. Where feasible, all supply-side terminations shall end in a socket, not a pin. Unused pin positions shall be sealed with sealing plugs. Adjacent connectors shall either use opposing pin genders, different insert orientations, or different connectors to prevent incorrect connections. All cable connectors shall be placed to provide adequate space for ease of removal and disconnection. All electrical connectors subjected to environmental exposure outside the passenger compartment shall be corrosion resistant and splash proof.

##### ELECTRICAL COMPONENTS

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

All electric motors shall be either heavy-duty brushless type where practical, or have a constant duty rating of no less than 40,000 hours. All electric motors shall be easily accessible for servicing. All motors to be brushless are listed in attachments to Section 5: Technical Specifications.

##### ELECTRICAL COMPARTMENTS

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

#### GENERAL ELECTRONIC REQUIREMENTS

If an electronic component has an internal clock, it shall provide its own battery backup to monitor time when battery power is disconnected for routine preventive maintenance.

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 (Refer to SAE J1455). Use of resistors, if necessary, to be reviewed and approved by CUSTOMER.

##### WIRING AND TERMINALS

Kinking, grounding at multiple points, stretching, and exceeding minimum bend radius shall be prevented. Any sources of abrasion shall be prevented. Wiring and harnesses shall be the appropriate length for the circuits supplied. No "baling" of wiring or harnesses is acceptable. Heat shrink is required on all exposed terminals at crimped or soldered areas. No butt splices are permitted to complete a wire length within a given wiring harness to a connector, terminal, or plug.

###### 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.

###### Shielding

All wiring that requires shielding shall meet the following minimum requirements. All wiring that requires shielding to prevent noise and crosstalk. 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 end 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. Shielding in high heat area shall be identified after contract award and subject to CUSTOMER review and approval.

###### 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. Further information on the physical wiring requirements associated with some available communication protocols in common use can be found in Appendix C.

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

###### 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 attribute 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.

###### Audio

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

##### MULTIPLEXING

###### 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 Section 5.5.5.3.

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

Ten percent (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 shall be approved after contract award.

|  |
| --- |
| * **Baseline***: Multiplexing required.*  ***Continental VDO KIBES System***   Versatility and future expansion shall be provided for by expandable system architecture. The multiplex system shall be capable of accepting new inputs and outputs through the addition of new modules and/or the utilization of existing spare inputs and outputs. All like components in the multiplex system shall be modular and interchangeable with self-diagnostic capabilities. The modules shall be easily accessible for troubleshooting electrical failures and performing system maintenance. Multiplex input/output modules shall use solid-state devices to provide extended service life and individual circuit protection. SAE J1939 output shall be required, as defined by Appendix ‘E’. |

###### 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.

###### 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 (0-12V, 10-24V, etc) or current signal (4-20ma). 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.

#### DATA COMMUNICATIONS

##### 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 CUSTOMER 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.

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

All components on the Drivetrain network shall communicate data over the network as specified in Section 5.5.5.2. The Multiplex Level shall use a communications network that meets the requirements of Section 5.5.5.3. Components integrated on the Information Level shall communicate data over the network selected in Section 5.5.5.4.

##### drivetrain level

###### General

Drivetrain components, consisting of the motor, motor inverter, transmission, anti-lock braking system, and all other related components shall communicate data using a combination of the SAE Recommended Communications Protocols J1939 and/or J1708/J1587, or other open protocols as referenced in Section 5.5.5.1.

###### Diagnostics and Fault Detection

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 functions. A laptop compatible source of power (24VDC – 28VDC to 110VAC source) shall be available in the operator area subject to CUSTOMER approval on 1st article.

OBD connections shall be available to view and/or retrieve diagnostic data, to the extent practicable.

###### Data Access

|  |
| --- |
| * ***Baseline****: Drive System Compartment and Operator Area Diagnostic Data Port.*   Access to Drivetrain data shall be provided through diagnostic device connector ports in the front and rear electrical compartments. Data transfer from the Drivetrain Level to the Multiplex Level, Information Level, and Central Data Access System shall comply with Sections 5.5.5.3, 5.5.5.4, and 5.5.6 respectively.  A laptop compatible source of power (24VDC – 28VDC to 110VAC source) shall be available in the operator area subject to CUSTOMER approval on 1st article.   * *Alternative: Additional diagnostic device connector ports*. |

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 functions.

###### Programmability (Software)

The Drivetrain Level components shall be programmable by CUSTOMER with limitations as specified by the sub-system supplier. All programmable firmware and software necessary to support bus operations in revenue service shall be provided to CUSTOMER. Software will be required for a PC application (compatible with the current Microsoft operating system) in order to test and verify on-board diagnostics at the Manufacturer's site.

##### MULTIPLEX LEVEL

###### 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. A hardware gateway and/or wireless communications system are options if requested by CUSTOMER in Worksheet 5.5.5.4.4.1. The communication port(s) shall be located as specified by CUSTOMER in attachment to Part 5: Technical Specifications.

* *Baseline: No requirement for Wireless Communication Port.*

###### 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 hand held unit. Either unit shall have the ability to check logic function. The diagnostic data can be incorporated into the Information Level Network (5.5.5.4.3.1.2) or the Central Data Access System (5.5.6).

An optional Mock-Up Board can be used for diagnostics, design verification, and training.

|  |
| --- |
| * *Baseline: No requirement for Mock-Up Boards* |

###### 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 insure 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.

###### Drive Motor/Auto Shift Gearbox

Provisions will be made for the CUSTOMER radio J1939 to be interfaced to the drive motor and auto shift gearboxJ1939 data bus. The multiplex system will also be interfaced with the J1939 data bus.

***It is CUSTOMER's intent for the radio to transmit a J1939 code to the multiplex system. This code will authorize the multiplex system to shut down the engine, thereby rendering the vehicle immovable.***

The radio manufacturer and the multiplex system manufacturer will agree on the format of the code, but the code will be transmitted using standard J1939 protocol. CUSTOMER will provide parameters that must be met before the multiplex system shuts down the vehicle.

##### INFORMATION LEVEL COMPONENT INTEGRATION

###### General

The purpose of this section is to assist CUSTOMER in specifying which Information Level components are to be installed, and provide a consistent integration interface.

Information Level components are those components whose primary function is the transmission of data to a system outside the vehicle; and/or the collection, control or display of data on the vehicle, none of which is necessary to the safe operation of the vehicle.

Information Level components can function independently of each other, or can be integrated with other components through a communications network to achieve greater functionality.

*NOTE: Sub-section 5.5.5.4.2 is a guideline specification for the common functionality for all Information Level components. The remainder of the Information Level section is NOT to be considered as a specification, but is instead a series of checklists that CUSTOMER can use to select a communications network, pre-wired cabling, and specific Information Level components with optional features.*

*The process of selecting Information Level components begins with a single checkbox found in sub-section 5.5.5.4.3. It provides an overall indication of the Information Level features and components that CUSTOMER wants installed. Individual Worksheets in sub-section 5.5.5.4.4 are then used to indicate:*

* *Components to be installed as part of this procurement, or into these vehicles at a later time by CUSTOMER or third-part supplier;*
* *If the component is to be integrated on a communications network;*
* *If the Human Machine Interface (HMI)/Radio VLU (CUSTOMER-provided) is to be a separate device or integrated with other networked components; and*
* *How the component is to be programmed.*

###### General Component Specifications

All Information Level components selected by CUSTOMER shall be networked on the Information Level, unless otherwise specified on the corresponding Worksheet, and have the capabilities as outlined in the following sub-sections.

Upgrade Ability

All programmable components shall be capable of upgrade without replacing the component. This is commonly done through EEPROM (flash), or replacement of EPROM(s). The flash upgrade shall be performed by either connecting a hand-held device, by contact-less device, PC Card, or via the network.

Central Control Unit

The Central Control Unit shall be the Radio Vehicle Logic Unit (VLU), to be provided by CUSTOMER. Installation requirements will be provided after contract award.

Instead of using separate devices, the components shall share the central control unit. This typically consists of both a display screen and a method of accepting operator input, usually via keypad and/or touch-screen.

Mobile Data Terminal (MDT)/Vehicle Logic Unit (VLU)

Note: The current practice is to use separate Human/Machine Interface (HMI) devices (e.g., keypads) for each component, which requires the operator to interact with many HMI devices and adds clutter to the operator’s workstation. The use of a single MDT, while not common today, is suggested to reduce the proliferation of distinct HMI devices.

Instead of using separate Human/Machine Interface (HMI) devices, the components shall share the MDT/VLU. This typically consists of both a display screen and a method of accepting operator input, usually via keypad and/or touch-screen.

Diagnostic Data

Component diagnostic data shall be available upon request of the network. If an error condition is self-detected on a component, then that condition, and any relevant diagnostic data, shall immediately be broadcast on the network.

Automatic/Manual Override

Any component that is controlled from the network shall have a means of providing an override. This override will then allow the operator to manually set/configure the device. This type of override is typically for disabling automatic update of route-displays and/or voice annunciation. If a Mobile Data Terminal (MDT) is specified, it shall provide this override functionality.

Power Requirements

To prevent battery drain, power shall not be supplied from the unswitched side of the Master Battery Switch. Unless otherwise specified, all components shall receive their power source from either a circuit enabled with the master-run switch, or have an internal timer that is configurable to place the component into a deep-sleep mode.

Unless otherwise specified, every electronic component shall be designed to operate at 12V and 24V with required power filtering provided by the individual component.

When multiple microprocessor-based components require a minimum sustained voltage of 9VDC, and also a clean (filtered) power source, it may be more cost effective to specify a shared DC/DC converter and/or dedicated electronic power supply as specified in 5.5.3.1.2. Requirements for a shared DC/DC converter are contained in attachments to Part 5: Technical Specifications.

Real Time Clock

Any networked component that maintains its own time shall allow that time to be updated via the network.

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###### Information Level Components

CUSTOMER shall use the following checkbox to select the Information Level features and components to be installed. After selecting component(s), CUSTOMER then completes the corresponding worksheet(s), which further define the options for each component.

|  |
| --- |
| * VEHICLE AREA NETWORK (VAN) 5.5.5.4.3.1 * ELECTRONICS (RADIO) BOX 5.5.5.4.3.2 * CENTRAL CONTROL UNIT 5.5.5.4.3.3 * RADIO 5.5.5.4.3.4 * EXTERNAL PASSENGER INFORMATION SYSTEM 5.5.5.4.3.5 * VOICE ANNUNCIATION 5.5.5.4.3.6 * PASSENGER STOP REQUEST SIGN 5.5.5.4.3.7 * COVERT EMERGENCY ALARM 5.5.5.4.3.8 * PUBLIC ADDRESS SYSTEM (PA) 5.5.5.4.3.9 * AUTOMATIC VEHICLE LOCATION (AVL) 5.5.5.4.3.10 * AUTOMATIC PASSENGER COUNTER (APC) 5.5.5.4.3.11 * AUTOMATIC FARE COLLECTION ***Provisions ONLY*** 5.5.5.4.3.12 * CLOSED CIRCUIT TV (CCTV) 5.5.5.4.3.13 * AUTOMATED EVENT RECORDING (AER) FLEET SAFETY SYSTEM (Opt) 5.5.5.4.3.14 * TRANSIT SIGNAL PRIORITY (TSP) 5.5.5.4.3.15 * WIRELESS AREA NETWORK (WAN) 5.5.5.4.3.16 * VEHICLE DATA LOGGER (VDL) 5.5.5.4.3.17   🞏 Other: |

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Vehicle Area Network (VAN)

* **Required, complete Worksheet 5.5.5.4.4.1**
* Not required

The Information Level network shall consist of an open and published data protocol that allows component manufacturers to interface to the network and communicate with other components.

*NOTE: The FTA recommended Vehicle Area Network is SAE J1708/J1587, or latest version as required by Appendix(s) E through I; which is used as the baseline in the corresponding worksheet. Alternative networks may be specified due to considerations such as component cost, compatibility, availability, and data transmission speeds. Any alternative network selected shall comply with the requirements of Section 5.5.5.1.*

*Due to the evolving nature of on-board communications networks and Intelligent Transportation System (ITS), Procuring Agencies are requested to keep informed of the most recent guidance concerning on-board communications networks.*

Network Cabling

* **Required, complete Worksheet 5.5.5.4.4.1**
* Not required

The cabling shall be as required by the specifications of the selected VAN protocol. Pre-wiring the vehicle with data communications cabling will minimize the cost of installing the cabling and additional Information level components after delivery.

*Note: For the FTA recommended VAN protocol of SAE J1708/J1587, or latest version as required by Appendix(s) E thru I; the cabling shall meet the requirements of SAE J2496.*

Network access points shall be located as specified by CUSTOMER in the corresponding worksheet.

Network Integration With Other Networks

* Required, complete Worksheet 5.5.5.4.4.1
* **Not required (CUSTOMER will provide and install after delivery. Verification of operation to be provided at factory.)**

There shall be a gateway installed between the Information Level network and all other vehicle networks.

The gateway(s) shall provide a translation between network protocols of information specified in the worksheet; and a filter to prevent overloading of any network level, and to prevent network transmissions to the Drivetrain Level.

Electronics (Radio) Box

* **Required,** complete Worksheet 5.5.5.4.4.2
* Not required

A location shall be provided for installing Information Level equipment, including the radio. The Electronics Box shall be located as agreed upon between CUSTOMER and vehicle manufacturer. It shall be sealed against moisture from road spray or washing equipment if located in an exposed area. This location shall provide:

1. Securable sliding mounting rack(s) that can accommodate a minimum of three (3) components with component dimensions of 17”x 24”x 6”. Alternate sizes to be determined after contract award.
2. Supplied “clean” power as specified in the corresponding worksheet.
3. VAN network connection (if pre-wired).
4. Keyed access as specified in the corresponding worksheet.
5. Fan forced ventilation depending on location. (As required to meet component OEM’s design/operating parameters.)

Mobile Data Terminal (MDT)

* **Required,** complete Worksheet 5.5.5.4.4.3
* Not required -- Power and provisions for CUSTOMER provided VLU.

The MDT shall consist of a display area, input keys, and shall be mounted in accordance with sections 5.4.6.1.3 and 5.4.6.1.5. The MDT shall be of sturdy construction and sealed against moisture from washing equipment.

Radio

* **Required,** complete Worksheet 5.5.5.4.4.4;
* Not required.  **Integrated with Radio system.** (***Provisions ONLY).*** Requires mounting, wiring and power provisions.

CUSTOMER shall provide a set of equipment (radio with VLU) for pilot mock up.

The radio includes an operator speaker, handset and cradle, and shall be programmable with multiple channels. A location convenient to the operator shall be provided for the radio control head, speaker, handset, and cradle. The location shall conform to SAE Recommended Practice J287 “Driver Hand Control Reach.” An interior location shall be provided for the radio box.

Provisions for attaching an antenna to the roof and routing an antenna lead to the radio compartment shall be provided. Antenna mounting shall conform to the electromagnetic suppression requirements of SAE J551. A roof mounted radio antenna requires a ground plane to prevent electronic noise being generated inside the vehicle. A metal roof can serve as a sufficient ground plane; however a fiberglass roof requires either a metallic surface, or an antenna with a virtual ground plane. To test and repair antenna connections, quick access shall be provided at the point where the antenna is mounted to the roof and where the antenna cable attaches to the antenna.

External Route Display (ERD)/External Passenger Information Signs

* **Required, complete Worksheet 5.5.5.4.4.5 Luminator Spectrum LED.**
* Not required

An ERD shall provide capabilities for front, side, and rear signs, and will meet all applicable Federal ADA requirements. The ERD shall be installed into the vehicle as specified in Section 5.4.9.1.

The front sign shall have a displayable area no less than 8”h by 50”w, and allow display of at least 12 alphanumeric characters of 7” height. The side sign shall have a displayable area no less than 2.7”h by 30”w, and allow display of at least 12 alphanumeric characters of 2.5” height. If optional curtain type signs are not selected, the rear sign shall have a displayable area no less than 6”h by 11”w, and allow display of at least 4 alphanumeric characters of 5” height.

An optional “Block” sign can be specified for placement on the dash. If selected it shall be capable of displaying at least five alphanumeric characters of 4” height.

A complete listing of sign messages, for initial configuration by the manufacturer, is provided in attachments to Part 5: Technical Specifications.

Baseline signs will be of electronic design, with the following requirements.

1. The bus “Master Run” switch shall control power to the ERD, and shall be operable in all switch positions except "Off". After the “Master Run” switch is placed in the “Off” position, all signs shall blank within 30 seconds, before powering down.
2. An emergency message may be specified by CUSTOMER, which will only be displayed on exterior signs and not the HMI, initiated by method(s) specified by CUSTOMER, and reset by method(s) as specified by CUSTOMER in Worksheet 5.5.5.4.4.8
3. Via the sign programming software, each sign shall be separately configurable, with an option for all signs to be consistently configured from a single alphanumeric message. Signs shall have alternating message capability with selectable transition effects.
   1. The rear run sign shall display a wheelchair icon or “Ramp In Use” when the wheelchair ramp has been activated. The programming permissive logic is as follows:
      1. Front door open.
      2. Wheelchair ramp power switch activated.
      3. One or more of the three(3) following states exists:
         1. Service brake is applied, and/or
         2. Door interlock is engaged, and/or
         3. Accelerator lockout is engaged.
      4. Rear destination sign displays “Ramp in Use” or wheelchair icon. Should flash alternatively with the rear route/run number display, if programmable.
      5. The sign should return to the original route programmed state by the display, after the wheelchair ramp is stowed and the wheelchair ramp power switch is deactivated.
4. The front sign shall have pixel elements of at least 16 rows by 105 columns. The side sign shall have pixel elements of at least 7 rows by 80 columns. The rear sign shall have pixel elements of at least 7 rows by 23 columns.
5. LEDs and LCDs shall not fade or discolor for the life of the bus, and shall have a rated life of at least 100,000 hours.
6. Requirement for a full color sign display on the Front, Side and Dash signs, and amber ONLY on rear route sign.

The Operator Control Unit (OCU), in conjunction with the Vehicle Logic Unit (VLU), shall provide a single operator log-on for electronic devices on the transit vehicles. The OCU shall provide a display and keypad, which are specifically adapted for transit operations. The OCU shall have the functionality to update both the destination signs and the voice annunciation system.

* **Required, complete Worksheet.**
* **Option, Not required (*Provisions only - - for connection to Destination Sign*.)**

Voice Annunciation and Signage System (VASS)

* Required, complete Worksheet 5.5.5.4.4.6
* **Not required** (***Provisions ONLY - - for connection to internal and external speakers***.)

The VASS system shall be capable of providing visual and audible announcements that meet all applicable “Federal ADA” requirements. There shall be a capability to make announcements both inside and outside the vehicle by utilizing the Public Address System (section 5.5.5.4.3.9). The Passenger Stop Sign (section 5.5.5.4.3.7) may be integrated with the VASS to minimize the number of onboard customer information displays. Automatic gain control shall be provided both internally and externally to adjust audio volume based on ambient noise levels. At least one internal sign shall be visible from any passenger area inside the vehicle.

The VASS usually requires some form of on-board AVL, and shall not duplicate this functionality if it is already provided by another on-board AVL system.

The voice announcement system shall be the single log-on for other in-vehicle electronics systems (such as; destination/header signs systems, and fare collection systems). The system shall include an easy-to-use means of specifying whether log-on and/or passwords are required, and what vehicle operator ID's and passwords are acceptable for each sub-system.

The Vehicle Logic Unit (VLU) shall provide the hardware and software necessary to coordinate audio announcements and sign displays and to communicate with other electronics as required and be capable of handling additional software or hardware features to meet future requirements.

Passenger Stop Request Sign

* **Required, complete Worksheet 5.5.5.4.4.7**
* Not required

Specific requirements for touch tape, pull cord and push button activated Passenger Stop Request Signs are defined in Section 5.4.9.3.

A "Stop Requested" message in red letters shall be illuminated when the passenger "Stop Requested" signal system is activated. The message shall remain visible until one or both passenger doors are opened. The message shall be visible to the seated operator and seated passengers. As an option, this sign could be integrated with other passenger displays.

The operator shall **not** **be** able to deactivate the signal system from the operator's area. A green light shall be mounted above the rear door, approximately on center of the rear door actuator compartment access panel, to indicate when the rear doors have been unlocked.

Covert Emergency Alarm

* **Required, complete Worksheet 5.5.5.4.4.8.**
* Not required

The Covert Emergency Alarm is for the operators use in dangerous situations. The alarm can be integrated with many of the Information Level components: the radio can transmit audio from a listen-in microphone as well as location data from the AVL; the External Route Display can signal an emergency; and the CCTV can tag and save recordings.

Public Address System (PA)

* **Required, complete Worksheet 5.5.5.4.4.9 - - Integrated with Radio system.** (***Provisions ONLY - - for connection to internal and external speakers***.)
* Not required

A public address system shall be provided that complies with the ADA requirements of 49 CFR, Part 38.35 and enables the operator to address passengers either inside or outside the bus. Inside speakers shall broadcast, in a clear tone, announcements that are clearly perceived from all seat positions at approximately the same volume level. A speaker shall be provided so announcements can be clearly heard by passengers standing outside the bus near the front door. An operator-controlled switch shall select inside or outside announcements. A separate volume control shall be provided for the outside system if volume adjustment would otherwise be necessary when switching from inside to outside. The system shall be muted when not in use. A provision shall be provided to secure the microphone in a stored position when not in use. An input jack and mounting clip shall be provided in the operator's area for a hand held microphone. The PA system will be wired to allow the CUSTOMER 900 MHz radio system to provide all PA announcements. All internal and external speaker locations shall require prior approval by CUSTOMER prior to 1st Article production.

Additional requirements for the PA system are defined in attachments to Part5: Technical Specifications.

|  |
| --- |
| *Baseline: Flexible gooseneck microphone.*  The microphone shall be vandal resistant, mounted on a heavy-duty, flexible gooseneck, which is secured with tamper-proof fasteners and will allow the operator to comfortably speak into it without using his/her hands.   * *Alternative: Built-in, hands-free microphone.* * ***Not Required – Provisions only for PA thru CUSTOMER-provided Radio equipment (Handset).*** |

Automatic Vehicle Location (AVL)

* **Required, complete Worksheet 5.5.5.4.4.10**
* Not required -- *AVL system provided thru CUSTOMER-provided Integrated Radio System equipment.*

The on-board AVL system shall calculate current location data, and provide that information to the network at a specified interval, from the time a vehicle leaves the garage to when it returns to the garage. A Global Positioning Satellite (GPS) system shall be used as one source of location input. The AVL system should provide at least one other location referencing method, such as dead reckoning (odometer), gyroscope, and/or signposts. The system shall be able to provide accurate location data when traveling through all environments, including urban canyons and dense tree coverage. For GPS system, the antenna should be located and installed so as to prevent interference between GPS and the radio (36 inches minimum separation at front of bus roof).

NOTE: All on-board AVL systems require an extensive back-end system to configure and update the scheduled route information. This should be a consideration in the selection of an AVL system.

If more than one on-board system is location driven, only one shall be designated as the master.

Automatic Passenger Counter (APC)

* Required, complete Worksheet 5.5.5.4.4.11
* **Not required**

The APC shall be capable of providing passenger counts, both ingress and egress, for every passenger doorway.

Automated Fare Collection (AFC)

* **Required, complete Worksheet 5.5.5.4.4.12: *Provisions ONLY - -*** for two (2) 12VDC Power, one (1) Ground, 15 AMP circuit breaker and mounting provisions for **GFI GenFare CENTSaBILL** system. CUSTOMER shall provide a unit for mock up on pilot and fit check on each production bus. One (1) J1587/J1708 with connectors between the radio box and farebox. Conditioned dead-reckoning location data from integrated Radio system unit shall be provided through J1587 /J1708 connection. Farebox to be provided by CUSTOMER.
* Separate 12V DC power supply with 10 AMP fuse provided for Smart Media processor.
* Not required

An AFC system shall be capable of storing cash and/or electronic payment transaction data. In the case of electronic payment, the AFC shall be capable of reading from and writing to the fare media.

A 15-amp minimum, specified on Worksheet 5.5.5.4.4.12, DC, protected circuit shall be available to power the fare box. This power service shall include a grounded lead with both wires enclosed in a flexible conduit. Installation requirements for the AFC shall be as specified in Section 5.4.4.7.

Closed Circuit TV (CCTV)

* **Required:** Bus shall be initially equipped with surveillance cameras, **GE MobileView** system. Installation shall be for five (5) cameras at interior locations, wire, mounts, and tinted cover subject to CUSTOMER approval on 1st article.
* Not required

The CCTV system shall include cameras, control system, and a recording storage device. The number of cameras and their location shall be specified in the Worksheet. The system shall have the capability of digitally tagging and saving an event. The system module shall be located in a secured location.

The vehicle shall be equipped with the number and placement of cameras as shown in Table 22 below. The cameras shall be mounted to provide a clear view of the entire passenger compartment, and be protected to prevent tampering and vandalism.

The camera system shall have the following characteristics:

1. System shall be compliant with applicable IEEE standards and NECA standards. Supplier shall have a quality control program (ISO 9000 or approved equal) in place.
2. The system shall have a recording capacity of no less than 72 hours and should be programmable to automatically tag events, such as panic button activation or a hard deceleration/impact. Tagged events should be stored, and when a recording is retrieved the tagged events should be easily identifiable.
3. Environmental Conditions:
   1. DVR should be capable of functioning at temperatures of 20 to 135 deg F.
      1. DVR should have a thermal switch to protect the hard drive during operation outside of this temperature range.
   2. Humidity range: 10% to 85% relative humidity, non-condensing.
4. On-board digital video recorder (DVR):
   1. Shall be mounted to protect the DVR against shocks.
   2. DVR shall contain an automotive-grade hard drive.
   3. Power shall be supplied by on-board power management system.
5. Power Management. System shall:
   1. Perform a timed and managed shutdown under the following two conditions:
      1. No later than 15 minutes after the master power switch is turned to the "off" position.
      2. When the vehicle voltage falls below 12 volts.
   2. Perform a managed power-up sequence when the master "run" switch is switched to the "On" position, unless environmental conditions are exceeded.
6. Image Quality and Retrieval.
   1. When viewed on a playback monitor, the image shall occupy no less than 90% of the screen height.
   2. Cameras should be equipped with an automatic exposure control. Maximum aperture size shall be no less than f/2.8, or the equivalent light sensitivity in digital systems.
   3. Camera resolution should be such that a subject may be identified at the maximum field of view.
   4. System shall use (at a minimum) MPEG-4 compression.

**Table 22**

**Camera Locations, Directions of View and Required Depth of Field**

| Camera # | Location and Direction | Minimum Depth of Field | Minimum Width of Field | Frames per Second |
| --- | --- | --- | --- | --- |
| 1 | Over operator's head, looking at Fare Collection Equipment and front (entrance) door | 8 feet | 5 feet | 15 |
| 2 | Above/Below the Front Stop Request Sign, looking rearward of the bus | 25 feet | 8 feet | 5 |
| 3 | Above the street side light panel, facing the rear door, looking at rear door (on 40-foot buses only) | 8 feet | 5 feet | 15 |
| 4 | Rear Wall of bus, looking forward. | 25 feet | 8 feet | 5 |
| 5 | Below the interior rear view mirror, looking outward over the front bumper. | 50 feet | 20 feet | 30 |

1. Image Retrieval and Storage:
   1. It should be possible to retrieve images with a standard laptop or remotely, through a wireless (Wi-Fi) network.
   2. Images should be downloadable from the DVR through USB or RS 232 connection (at a minimum) for transfer to an external source for later playback (e.g., external hard drive or DVD).
2. Maintenance:
   1. Wherever possible, camera components shall be interchangeable, for the ease of maintenance.
   2. Camera components shall be readily accessible, such that a 3M mechanic may change a camera in five (5) minutes or less.

Automated Event Recorder (AER) Fleet Safety Device

* **Option: Complete Worksheet 5.5.5.4.4.14**
* Not required

Bus shall be equipped with the **Automated Event Recording (AER) Fleet Safety (SmartDrive System) device**.

The SmartDrive in-vehicle video-based measured safety program system includes an automated event recorder system (AER) that captures 30 seconds of audio and video inside and outside of a vehicle when triggered by sudden movements, such as swerving, sudden braking and speeding. A professional service reviews and scores these events for operator safety assessments. This information can later be retrieved for use in incident investigation and operator training programs.

The AER shall conform to the following technical specifications.

1.0 General System Requirements

* 1. The system shall be video-based to provide objective and comprehensive insight.
  2. The system shall be exception-based, recording events only upon trigger, to respect the privacy of the operators and supervisors participating.
  3. The system shall support automated data upload to the vendor’s data center for analysis and viewing.
  4. The system shall accurately identify operators associated with events.
  5. The vendor shall review each event, record observations, and score event for severity.
  6. All recorded events, observations, and scores shall be made available for timely viewing online.
  7. The system shall include an integrated training module to record outcomes.
  8. The vendor shall provide training programs to trainers, site managers, and operators, and CUSTOMER-selected account management.

2.0 Data Recorder

* 1. The AER shall include dual camera lenses (internal and external view).
  2. The AER shall provide expansion capabilities to provide up to 4 camera angles.
  3. The cameras shall be detachable to enable optimum placement within the vehicle and independent adjustment of viewing angles.
  4. The internal view camera shall include a wide angle lens (at least 160 degrees) to record both operator and passenger behaviors
  5. The height of the camera shall not exceed 6 mm to ensure maximum operator visibility.
  6. The AER shall support video resolution of at least 752x480 pixels, WVGA format.
  7. The AER shall incorporate an infrared night illuminator.
  8. The AER shall include internal storage of at least 1GB, and must be able to hold at least 200 events locally
  9. The AER shall record a minimum of 30 seconds, including at least 15 seconds prior to the trigger.
  10. The system shall record at a minimum of 4 frames per second.
  11. The AER shall record audio
  12. The AER shall include integrated NMEA protocol GPS.
  13. The AER shall contain a vehicle interface device compatible with 16-pin OBDII and 6-pin or 9-pin J connectors, and capable of communicating with J1939, J1708, and J1939 Engine Control Unit (ECU) protocols.
  14. The system shall support an operating temperature range of at least -40C – 85C.
  15. The system shall be manufactured by the vendor according to ISO 9001-2000 standards.
  16. The system shall include security and tamper-resistant features.
  17. The system shall include a 1-year warranty on all major components.

3.0 Triggering Methodology

* 1. The system shall include a g-force accelerometer.
  2. The system shall include an adjustable speed-based trigger.
  3. The system shall include a manual trigger mounted in the vicinity of the operator.
  4. The system shall be able to manage triggering sensitivity levels and customize them for a specific application.
  5. The system shall be able to filter out extraneous triggers from uneven roads, engine vibration, etc.
  6. The system shall accommodate different types of accelerometer triggers can you support simultaneously for real-time processing.
  7. Please list the unique types of triggering algorithms that you support.
  8. Please list the specific vehicle maneuvers/events can your triggering algorithms identify.

4.0 Data Transmission

* 1. The system shall support Wi-Fi protocol 802.11 b/g/n.
  2. The system shall support Wi-Fi security WPA2, WPA, and WEP.
  3. The system must support 3G mobile wireless.

5.0 Operator Identification

* 1. The program shall enable operator identification through integration with operator dispatch system.
  2. Changes and corrections to operator identification shall be possible from the video player.

6.0 Event Review Process

* 1. Event review shall be conducted with 24-hour maximum turnaround.
  2. Each event shall be reviewed for fundamental driving errors, infractions, and operator distraction including mobile phone use and text messaging.
  3. Observations shall be specific with respect to type of distraction, type of infraction or type of error.
  4. Event review must include a quality control process that includes a secondary review of a sampling of events to ensure consistent evaluation of event.
  5. Each event must be scored and labeled according to severity.

7.0 Web Application

* 1. Events must be available immediately upon completion of review.
  2. Events must be searchable based on criteria including operator, vehicle, event ID, severity, or specific observation.
  3. Events that meet searched-upon criteria must be viewable on a map.
  4. Web application must support multiple user roles, including trainer, fleet manager, and administrator and only show information relevant to that role.
  5. The system must be password protected to ensure integrity of web application data.
  6. The application must be web-based, provide 24x7 access, and be automatically updated by vendor.
  7. The system shall provide facility security, data security, encryption, firewalls, and intrusion detection.
  8. Each event shall include an event report that includes operator, GPS location, integrated interactive map, description of observations, and severity.
  9. Each event shall be viewable in an integrated player providing time, speed, g-force, frame-by-frame video of all recorded angles, audio, and a timeline of observations.
  10. Videos shall be exportable to WMV format.
  11. Still images in JPG format must be downloadable from the player.
  12. The application shall provide an operator training module that enables sharing of queued videos and allows action steps to be taken and recorded by the trainer.
  13. Reports shall be viewable by Administrator, by observation type.
  14. The system shall provide for mapping of daily routes by operator.
  15. The system shall report on excessive speed, excessive idling, and off-hours activity by operator.
  16. The system shall enable geofences to be designated by operator and provide for notification of geofence violations.
  17. The system shall archive events for a minimum of 72 hours*.*
  18. Events shall be searchable by day, week, month, last month, last 3 months, last six months, last 12 months, or by custom date range.
  19. Reports shall be provided to managers regarding training effectiveness.
  20. Weekly summary and training reports shall be provided identifying overall operator risk by site.
  21. Weekly reports shall be provided for troubleshooting hardware issues.

Transit Signal Priority (TSP)

* Required, complete Worksheet 5.5.5.4.4.15
* **Not required**

CUSTOMER must specify the TSP component model. TSP will only work in an area where the necessary equipment is specified and allowed by regional Traffic Engineers.

Wireless Area Network (WAN)

* Required, complete Worksheet 5.5.5.4.4.16
* **Not required**

The Information Level network shall extend from the vehicle to a remote location. This is frequently done by using low-power radios, or by using an infrared communications system. The purpose of the WAN is to offload collected operational data and/or to upload new configuration data such as schedules and audio/visual messages. By definition, the WAN shall have no interfaces, except as a link between the Information Level network and the remote location.

Vehicle Data Logger (VDL)

* **Required, complete Worksheet 5.5.5.4.4.17**
* Not required (***Provisions ONLY - - for connections to CUSTOMER provided IRS/VLU***)

The VDL shall be an active system capable of monitoring and recording vehicle activity on a continuous basis. The VDL shall have two (2) modes of operation, one for routine data logging and another, at a higher scan rate, for recording “incidents” triggered automatically by the VDL or manually by the operator. The VDL shall be capable of assisting in incident investigations and vehicle maintenance activity assessments. The VDL shall comply with all requirements of SAE J1455 and NEMA enclosures standards for heavy-duty vehicles.

1. Data Storage
   1. Duration
      1. In the event of an “incident” triggered by a defined event, all relevant data shall be stored for a minimum of thirty (30) seconds before and fifteen (15) seconds after such “incident.”
      2. Memory capacity shall be sufficient to store a minimum of two (2) weeks of data under normal industry operating conditions before reaching the end of the data cycle and being overwritten.
   2. Size
      1. The VDL storage capacity shall be as large as practical, no less than 32 GB, but shall still allow for backup of data on a single USB flash drive.
      2. The VDL shall allow for system parameter expansion.
   3. Format
      1. Data shall be stored in an industry-standard format that is retrievable by the VDL user software.
2. Data Monitoring and Recording
   1. The VDL shall be capable of monitoring data elements (Minimum: 64 Digital / 16 Analog inputs) from the vehicle multiplex control systems and/or from the vehicle CAN bus (J1939) using standard SAE Gateway J1939 protocols. The inputs shall be scanned at no less than 200 Hz rate. The minimum data are defined in Appendix G.
   2. The digital inputs shall be programmed such that the user can choose to activate or deactivate the monitoring and recording functions of any combination of inputs as desired.
   3. The VDL shall be capable of recording all relevant data from multiple incidents during an event. “Relevant data” refers to but is not limited to all selectable inputs listed in Appendix "G," and all manufacturer provided default inputs.
   4. The VDL shall monitor and accept input from the manual Operator Alert (panic button, see section 5.5.5.4.3.8) on the J1939 network. The alert shall be used for storing either “incident” or maintenance information at high scan rates. An optional “Incident Alert” indicator shall be located on the operator floor between the natural operator heel locations. A visual alert shall be provided on the front exterior sign and the rear exterior sign.
   5. The VDL shall have integral GPS recording capability to maintain, as a minimum, a “historic” record of vehicle location and time. Minimum update time shall be in two (2) second intervals.
   6. The VDL shall be capable of monitoring J1939 compatible tri-axial accelerometer(s). Accelerometer requirements are further defined under 5.5.5.4.3.16.1.
   7. The CAN VDL shall be capable of supporting communications with other vehicle electronic systems using industry-standard communications protocols such as J1939, J1708, RS/232, and RS/485.
   8. Appendix "G" provides a listing of various data elements that CUSTOMER requires to be incorporated into the monitoring and data logging functions of the VDL. All accelerometer inputs are independent and in addition to these data elements.
3. Data Download and Retrieval
   1. All data shall be available for downloading manually at any time by authorized personnel using a standard laptop computer or other similar means. After downloading, all original data shall remain stored in the VDL’s permanent memory until overwritten or manually purged, including a purge of all triggered data.
   2. The VDL shall be provided with software and hardware for extracting data from the ECM, ABS, Transmission and other electronic vehicle subsystems. All data shall be the property of CUSTOMER.
   3. The VDL shall generate structured reports using the gathered data. The reports shall be displayed in a discernible format.
   4. CUSTOMER shall be able to select and display data as a chart or graph, with selected parameter values along the time scale (*x* axis).
4. Data Security/Backup
   1. All data shall be stored in non-volatile memory.
   2. Downloaded data does not result in automatic deletion of data. Data purge shall be password protected.
   3. The VDL shall include an integral battery with a 2-year life, with a continuous “trickle” charger to insure continuing operation of the VDL in the event of an interruption of vehicle power during or after an “incident”.
   4. The VDL manufacturer shall provide software tools for data storage, system backup, data analysis, and data presentation.
5. Trigger Events Definitions:
   1. All accelerometer trigger levels (in the *x*, *y,* and *z* axes), and high scan rate time duration shall be user programmable. Accelerometer requirements are further defined under 5.5.5.4.3.16.1
   2. An operator emergency alarm shall define a triggered "event."
   3. Bus operational parameters exceeding user-defined limits (e.g., engine overspeed, coolant high temperature, ABS activation, etc.) shall be defined as triggered "events."

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|  |
| --- |
| VDL Accelerometers:  The VDL shall monitor tri-axial accelerometer(s). CUSTOMER, the Bus OEM and the VDL OEM shall mutually determine the location of the accelerometer(s).   * 1. Accelerometer Performance Requirements:      + Changes in velocity and the resulting “g” forces shall be recorded longitudinally, laterally, and vertically. The accelerometers for the X-axis (longitudinal) and the Y-axis (lateral) shall be rated for a minimum of 50g. The accelerometers for the Z-axis (vertical) shall be rated for 12 g. All accelerometers shall be capable of operating at a minimum of 200Hz.      + Accelerometer(s) shall be capable of providing a SAE J1939 output. The accelerometer shall be a 3-axis configuration and record accelerations and decelerations in longitudinal, vertical, and lateral (X, Y, Z) directions. Accelerometer device(s) shall be configured to allow it to detect and record "g" forces in 3 axes, front/rear – left/right – up/down. The positive directions of the X, Y, Z axes are as follows:        - 1. X – Forward/Rearward, rear-to-front of the vehicle          2. Y – Left/Right, Curbside- to Street-sides of the vehicle          3. Z – Up/Down, roof to floor of the vehicle      + Accelerometer device(s) shall be capable of programming trigger thresholds for each axis and also for when the vehicle is moving or stationary. Once a threshold is exceeded, the Accelerometer device(s) triggered, the devices shall be capable of producing a high-resolution data buffer that is stored permanently in a flash memory.      + See Appendix 'E' and 'G' for Interface Protocol Guidelines and CUSTOMER-user definable parameters. |

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###### Information Level Components Worksheets

###### *Note: The specification of brand name and model is for the purpose of illustrating the functionality required, and shall be in all cases deemed to include the phrase "Or Approved Equal”, during the solicitation phase of the procurement .*

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Vehicle Area Network (VAN)

|  |
| --- |
| * *Baseline:* SAE J1708/J1587 * *Alternative:* CAN *based networks (*select one*)* * DeviceNet (IEC – 62026) * LonWorks (IEEE – 1473-L)   + - SAE J1708/J1587     - SAE J1939 * SAE J2284 High Speed CAN * SAE J2411 Single Wire CAN * As supplied by manufacturer * *Alternative:* TCP/IP * Other *Alternative: Specified*: |

|  |
| --- |
| * *Baseline: Select* *cabling with Device Access Boxes (DABs) at the following specified locations* (check only those required): * Inside Radio/Electronics Box * Inside Dash Area * Front Overhead Sign Compartment   + Above Front Door   + Above Rear Door   + Others: * *Alternative: Other pre-wired.*   Specify cable type:  With connections at the following specified locations:   * Inside Electronics Box * Inside Dash Area * Front Overhead Sign Compartment   Above Front Door  Above Rear Door   * Others: Subject to CUSTOMER approval on 1st article   🞏 *Alternative: Not pre-wired* |

|  |
| --- |
| 🞏 *Baseline: Gateway(s) between* Information Level *and*  🞏 Multiplex Level *(Attach translation requirements)*  🞏 Drivetrain Level *(Attach translation requirements)*   * *Alternative: No gateway(s) installed* |

**5.5.5.4.4.2 Electronics (Radio) Box**

|  |
| --- |
| * *Baseline:* Interior Location   🞏 *Alternative*: Exterior Location. Corrosion and weather-proof  AND   * 12V required 🞏 24V required 🞏 Either 12V and 24V   Power: 🞏 ignition-run switch 🞏 battery  AND   * *Baseline:* Keyed   Specify loc Specify model and key number: **Ford**; Manufacturer recommended all buses same-key.  🞏 *Alternative:* Not Keyed  AND   * ***Provisions ONLY*** - - Able to accommodate passenger information system with inside dimensions of 28” l x 24” w x 24” h to house CUSTOMER radio equipment plus additional specified equipments CUSTOMER shall provide radio units for mock up within the Electronic (Radio) Box on 1st Article bus. |

**5.5.5.4.4.3 Mobile Data Terminal (MDT)**

|  |
| --- |
| 🗹 Specified Name & Model:  🞎 Or Specifications Attached  AND   * Provided by CUSTOMER   🞎 Or Provided by Vendor |

**5.5.5.4.4.4 Radio**

|  |
| --- |
| 🗹 Specified Name & Model: ***Trapeze / Continental Radio***  🞎 Or Specifications Attached   * Bus Manufacturer provided provisions for CUSTOMER radio equipment, subject to CUSTOMER approval on 1st article.   AND  🗹 Provided by CUSTOMER. Mock up shall be provided prior to completion of 1st Article bus.  ~ *To be provided after contract award*  🞎 Or Vendor Provided |

|  |
| --- |
| 🞏 *Baseline*: The radio is controlled by a networked component   * *Alternative*: The radio is not controlled by a networked component |

|  |
| --- |
| Antenna   * Specified Name and Model w/ Contact Name and Phone   Manufacturer: ***to be provided after contract award***  Model: ***to be provided after contract award***  Location: ***to be provided after contract award***  Equipment Manufacturer recommended locations front of bus, and subject to CUSTOMER approval on 1st article. All exterior antennas shall be installed to roof using keyed nutserts and screws with antenna(s) mounted 36 inches minimum from any other antenna. Conduit shall be equipped with pull wire / cable and internal access for GPS and radio systems, all subject to CUSTOMER approval on 1st article.  AND  🞏 Provided by CUSTOMER   * Or Vendor Provided   Antenna Cable   * Specified Name & Model: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   Bus Manufacturer provided: ***Provisions ONLY*** - - One (1): Pl-259, TNC male connectors and one low loss Pro-Flex type cable shall be provided. Specifics to be provided after contract award. Connects both ends with interface to CUSTOMER-provided IRS/VLU equipment. |

|  |
| --- |
| * *Baseline*: Human Machine Interface (HMI) provided by other networked component   + *Alternative*: Separate HMI   Specified Name & Model:  Or Additional Specifications Attached  AND   * Provided by CUSTOMER * Or Provided by Vendor * Or Provided with Radio * *Alternative:* No HMI |

**5.5.5.4.4.5 External Route Display (ERD)/External Passenger Information System**

|  |
| --- |
| * *Baseline*: The ERD is networked   🞏 *Alternative*: The ERD is not networked  🞏 *Alternative*: Curtain style ERD |

|  |
| --- |
| * *Baseline*: Electronic Block Number Sign   🞏 *Alternative*: Manual Block Number Sign  🞏 *Alternative*: No Block Number Sign is required |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module   * *Alternative*: Programmable via specified: (Choose all that are required) * Network * Contact-less Device * PC Card   🞏 Plug-In Device  🞏 Chip replacement   * Other (Specify): Flash card/USB; subject to CUSTOMER approval on 1st article. |

|  |
| --- |
| * *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing   Quantity: 1 per 100 buses  🞏 *Alternative:* No required devices |

|  |
| --- |
| * Specified Name & Model: **Luminator Spectrum** **LED** * Or Specifications Attached -- See Section 5.4.9.1 for details.   AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor |

**5.5.5.4.4.6 Voice Annunciation And Signage System (VASS)**

|  |
| --- |
| * Specified Name & Model: ***Provisions for connections to CUSTOMER’s Integrated Radio System(IRS) and Bus manufacturer to provide internal and external speakers*** * Or Specifications Attached   AND   * Provided by CUSTOMER   🞏 Or Provided by Vendor |

|  |
| --- |
| 🞏 *Baseline*: The VASS is networked (Semi-Automatic)   * *Alternative*: The VASS is not networked (Automatic) |

|  |
| --- |
| * *Baseline:* Control or Display is provided by Voice Annunciation System. * *Alternative*: Control or Display is provided by other networked component |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  Manual Network Override  🞏 *Alternative*: Separate HMI  🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor  🞏 Or Provided with VASS   * *Alternative:* No HMI *(Provided through CUSTOMER IRS)* |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module  🞏 *Alternative*: Programmable via specified: (Choose all that are required)  🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement |

|  |
| --- |
| 🞏 *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing  Quantity:  🞏 *Alternative:* No required devices |

**5.5.5.4.4.7 Passenger Stop Request Sign**

|  |
| --- |
| * Specified Name and Model: **Luminator NextStop LED or latest model.**   🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor |

|  |
| --- |
| * *Baseline*: Is networked   🞏 *Alternative*: Is not networked |

**5.5.5.4.4.8 Covert Emergency Alarm**

|  |
| --- |
| 🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER   * Or Provided by Vendor – Contractor/Bus Manufacturer |

|  |
| --- |
| 🞏 *Baseline*: Is networked  🞏 *Alternative*: Is not networked |

|  |
| --- |
| Specify other components to respond to Covert Emergency Alarm:   * Left side console switch location subject to CUSTOMER approval on 1st article.   Specify the method and/or sequence of events required to enable/activate an emergency alarm.   * Press once   Specify the method and/or sequence of events required to disable an activated emergency alarm.   * Press again |

**5.5.5.4.4.9 Public Address System (PA)**

|  |
| --- |
| * Specified Name & Model: ***Agency supplied Integrated Radio System.***   🞏 Or Specifications Attached  AND   * Provided by CUSTOMER   🞏 Or Provided by Vendor |

|  |
| --- |
| * + *Baseline*: The PA is not networked     - *Alternative*: The PA is networked to the CUSTOMER-supplied Integrated Radio System. |

|  |
| --- |
| * + - *Alternative:* Control on display is provided by other networked component.   **☑** Specified Name and Model: ***Agency supplied Integrated Radio System.*** |

|  |
| --- |
| * Programmable via specified: (Choose all that are required): *Same as CUSTOMER’s* Integrated Radio System *on existing CUSTOMER bus fleet.* |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module   * *Alternative*: Programmable via specified: (Choose all that are required)   🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement   * + Same as CUSTOMER's Integrated Radio System on existing CUSTOMER bus fleet. |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  🞏 Manual Network Override   * *Alternative*: Separate HMI * Specified Name & Model: CUSTOMER supplied Integrated Radio System   + Or Specifications Attached   AND   * + Provided by CUSTOMER   + Or Provided by Vendor   + Or Provided with PA   🞏 *Alternative:* No HMI |

|  |
| --- |
| * + - *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing   Quantity: 1 per 100 buses  🞏 *Alternative:* No required devices |

**5.5.5.4.4.10 Automatic Vehicle Location (AVL)**

|  |
| --- |
| * Specified Name & Model: Agency supplied Integrated Radio System   🞏 Or Specifications Attached  AND   * + Provided by CUSTOMER   🞏 Or Provided by Vendor |

|  |
| --- |
| 🞏 *Baseline*: The AVL is networked   * *Alternative*: The AVL is not networked |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  Manual Network Override   * + *Alternative*: Separate HMI   🞏 Specified Name & Model: CUSTOMER IRS VLU  🞏 Or Specifications Attached  AND   * CUSTOMER supplied Integrated Radio System   Or Provided by Vendor  Or Provided with AVL |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module  🞏 *Alternative*: Programmable via specified: (Choose all that are required)  🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement |

|  |
| --- |
| 🞏 *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing  Quantity:  🞏 *Alternative:* No required devices |

**5.5.5.4.4.11 Automatic Passenger Counter (APC)**

|  |
| --- |
| * *Baseline:* The APC is not networked or required. * Specified Name & Model: * Or Specifications Attached   AND   * Provided by CUSTOMER * Or Provided by Vendor |

|  |
| --- |
| **□** *Baseline*: The APC is networked  **□** *Alternative*: The APC is not networked |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  🞏 Manual Network Override  🞏 *Alternative*: Separate HMI  🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor  🞏 Or Provided with APC  🞏 *Alternative:* No HMI |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module  🞏 *Alternative*: Programmable via specified: (Choose all that are required)  🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement |

|  |
| --- |
| 🞏 *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing  Quantity:  🞏 *Alternative:* No required devices |

**5.5.5.4.4.12 Automated Fare Collection (AFC)**

|  |
| --- |
| * + Specified Name & Model: ***Mounting, power and ground provisions for GFI CENTSaBILL farebox with TRiM Unit. Provisions only.***   🞏 Or Specifications Attached  **☑** Specify voltage and current protection required two (2) each; 12 VDC, 15 AMP CB, J1587 /1708 interface radio compartment to farebox, and  **☑** One (1) each 12 VDC, 10 AMP fuse, J1587/J1708 interface radio compartment to Smart Media processor.   * Provided by CUSTOMER. * 12V required 🞎 24V required 🞎 12 and 24V DC   AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor |

|  |
| --- |
| * *Baseline*: The AFC is not networked   + *Alternative:* The AFC network provisions through CUSTOMER's Integrated Radio System J1587/J1708 |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  🞏 Manual Network Override  🞏 *Alternative*: Separate HMI  🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor  🞏 Or Provided with AFC   * *Alternative:* No HMI (Provided through CUSTOMER IRS) |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module  🞏 *Alternative*: Programmable via specified: (Choose all that are required)  🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement |

|  |
| --- |
| 🞏 *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing  Quantity:   * ***Alternative****:* No required devices |

**5.5.5.4.4.13 Closed Circuit TV (CCTV)**

|  |
| --- |
| * Specified Name & Model: ***G-E Security Systems' MobileView***.   🞏 Or Additional Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor |

|  |
| --- |
| 🗹 *Baseline*: The CCTV is networked  *🞎 Alternative*: The CCTV is not networked |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  🞏 Manual Network Override  🞏 *Alternative*: Separate HMI  🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor  🞏 Or Provided with CCTV   * + *Alternative:* No HMI |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module   * *Alternative*: Programmable via specified: (Choose all that are required)   🞏 Network  🞏 Contact-less Device  🞏 PC Card   * Plug-In Device   🞏 Chip replacement |

|  |
| --- |
| * Specify the number of cameras, and for each camera provide a description of the desired view or provide a sketch showing the camera location.   1. Over Operator's head looking at Fare Collection Equipment / Front (entrance) door;   2. Front/above Stop Requested Sign looking rearward   3. Above Streetside light panel looking Exit Door; and   4. Rear wall of bus looking forward.   5. Below the interior rear view mirror, looking outward over the front bumper. |

|  |
| --- |
| * *Baseline*: An adequate number of decals/signs notifying passengers of surveillance cameras on-board shall be installed in plain view throughout the bus.   🞏 *Alternative:* No decals/signs installed. |

|  |
| --- |
| * *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing   Quantity: *3 each*  🞏 *Alternative:* No required devices |

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**5.5.5.4.4.14 Automated Event Recording (AER) Safety Device**

|  |
| --- |
| * *Baseline:* No required devices. * Optional: Specified Name & Model: Automated Event Recording Smart Drive system   🞏 Or Specifications Attached  AND   * + - * Provided by CUSTOMER * Or Provided by Vendor |

|  |
| --- |
| * *Baseline*: The AER is networked   🞏 *Alternative*: The AER is not networked |

|  |
| --- |
| * *Baseline*: Human machine Interface (HMI) provided by other networked component   🞏 Manual Network Override  🞏 *Alternative*: Separate HMI  🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor  🞏 Or Provided with TSP  🞏 *Alternative:* No HMI |

|  |
| --- |
| * *Baseline:* SAE J1708/J1939 * *Alternative:* CAN *based networks (*select one*)*   🞏 DeviceNet (IEC – 62026)  🞏 LonWorks (IEEE – 1473-L)   * + - SAE J1587     - SAE J1708/J1939   🞏 SAE J2284 High Speed CAN  🞏 SAE J2411 Single Wire CAN   * As supplied by manufacturer   🞏 *Alternative:* TCP/IP  🞏 Other *Alternative: Specified*: |

**5.5.5.4.4.15 Transit Signal Priority (TSP)**

|  |
| --- |
| * *Baseline:* No required devices.   🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor |

|  |
| --- |
| 🞏 *Baseline*: The TSP is networked  🞏 *Alternative*: The TSP is not networked |

|  |
| --- |
| 🞏 *Baseline*: Human machine Interface (HMI) provided by other networked component  🞏 Manual Network Override  🞏 *Alternative*: Separate HMI  🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor  🞏 Or Provided with TSP  🞏 *Alternative:* No HMI |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module  🞏 *Alternative*: Programmable via specified: (Choose all that are required)  🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement |

|  |
| --- |
| 🞏 *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing  Quantity:  🞏 *Alternative:* No required devices |

**5.5.5.4.4.16 Wireless Area Network (WAN)**

|  |
| --- |
| * *Baseline: Not required* |

|  |
| --- |
| 🞏 Specified Name & Model:  🞏 Or Specifications Attached  AND  🞏 Provided by CUSTOMER  🞏 Or Provided by Vendor |

|  |
| --- |
| 🞏 *Baseline*: Programmable via network messages and also via plug-in module  🞏 *Alternative*: Programmable via specified: (Choose all that are required)  🞏 Network  🞏 Contact-less Device  🞏 PC Card  🞏 Plug-In Device  🞏 Chip replacement |

|  |
| --- |
| 🞏 *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing  Quantity:  🞏 *Alternative:* No required devices |

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5.5.5.4.4.17 Vehicle Data Logger (VDL)

|  |
| --- |
| * *Baseline***:** *Provisions ONLY - - for connection of specified components to CUSTOMER provided IRS. Data Recording Required; Except as provided by: existing engine ECM, transmission ECU and/or ABS ECU; or other systems specified to provide to meet specification.* * ***Alternative****: Required.* * Specified Name and Model:   Or Specifications Attached -- See requirements listed in Section 5.5.5.4.3.17 |

|  |
| --- |
| * *Baseline*: *The VDL is not networked*. * *Alternative: CAN based networks* * DeviceNet (IEC – 62026) * LonWorks (IEEE – 1473-L) * SAE J1708/J1587 * SAE J1939 * SAE J2284 High Speed CAN * SAE J2411 Single Wire CAN * As supplied by manufacturer * *Alternative: TCP/IP* |

|  |
| --- |
| 🞏 *Baseline*: Human Machine Interface (HMI) provided by other networked component  🞏 Manual Network Override   * *Alternative*: Separate HMI   🞏 Specified Name & Model:   * Or Specifications Attached   For interface requirements, please see Section 5.5.5.4.3.17.  AND  🞏 Provided by CUSTOMER   * Or Provided by Vendor |

|  |
| --- |
| * *Baseline: Select* *cabling with Device Access Boxes (DABs) at the following specified locations* (check only those required): * Inside Radio/Electronics Box * Inside Dash Area * Front Overhead Sign Compartment * Above Front Door * Above Rear Door * Others: Wireless access through the following:   + FR   + GSM   + GPRS   + CDMA   + WiFi 802.11   + RF (Provisions only) * *Alternative: Other pre-wired.*   Specify cable type:  With connections at the following specified locations:   * Inside Electronics Box * Inside Dash Area * Front Overhead Sign Compartment * Above Front Door * Above Rear Door * Others: Subject to CUSTOMER approval on 1st article   🞏 *Alternative: Not pre-wired* |

|  |
| --- |
| 🞏 *Baseline: Gateway(s) between* Information Level *and*  🞏 Multiplex Level *(Attach translation requirements)*  🞏 Drivetrain Level *(Attach translation requirements)*   * *Alternative: No gateway(s) installed* |

|  |
| --- |
| Data Transfer Method  **☑** *Baseline:* ***See Appendix ‘E’ through Appendix ‘I’.*** |

|  |
| --- |
| * *Baseline: Software (Check all that are required)* * Reporting Software * Special Reporting |

|  |
| --- |
| * + *Baseline:* Vendor provided plug-in devices for programming and/or diagnosing   Quantity:  🞏 *Alternative:* No required devices |

#### CENTRAL DATA ACCESS

**Charging Systems**

The Contractor shall supply and install Charging Systems to recharge the propulsion batteries of the buses provided under the terms of this Contract which shall include at least one Automated Charging Station. The Chargers will be installed on the route selected for operation of the buses in such a way as to enable charging the bus while exchanging passengers at a normal stop.

The Charging System shall operate from a 480 VAC, 1000 amp, 3 phase supply, . The bus shall be equipped with a charging connector on the roof of the vehicle capable of mating to the provided Automated Charging Station. A secondary Charger may be provided to supply lower rates of electricity for night-time or supplemental charging which can operate below 480 VAC.

The Charging System including the Automated Charging Station must include the following protections and driver alerts: (i) dynamic state of charge of the Energy Storage System, (ii) charge rate, and (iii) fault codes for Charging System failure alerting the operator to the severity of the fault. The bus should be equipped with at least one backup, manual charger port connection suitable for use in emergency situation with the charger or a comparable unit located at the shop.

The bus must be immobilized during charging.

###### Performance

The opportunity charging system (Fast Charge) must be capable of recharging the propulsion battery from 10% SOC to 90%SOC in 10 minutes or less. The extended range charging system shale be capable of up to 100 kwh of charge per hour.

###### Operating Environment

The Charger shall be capable of operating continuously without performance or safety degradations in environmental conditions typically found at the Agency location. For the purposes of these Specifications such environmental conditions shall mean that the Charger shall operate in the following parameters without performance or safety degradation:

* Storage temperature when not in service: -25 to +60 Deg C
* Ambient service temperature: 0 to 40 Deg C
* Maximum service altitude: 1000m above sea level @40 Deg C w/o de-rating
* Relative humidity range: 5 to 95%, no condensation allowed

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##### COnnector port option

The connector port option is an extension of what is already provided on transit vehicles today. Presently, all vehicles have a large assortment of connector ports in multiple locations throughout the vehicle with which to access diagnostic and online information (i.e., from the motor, transmission, multiplexing, HVAC, doors, etc.). This option is capable of bringing all of the connector ports to a central location for easy access. This could be achieved by replacing the existing ports, or by running another set of parallel ports to one central location. Once positioned at a central location, the ports could remain as individual ports or be merged into one standardized connector adopted by the industry. A laptop computer or diagnostic reading device could then be used to access the required diagnostic or logged data/information from this one location.

Any connector port will require a protective cover, dependent on its location. At a minimum, two locations are required:

1. In the operator's cockpit area, and

2. In the rear electrical compartment.

##### microprocessor-based option

In a physical sense, the microprocessor-based approach is an extension of the connector port option, where the microprocessor-based device (i.e., PC) is connected to all communications ports on-board the vehicle. Most electronic devices and systems provide some type of computer interface; therefore, implementing a microprocessor-based device becomes an extension of what is already provided today. The device could be a ruggedized computer with or without a monitor, keyboard and mouse.

#### RESPONSIBILITIES FOR SYSTEMS INTEGRATION & TESTING

##### general

This section identifies the responsibilities of CUSTOMER, vehicle manufacturer and subsystem supplier or other third party integrator concerning the integration and testing of electronic equipment.

Upon bid award, the vehicle manufacturer shall provide to CUSTOMER, preferably in PDF format, a representation of the multiplex logic program. CUSTOMER will return to the vehicle manufacturer any required markups or corrections to the multiplex logic not later than 90 days prior to the start of production. The vehicle manufacturer shall bear the responsibility of ensuring that CUSTOMER’s logic requirements will result in the safe operation of the vehicle, and shall make CUSTOMER aware of any inconsistencies regarding normal vehicle operations.

##### CUSTOMER's responsibilities

CUSTOMER shall provide softcopy of the complete Section 5 technical specification to the vehicle manufacturer in PDF format. Hardcopy is optional.

Upon request from the vehicle manufacturer, CUSTOMER shall be responsible for providing, at least 30 days prior to bid closure, technical specifications that contain a clear and concise description of the operational and functional requirements expected from the multiplex system and the integration of Procuring Agency-specified electronic systems and components. Any changes to such electronic systems or components shall be communicated to the vehicle manufacturer not less than 120 days before start of production (including initial production, subsequent lots, or exercise of options). If needed, CUSTOMER shall ensure that contact information is provided to both the subsystem supplier and the vehicle manufacturer.

##### manufacturer's role and responsibility

###### Specification Adherence

The vehicle manufacturer shall analyze and become familiar with CUSTOMER's specifications, functional requirements and vehicle operational characteristics, as described in Section 5, herein.

When the integration requirements and specifications requested by the agency have not been engineered into a previous vehicle configuration, the vehicle manufacturer shall inform the agency. The vehicle manufacturer shall then create for its own purposes the necessary design requirements and performance specifications that will insure integration of the product(s) needed to achieve the functional requirements as specified by CUSTOMER.

###### Requirement Analysis

Based upon the analysis of CUSTOMER's requirements, the vehicle manufacturer shall provide the subsystem requirements to the subsystem supplier as may be needed to ensure proper functioning of those subsystems and their integration with other vehicle subsystems. (i.e., CUSTOMER specifications and/or manufacturer’s specific requirements)

Upon request by the subsystem supplier, the vehicle manufacturer shall provide a complete softcopy (hardcopy is optional) specification, PDF format.

###### Inspection & Approval

Prior to inspection, approval and installation of the subsystem integration, the vehicle manufacturer shall obtain the written approval from all subsystem suppliers that their products meet, and are being installed in accordance with, all applicable integration and interface requirements and that the product(s) installed will function properly as intended.

The vehicle manufacturer shall demonstrate proper integration of all on-board subsystems in accordance with CUSTOMER's specification requirements.

Should manufacturing requirements and/or additional changes requested by CUSTOMER that affect the installation and integration of the subsystem occur after initial approval, the sub-system supplier or third party integrator shall be notified and again have the opportunity to inspect such changes, and sign off and approve changes that may affect their systems.

##### SUBSYSTEM SUPPLIER OR OTHER THIRD PARTY INTEGRATOR RESPONSIBILITIES

###### Qualification Testing and Specification Adherence

The subsystem supplier or third party integrator is responsible for providing products that have been qualified or validated to meet current applicable standards as incorporated in the specification by reference, and for designing the product to integrate into basic vehicle configurations as defined by the vehicle manufacturer.

The subsystem supplier shall be responsible for providing to both CUSTOMER and the vehicle manufacturer, at least 30 days prior to bid closure, technical specifications that contain a clear and concise description of the operational and functional requirements provided by their system. Any changes to such electronic systems or components shall be communicated to CUSTOMER and vehicle manufacturer not less than 120 days before start of production (including initial production, subsequent lots, or exercise of options).

The subsystem supplier or other third party integrator shall provide to CUSTOMER and the vehicle manufacturer the testing and interface information required regarding system integration, or shall be required to demonstrate how system integration was performed.

###### Interface Information

Not later than 120 days prior to the start of production, the subsystem supplier or third party integrator shall provide the vehicle manufacturer with the communications interface specifications and installation requirements. The subsystem supplier or third party integrator shall:

1. ensure that the vehicle manufacturer has all necessary documentation, drawings, and/or product information necessary to review product integration
2. provide product samples upon the vehicle manufacturer's request for testing and integration purposes
3. work with vehicle manufacturer on any design changes required to integrate the system into vehicle configuration

###### Installation Approval / Sign-Off

Prior to inspection, approval and installation of the subsystem integration, the subsystem supplier shall provide to the vehicle manufacturer written approval that their products meet, and are being installed in accordance with, all applicable integration and interface requirements and that the product(s) installed will function properly as intended.

### ATTACHMENTS TO PART 5, TECHNICAL PROVISIONS

CUSTOMER SPECIFICATIONS

*The following is a list of those subsections of Part 5, Technical Specifications, which call for each Procuring Agency to attach additional detail.*

**5.1 GENERAL**

5.1.2 Definitions

(20) Design Operating Profile *[CUSTOMER can provide additional operating characteristics to expand on the above Design Operating Profile definition]*

(21) Class of Failures *In attachments to Part 5: Technical Specifications, CUSTOMER may relate the skill levels and ratings of mechanics in its operation to the above definitions*

(22) Maintenance Personnel Skills *In attachments to Part 5: Technical Specifications, CUSTOMER may relate the skill levels and ratings of mechanics in its operation to the above definitions.*

5.1.5 Overall Requirements

Maintenance and Inspection Equipment: *Any special tools required to maintain the bus shall be provided in quantities as specified in attachments to Part 5: Technical Specifications. Additional requirements for Maintenance and Inspection Equipment are also provided in these attachments. [Shown below is a sample list of such equipment. Items and quantities are required. CUSTOMER shall identify additional equipment as required and/or* ***unless otherwise specified in Exhibit K – Training requirements****.]*

Item Quantity\*

Radio Box Key (#CH751) - ***All keyed the same*** One(1) per bus

Towing adapters 1 set per 100 buses

Destination sign PCMCIA programming cards 1 per 100 buses

Wheel alignment tools (If required) None; provide listing

Handheld diagnostic readers None; provide listing

Diagnostic readers for HVAC system None; provide listing

Portable hand held readers for troubleshooting of the

multiplex system None; provide listing

Motor removal adapters 3 each only

Camera system diagnostic tool(s) None; provide listing

\*Fractional quantities shall be rounded up to nearest whole number.

5.1.5.5 Operating Environment *CUSTOMER may include additional details of operating environment including climatic and service/duty conditions.*

**5.2 PROPULSION SYSTEM**

5.2.2 Drive Train

5.2.2.1. Drive Motor

5.2.2.2 Mounting

5.2.2.2.3 Hydraulic Systems *(Alternative): Specific systems for which low hydraulic fluid level sensors are required are included in attachments to Part 5: Technical Specifications.*

**5.3 CHASSIS**

5.3.1 Suspension

5.3.1.2.3 Lubrication: *Additional requirements for lubrication are contained in Attachments to Part 5: Technical Specifications.*

5.3.4 Pneumatic System

5.3.4.1 General: A *quick disconnect fitting specified in attachments to Part 5: Technical Specifications shall be easily accessible and located in the engine compartment and near the front bumper area for towing.*

* 1. **BODY**

5.4.1 General

5.4.1.4 Corrosion: *Additional requirements for corrosion protection are contained in attachments to Part 5: Technical Specifications.*

5.4.3 Exterior Panels and Finishes

5.4.3.2 Alternative: *Additional requirements for anti-graffiti/vandalism treatments for exterior surfaces are contained in attachments to Part 5: Technical Specifications*

* + - * 1. Access Doors *(with locks): The locks shall be standardized as defined by CUSTOMER in the attachments to Part 5: Technical Specifications so that only one tool is required to open all major access doors on the bus.*

5.4.3.10 Finish And Color: *Colors and paint schemes shall be in accordance with the attachments to Part 5: Technical Specifications.*

5.4.3.11 Numbering And Signing:  *The exact wording, size, color, and location for these signs are found with requirements for other special signs in attachments to Part 5: Technical Specifications.*

* + - 1. Exterior Lighting:  *Specific number and mounting requirements are defined in attachments to Part 5: Technical Specifications.*
      2. Bicycle Racks:  *Specific requirements are defined in attachments to Part 5: Technical Specifications.*

5.4.4 Interior Panels and Finishes

* + - 1. Alternative: *Additional requirements for anti-graffiti/vandalism treatments for interior surfaces are contained in attachments to Part 5: Technical Specifications*

5.4.4.2 Operator's Barrier and Operator's Enclosure/Shield. *Requirements are contained in Part 5. Technical Specifications.*

5.4.4.3 Rear End: *Colors, patterns, and materials are defined in attachments to Part 5: Technical Specifications.*

5.4.4.4 Interior Panels

5.4.4.4.1 General: *Colors, patterns, and materials for the interior trim are defined in attachments to Part 5: Technical Specifications.*

5.4.4.4.5 Headlining: *Colors, patterns, and materials for the headlining are defined in attachments in Part 5: Technical Specifications.*

5.4.4.5 Floor Covering: *Color and material of the floor covering is defined in attachment to Part 5: Technical Specifications.*

5.4.4.7 Fare Collection: *The fare box, including make, model, size, weight, and meter locations, and transfer equipment is defined in attachments to Part 5: Technical Specifications. Also, see 5.5.4.3.12 and worksheet 5.5.5.4.4.12.*

5.4.5 Passenger Accommodations

5.4.5.1 Passenger Seating

5.4.5.1.4 Construction and Materials: *Color of the seat material and optional safety padding is defined in attachments to Part 5: Technical Specifications.*

5.4.5.4 Accessibility Provisions

5.4.5.4.1 General: *Specific requirements, including the number of wheelchairs to be accommodated, the tiedown and securement devices, and fold-down seats, are provided in attachments to Part 5: Technical Specifications.*

5.4.6 Operator Provisions

5.4.6.1 Operator’s Area *(Also see requirements in Section 5.4.4.2)*

5.4.6.1.1 General: *Additional provisions for operator’s area are included in attachments to Part 5: Technical Specifications.*

5.4.6.5.2 Structure and Materials: *Color of the operator's seat is defined in the attachments to Part 5: Technical Specifications.*

* + - * 1. *Additional details on exterior mirrors, including size, location and mounting, are contained in Attachments to Part 5: Technical Specifications.*
        2. *Additional details on interior mirrors, including size, location and mounting, are contained in Attachments to Part 5: Technical Specifications.*

5.4.7 Windows

5.4.7.4.1 Dimensions *(Cyclone cleaner opening): Minimum size of this opening is defined in attachment to Part 5: Technical Specifications.*

5.4.8 Heating, Ventilating, and Air Conditioning

* + - 1. *Additional HVAC system and performance requirements are contained in Attachments to Part 5: Technical Specification.*

5.4.9.2.1 Interior Displays: *Additional requirements for interior advertising are defined in the attachments to Part 5: Technical Specifications.*

5.4.9.2.2 External Displays: *Additional requirements for exterior advertising may be defined in the attachments to Part 5: Technical Specifications.*

* 1. **ELECTRICAL, ELECTRONIC AND DATA COMMUNICATION SYSTEMS**

5.5.3.1.1 Main power supply: provide details of Jump Start connector if required.

* + - * 1. Master Battery Switch: *Any equipment that requires power with the Master Battery switch “OFF” shall be listed in attachments to Part 5: Technical Specifications*
      1. Electrical Components. *CUSTOMER to list specific brushless motor requirements.*
         1. Data Access. *CUSTOMER to specify location of communication port(s).*

5.5.5.4.2.5 Power requirements. Specify requirements for a shared DC/DC converter.

5.5.5.4.3.5 External Passenger Information Signs

*A complete listing of destination sign readings for initial sign programming by the manufacturer are provided in attachments to Part 5: Technical Specifications. Also, see worksheets 5.5.5.4.4.5 and 5.5.5.4.4.8.*

5.5.5.4.3.9 Public Address System: Additional requirements for the PA system are provided. Also see worksheets 5.5.5.4.4.6 and 5.5.5.4.4.9.

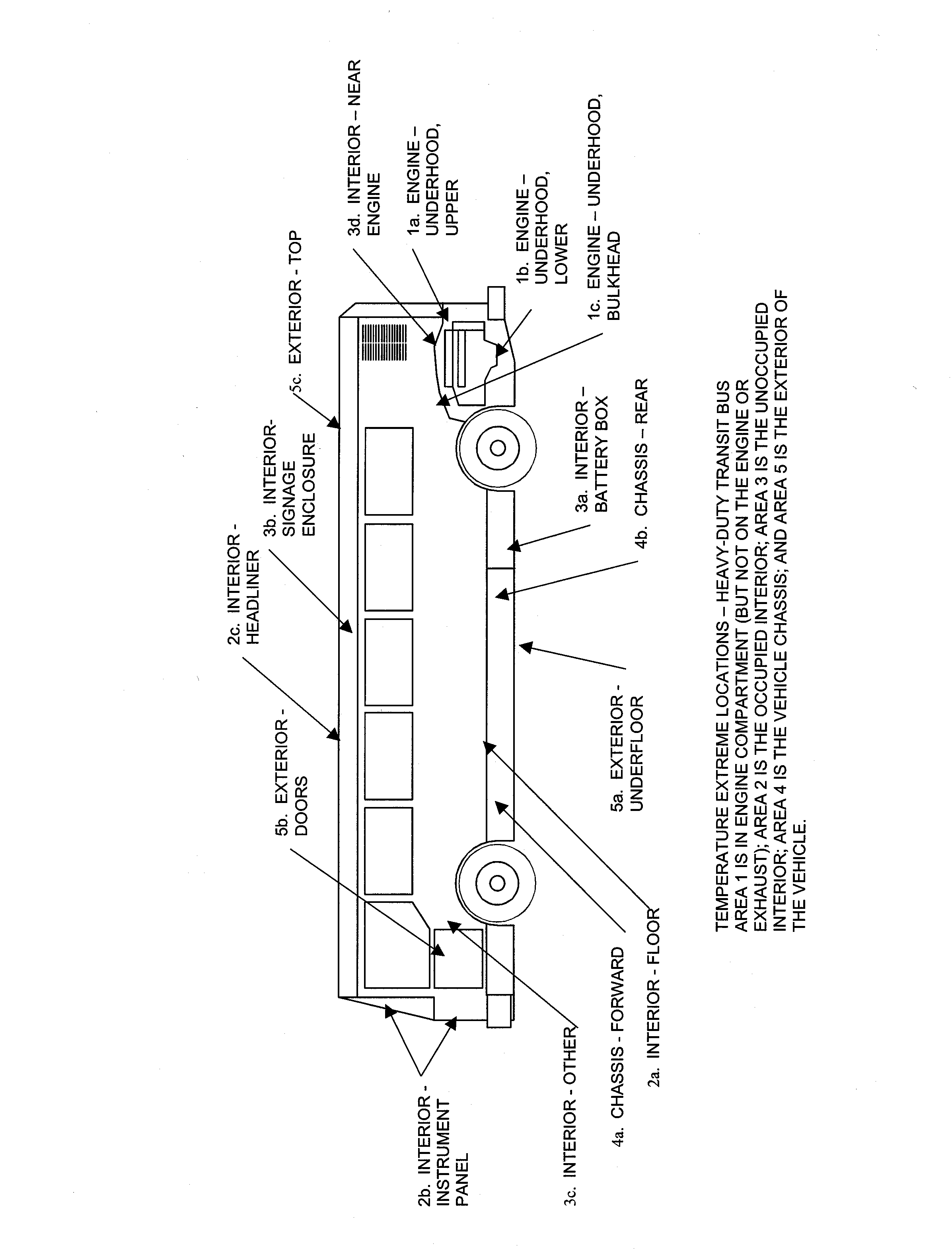
5.5.5.4.3.13 Closed Circuit TV (CCTV): Complete Worksheet 5.5.5.4.4.13*.*

### APPENDIX A - OPERATING TEMPERATURES FOR HEAVY DUTY TRANSIT BUS COMPONENTS

TEMPERATURE EXTREMES SUMMARY - HEAVY-DUTY TRANSIT BUS (1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Operating Temperature (3, 4) | | Storage Temperature (3, 4) | |
|  | Location (2) | Temperatures MIN | Transit Bus MAX | Temperature MIN | Temperatures MAX |
| Drive MOtor (5): | 1a Underhood – Lower | -20 °F | 185 ° F | -40 °F | 212 °F |
|  |  |  |  |  |  |
|  | 1b Underhood – Upper | -20 °F | 212° F(5) | -40 °F | 221°F |
|  |  |  |  |  |  |
|  | 1c Underhood – Bulkhead | -20 °F | 185 ° F | -40 °F | 212 °F |
|  |  |  |  |  |  |
| INTERIOR, OCCUPIED: | 2a Floor (7) | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 2b Instrumental Panels | -20 °F | 158 ° F(6) | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 2c Headliner (7) | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 2d Doors (7) | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
| INTERIOR, UNOCCUPIED: | 3a Battery Box | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 3b Signage Enclosure | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 3c Enclosure, Other | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 3d Enclosure, Near Engine | -20 °F | 185 ° F | -40 °F | 212 °F |
|  |  |  |  |  |  |
| CHASSIS: | 4a Forward (7) | -20 °F | 158° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 4b Rear (7) | -20 °F | 185° F | -40 °F | 212 °F |
|  |  |  |  |  |  |
| EXTERIOR: | 5a Underfloor | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 5b Rear | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 5c Doors (7) | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |
|  | 5d Top | -20 °F | 158 ° F | -40 °F | 185 °F |
|  |  |  |  |  |  |

|  |
| --- |
| NOTES:   1. This table is based on TABLE 1A in SAE J1455 (AUG94); The J1455 information has been revised for Transit Bus Applications by APTA Electrical Interface Working Group, 2000. 2. See following page for Pictorial Description of Locations. 3. If temperature characterization has been performed on the target vehicle, then the measured temperature may be substituted for the values in the Operating columns of the Table. 4. Maximum ambient temperature may reach 158 °F. Minimum ambient is –40 °F. The MAX Storage temperatures are based on the ambient and an estimate of the effects of thermal soakback. 5. Exhaust Manifold and Turbo surfaces can reach 1500 °F. Mount electronic control units and other electronics at least 18” away from these surfaces and at least 6” away from the Engine unless mounting instructions allow otherwise. 6. Direct Sunlight surface temperature can be 185°F. 7. Suggested limits for areas where no significant data is recorded. See notes above. |



### APPENDIX B - WIRE AMPACITY CHARTS

Wire Gauge 0000 – 0

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | DISTANCE IN FEET/METERS | | | | | | | |
| OHMS | 0.04901 | | 0.06182 | | 0.07793 | | 0.09825 | |
| AMP  LOAD | WIRE GAUGE | | | | | | | |
| 0000 | | 000 | | 00 | | 0 | |
| 10 | 1763 | 537 | 1398 | 426 | 1109 | 338 | 880 | 268 |
| 20 | 882 | 269 | 699 | 213 | 554 | 169 | 440 | 134 |
| 30 | 588 | 179 | 466 | 142 | 370 | 113 | 293 | 89 |
| 40 | 441 | 134 | 349 | 107 | 277 | 84 | 220 | 67 |
| 50 | 353 | 107 | 280 | 85 | 222 | 68 | 176 | 54 |
| 60 | 294 | 90 | 233 | 71 | 185 | 56 | 147 | 45 |
| 70 | 252 | 77 | 200 | 61 | 158 | 48 | 126 | 38 |
| 80 | 220 | 67 | 175 | 53 | 139 | 42 | 110 | 34 |
| 90 | 196 | 60 | 155 | 47 | 123 | 38 | 98 | 30 |
| 100 | 176 | 54 | 140 | 43 | 111 | 34 | 88 | 27 |
| 110 | 160 | 49 | 127 | 39 | 101 | 31 | 80 | 24 |
| 120 | 147 | 45 | 116 | 36 | 92 | 28 | 73 | 22 |
| 130 | 136 | 41 | 108 | 33 | 85 | 26 | 68 | 21 |
| 140 | 126 | 38 | 100 | 30 | 79 | 24 | 63 | 19 |
| 150 | 118 | 36 | 93 | 28 | 74 | 23 | 59 | 18 |
| 160 | 110 | 34 | 87 | 27 | 69 | 21 | 55 | 17 |
| 170 | 104 | 32 | 82 | 25 | 65 | 20 | 52 | 16 |
| 180 | 98 | 30 | 78 | 24 | 62 | 19 | 49 | 15 |
| 190 | 93 | 28 | 74 | 22 | 58 | 18 | 46 | 14 |
| 200 | 88 | 27 | 70 | 21 | 55 | 17 | 44 | 13 |
| 210 | 84 | 26 | 67 | 20 | 53 | 16 | 42 | 13 |
| 220 | 80 | 24 | 64 | 19 | 50 | 15 | 40 | 12 |
| 230 | 77 | 23 | 61 | 19 | 48 | 15 | 38 | 12 |
| 240 | 73 | 22 | 58 | 18 | 46 | 14 | 37 | 11 |
| 250 | 71 | 21 | 56 | 17 | 44 | 14 | 35 | 11 |
| 260 | 68 | 21 | 54 | 16 | 43 | 13 | 34 | 10 |
| 270 | 65 | 20 | 52 | 16 | 41 | 13 | 33 | 10 |
| 280 | 63 | 19 | 50 | 15 | 40 | 12 | 31 | 10 |
| 290 | 61 | 19 | 48 | 15 | 38 | 12 | 30 | 9 |
| 300 | 59 | 18 | 47 | 14 | 37 | 11 | 29 | 9 |
| 310 | 57 | 17 | 45 | 14 | 36 | 11 | 28 | 9 |

**Ampacity Expressed in Length of Cable (1 Ga - 18 Ga)**

Temperature: 60°C Voltage Drop: 1V Wire Gauge 1-18

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | DISTANCE IN FEET/METERS | | | | | | | | | | | | | | | | | | | | |
| OHMS | 0.1239 | | 0.1563 | | 0.2488 | | 0.3952 | | 0.8281 | | 0.9988 | | 1.59 | | 2.52 | | 4.02 | | 6.39 | | |
| AMP | WIRE GAUGE | | | | | | | | | | | | | | | | | | | | |
| LOAD | 1 | | 2 | | 4 | | 6 | | 8 | | 10 | | 12 | | 14 | | 16 | | 18 | | |
| 5 | 1395 | 425 | 1106 | 337 | 696 | 212 | 437 | 133 | 275 | 84 | 173 | 53 | 109 | 33 | 69 | 21 | 43 | 13 | 27 | 8 |
| 10 | 697 | 213 | 553 | 168 | 348 | 106 | 219 | 67 | 138 | 42 | 87 | 26 | 54 | 17 | 34 | 10 | 21 | 7 | 14 | 4 |
| 15 | 465 | 142 | 369 | 112 | 232 | 71 | 146 | 44 | 92 | 28 | 58 | 18 | 36 | 11 | 23 | 7 | 14 | 4 | 9 | 3 |
| 20 | 349 | 106 | 276 | 84 | 174 | 53 | 109 | 33 | 69 | 21 | 43 | 13 | 27 | 8 | 17 | 5 | 11 | 43 | 7 | 2 |
| 25 | 279 | 85 | 221 | 67 | 139 | 42 | 87 | 27 | 55 | 17 | 35 | 11 | 22 | 7 | 14 | 4 | 9 | 3 | 5 | 2 |
| 30 | 232 | 71 | 184 | 56 | 116 | 35 | 73 | 22 | 46 | 14 | 29 | 9 | 18 | 6 | 11 | 3 | 7 | 3 | 5 | 1 |
| 35 | 199 | 61 | 169 | 48 | 99 | 30 | 62 | 19 | 39 | 12 | 25 | 8 | 16 | 5 | 10 | 3 | 6 | 2 | 4 | 1 |
| 40 | 174 | 53 | 138 | 42 | 87 | 26 | 55 | 17 | 34 | 10 | 22 | 7 | 14 | 4 | 9 | 3 | 5 | 2 | 3 | 1 |
| 45 | 155 | 47 | 123 | 37 | 77 | 24 | 49 | 15 | 31 | 9 | 19 | 6 | 12 | 4 | 8 | 2 | 5 | 1 | 3 | 1 |
| 50 | 139 | 43 | 111 | 34 | 70 | 21 | 44 | 13 | 28 | 8 | 17 | 5 | 11 | 3 | 7 | 2 | 4 | 1 | 3 | 1 |
| 55 | 127 | 39 | 101 | 31 | 63 | 19 | 40 | 12 | 25 | 8 | - | - | - | - | - | - | - | - | - | - |
| 60 | 116 | 35 | 92 | 28 | 58 | 18 | 36 | 11 | 23 | 7 | - | - | - | - | - | - | - | - | - | - |
| 65 | 107 | 33 | 85 | 26 | 54 | 16 | 34 | 10 | 21 | 6 | - | - | - | - | - | - | - | - | - | - |
| 70 | 100 | 30 | 79 | 24 | 50 | 15 | 31 | 10 | 20 | 6 | - | - | - | - | - | - | - | - | - | - |
| 75 | 93 | 28 | 74 | 22 | 46 | 14 | 29 | 9 | 18 | 6 | - | - | - | - | - | - | - | - | - | - |
| 80 | 87 | 27 | 69 | 21 | 43 | 13 | 27 | 8 | 17 | 5 | - | - | - | - | - | - | - | - | - | - |
| 85 | 82 | 25 | 65 | 20 | 41 | 12 | 26 | 8 | 16 | 5 | - | - | - | - | - | - | - | - | - | - |
| 90 | 77 | 24 | 61 | 19 | 39 | 12 | 24 | 7 | 15 | 5 | - | - | - | - | - | - | - | - | - | - |
| 95 | 73 | 22 | 58 | 18 | 37 | 11 | 23 | 7 | 14 | 4 | - | - | - | - | - | - | - | - | - | - |
| 100 | 70 | 21 | 55 | 17 | 35 | 11 | 22 | 7 | 14 | 4 | - | - | - | - | - | - | - | - | - | - |
| 105 | 66 | 20 | 53 | 16 | 33 | 10 | 21 | 6 | 13 | 4 | - | - | - | - | - | - | - | - | - | - |
| 110 | 63 | 19 | 50 | 15 | 32 | 10 | 20 | 6 | 13 | 4 | - | - | - | - | - | - | - | - | - | - |
| 115 | 61 | 18 | 48 | 15 | 30 | 9 | 19 | 6 | 12 | 4 | - | - | - | - | - | - | - | - | - | - |
| 120 | 58 | 18 | 46 | 14 | 29 | 9 | 18 | 6 | 11 | 3 | - | - | - | - | - | - | - | - | - | - |
| 125 | 56 | 17 | 44 | 13 | 28 | 8 | 17 | 5 | 11 | 3 | - | - | - | - | - | - | - | - | - | - |
| 130 | 54 | 16 | 43 | 13 | 27 | 8 | 17 | 5 | 11 | 3 | - | - | - | - | - | - | - | - | - | - |
| 135 | 52 | 16 | 41 | 12 | 26 | 8 | 16 | 5 | 10 | 3 | - | - | - | - | - | - | - | - | - | - |
| 140 | 50 | 15 | 39 | 12 | 25 | 8 | 16 | 5 | 10 | 3 | - | - | - | - | - | - | - | - | - | - |
| 145 | 48 | 15 | 38 | 12 | 24 | 7 | 15 | 5 | 9 | 3 | - | - | - | - | - | - | - | - | - | - |
| 150 | 46 | 14 | 37 | 11 | 23 | 7 | 15 | 4 | 9 | 3 | - | - | - | - | - | - | - | - | - | - |
| 155 | 45 | 14 | 36 | 11 | 22 | 7 | 14 | 4 | 9 | 3 | - | - | - | - | - | - | - | - | - | - |
| 160 | 44 | 13 | 35 | 11 | 22 | 7 | 14 | 4 | 9 | 3 | - | - | - | - | - | - | - | - | - | - |
| 165 | 42 | 13 | 34 | 10 | 21 | 6 | 13 | 4 | 8 | 3 | - | - | - | - | - | - | - | - | - | - |
| 170 | 41 | 13 | 33 | 10 | 20 | 6 | 13 | 4 | 8 | 2 | - | - | - | - | - | - | - | - | - | - |

### APPENDIX C - SELECTION OF A COMMUNICATION NETWORK

**Protocol Comparisons**

Subject Area J1939 J1587/J1708 J2284 High Speed CAN J2411 Single Wire CAN DeviceNet Lon Works

Line Driver Differential Bus Modified RS-485 Differential Bus Single Wire Bus Differential Bus Differential Bus

Differential Bus (random laid)

Baud Rate 250 Kbps 9.6 Kbps 500 Kbps 40 Kbps (note 3) 125Kbps, 250Kbps, 500Kbps supported 1.25 Mbps

Network Access Random Random Random Random Random Random

Arbitration Non-destructive Destructive Non-destructive Non-destructive Non-destructive Non-destructive

Identifier 29-bit 8-bit 11-bit (note 1) 11 or 29-bit 11-bit 48-bit unique ID/node

Maximum nodes 30 20 16 32 64 32, 385 (see notes 4&5)

Max. Bus Length 40 meters 40 meters 30 meters (note 2) 40 meters 500m, 250m, 100m supported 2000m

Max. Stub Length 1 meter 40 meters 1 meter N/A 3 meters (156m collectively) Physical layer dependent

Bus Termination 2 120 Ohms Parallel None required 2 120 Ohms Parallel N/A 2 120 Ohms parallel Physical layer dependent

Bus Wire STP UTP UTP - Optional Shield Single Unshielded 2 STP plus Shield TP, Power Lines, RF, IR,

Coax, Fiber Optic

Bus Configuration Linear w/Stubs Non-Linear Linear w/Drops Ring, Star or Both Linear Bus, Star, Ring,

Combination

Data Link Connector SAE J1939/11 SAE J1962 SAE J1962 SAE J1962 See DeviceNet Specification See Specification

(3 pin unshielded)

Max. Bus Voltage +16 volts +5 volts +16 volts +16 volts +11 volt to +25 volt Physical layer

dependent

(node input)

Nom. Bus Voltage 2.0 volt differential +5 volts +2.0 volt differential +4.0 volt +2.0 volt differential Physical layer

dependent

Application Layer Defined Not Specified Not Defined Not Defined Defined Defined

Note 1 - - Modules that support OBDII requirements must also support 29-bit

Note 2a - - Maximum distance between any two ECUs on the bus, including cable stubs and any off-board node (tool). The maximum distance between any two on-board ECUs is 25 meters (SAE J2284)

Note 2b - - SAE J2284 specifies a unique bus configuration for a single on-board ECU. The maximum distance from DLC (Data Link Connector) and the on-board. ECU is 5 meters. Likewise, the maximum distance from the DLC and the off-board node (tester) is 5 meters

Note 3 - - High speed is 80 Kbps. SAE J2411 uses a normal operation baud rate of 40 Kbps. The high-speed mode for the test tool is 80 Kbps, for rapid downloading to modules. Manufacturing, however, may utilize more than one high-speed baud rate for programming various modules

Note 4 - - Subnets/domain (255) times nodes/subnet (127) = 32,385 nodes/domain. Domain is a logical collection of nodes on one or more channels

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Note 5 -- | Channel Types | Medium | Data Rate | Max Nodes | Max Distance |
|  | TPIXF1250 | TP, bus | 1.25Kbps | 64/channel | 125m |
|  | TPIXF – 78 | TP, bus | 78Kbps | 64/channel | 1330m |

**Selecting a Communications Network**

The Guideline Specification strongly encourages the use of an open communications network where the rules, or protocols, that define how messages are coded and transmitted on the network are documented to the public. Closed networks are proprietary in nature because most, if not all, of the communications protocols are restricted to licensed vendors.

The degree to which networks are open or closed depends upon how they interface with seven layers of an Open Systems Interconnection (OSI) reference model developed by the International Standards Organization (ISO). This model was developed to standardize the communication between computer-based systems. A fully open network is one where documentation for all layers is available to the public, while a completely closed network does not publish any of its interface protocols to the public.

The concept of pen networks is important because it allows components from several different manufacturers to be used on the network in a "plug-and-play" fashion, giving agencies a variety of products to choose from at competitive prices. Conversely, components integrated on a closed network may restrict choices and result in higher equipment costs. Additionally, the CUSTOMER may find itself with unsupportable equipment if the vendor should leave the market.

Prior to selecting a network, Procuring Agencies are advised to become aware of its capabilities and limitations. In particular, agencies should determine the extent to which a network is open, and if any network components are proprietary and only available through select vendors. Procuring Agencies are also advised to consider pre-wiring transit buses at time of manufacture with data/power cabling to facilitate future expansion of Information Level components.

The Protocol Comparison Chart shown on the preceding page provides information on essential characteristics of the more common communications networks available today.

*The remainder of this page is intentionally left blank.*

### APPENDIX D - NOT USED

### APPENDIX E - CUSTOMER J1939/J1587 - Interface Protocol Guideline

**Purpose**

This document is intended to provide a guideline for the minimum level of J1939 or J1587/J1708 protocol conformance necessary to enable devices on the chassis or drive train networks to provide meaningful performance and fault (diagnostic) information to the CUSTOMER Vehicle Logic Unit (VLU) system. Successful integration of a vendor’s device on the network is contingent upon conformance to these criteria, which represent a subset of, and fully adhere to, SAE J1939 or SAE J1587/J1708. Applicable sections of these specifications are referenced below as appropriate.

In addition, a description of time and date information provided (on request) by the CUSTOMER VLU system, via both the J1939 and J1587/J1708 networks, is included; and a recommended means of support for detecting the presence and software revision of a device on both the J1939 and J1587/J1708 networks is described.

Lastly, Appendix A includes J1939 DM1 message packet details, and Appendix B includes further detail regarding J1939 and J1587 software ID by request.

**Definitions**

**MID** – Message ID. Identifies the source (xmitter, node) of the message. A MID is unique to only one transmitter.

**PID** – Parameter ID. Identifies the data from a MID

**SID** – Subsystem ID. Identifies a section of an ECU or MID that does not have a related PID.

**FMI** – Failure Mode Identifier. Identifies what is wrong with a PID or a SID. There are a total of 31 FMI’s. 21 FMI’s have been defined.

**DTC** – Diagnostic Trouble Code. A MID, PID or a SID + a FMI = a DTC

**PGN** – Parameter Group Number. Identifies the type of data in the message.

**SPN** – Suspect Parameter Number. Identifies a specific component/parameter or fault. SPN’s that share common characteristics are grouped into a parameter group (PG) and are transmitted to the network using the same PGN.

**SA** – Signal Attribute. Contains status information about the validity of data signals included in the data record.

**DM1** – Diagnostic message (active fault)

**CAN** – Controller Area Network

**J1939 / J1587 Source Addresses**

The CUSTOMER VLU system J1939 Source Address shall be determined after contract award. The J1587/J1708 MID will also be determined after contract award.

**J1939 Performance Data**

All non-diagnostic application layer messages must be formatted and transmitted in conformance with SAE J1939-71, “Vehicle Application Layer” (Revised December, 2004). All performance data not made available through a broadcast must be available to CUSTOMER VLU via the Request PGN (59904), as described in SAE J1939-21, “Data Link Layer” (Revised April, 2001).

**J1939 Fault Reporting (DM1 Diagnostic Messages)**

All diagnostic (fault) application layer messages must conform to the requirements described in SAE J1939-73 “Application Layer – Diagnostics” (Revised September, 2006).

Specifically, at a minimum, all active faults must be formatted and transmitted in accordance with paragraph 5.7.1 (“Active Diagnostic Trouble Codes” – Message Type DM1 [PGN 65226]). These messages are to be broadcast, but should also be available on request (per the specification), using the Request Message PGN [59904]. The Request PGN is described in J1939-21, “Data Link Layer” (Revised April, 2001). The response to the DM1 request must be in accordance with paragraph 5.7.1 with regard to the formatting of DM1 messages. See “Transport Protocol”, below for details regarding transmission of multiple packets, containing Diagnostic Trouble Codes (DTCs), using the Broadcast Announce Message (BAM).

The DM1 message involves the use of Suspect Parameter Numbers (SPNs) to identify a particular element, component or parameter associated with a J1939 network device Diagnostic Trouble Code (DTC). Where possible, vendors should use SPN’s defined in the SAE J1939 specification when reporting faults. However, if there is no correlation to an existing SPN, values in the proprietary range must be used. These are the SPN values that span from 520192 (7F000 hex) to 524287 (7FFFF hex), inclusive.

Refer to Appendix A for additional detail regarding DM1 transmission and formatting.

**J1939 Transport Protocol - Broadcast Announce Message (BAM)**

In all cases where a response or broadcast message will require greater than 8 data bytes, the capabilities of the Transport Protocol must be employed.

Specifically, the Broadcast Announce Message Transport Protocol, as described in SAE J1939-21, “Data Link Layer” (Revised April, 2001), paragraph 5.10, provides for the transmission of messages that encompass multiple packets of data. An example of such a transmission would be a DM1 message with more than one Diagnostic Trouble Code (DTC) being reported.

Refer to Appendix A for additional detail regarding multi-packet DM1 transmission and formatting.

J1587 Performance Data

All non-diagnostic or fault application layer status messages must be formatted and transmitted in conformance with SAE J1587, “Electronic Data Interchange Between Microcomputer Systems in Heavy Duty Vehicle Applications” (Revised February, 2002) and SAE J1708, “Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications” (Revised October, 2003). All performance data is expected to be available via appropriate Message ID (MID) and Parameter ID (PID) assignments in accordance with these specifications.

**J1587 Fault Reporting**

All diagnostic (fault) application layer messages must be formatted and transmitted in conformance with SAE J1587, “Electronic Data Interchange Between Microcomputer Systems in Heavy Duty Vehicle Applications” (Revised February, 2002) and SAE J1708, “Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications” (Revised October, 2003). Specific attention should be devoted to the use of PID 194 (Transmitter System Diagnostic Occurrence Count Table) to report the diagnostic condition of a device on the network.

**J1587 Multi-section Parameter**

PID 192 (Multi-section Parameter) is used to transmit parameters that are longer than what is limited by SAE J1708. A specified parameter can be broken into sections with each section being transmitted in a different message. This should be used as appropriate.

**Time and Date Information**

On request, after the CUSTOMER VLU system has initialized, time and date information will be available from the VLU system via the J 1939 and J 1587 (J 1708) networks as follows:

**J1939 Network Interface:**

Using the Request Message [PGN 59904], a device may query the VLU system for the Time/Date message (PGN 65254) using a directed request. The Request PGN is described in SAE J1939-21, “Data Link Layer” (Revised April, 2001). The Time/Date PGN is described in SAE J1939-71, “Vehicle Application Layer” (Revised December, 2004).

**J1587/J1708 Network Interface:**

Using the Request Parameter [PID 0 or PID 128], a device may query the VLU system for the Clock message parameter (PID 251) or the Date message parameter (PID 252). The protocol and message formats are in conformance with SAE J1708 and SAE J1587.

NOTES: Devices requesting time and date information at startup must resend the request every 30 seconds until they receive a response as the VLU system may not yet have initialized. Time/Date requests should not occur more frequently than every 5 seconds.

**GPS (Location) Information**

On request, after the CUSTOMER VLU system has initialized, GPS Latitude and Longitude information will be available from the CUSTOMER VLU system via the J1939 and J1587 (J1708) networks as follows:

**J1939 Network Interface:**

Using the Request Message [PGN 59904], a device may query the CUSTOMER VLU system for the Vehicle Position message (PGN 65267) using a directed request. The Request PGN is described in SAE J1939-21, “Data Link Layer” (Revised April, 2001). The Vehicle Position PGN is described in SAE J1939-71, “Vehicle Application Layer” (Revised December, 2004).

**J1587/J1708 Network Interface:**

Using the Request Parameter [PID 0 or PID 128], a device may query the CUSTOMER VLU system for the Position message parameter (PID 239). The protocol and message formats are in conformance with SAE J1708 and SAE J1587.

NOTES: Devices requesting position information at startup must resend the request every 30 seconds until they receive a response as the CUSTOMER VLU system may not yet have initialized. Position requests should not occur more frequently than every 5 seconds.

**Component and Software Revision Information**

All devices on the J 1939 and J 1587 (J 1708) networks must respond to directed requests for Component Identification and Software Identification as follows:

**J1939 Network Interface:**

Using the Request Message [PGN 59904], a device may query other network devices for the ECU Identification Information Message (PGN 64965) and the Software Identification Message (PGN 65242). The Request PGN is described in SAE J1939-21, “Data Link Layer” (Revised April, 2001). The ECU Identification Information PGN and the Software Identification PGN are described in SAE J1939-71, “Vehicle Application Layer” (Revised December, 2004).

Refer to Appendix B for additional detail regarding J1939 Software ID request / response message formatting.

**J1587/J1708 Network Interface:**

Using the Request Parameter [PID 0 or PID 128], a device may query other network devices for the Component Identification parameter (PID 243) or the Software Identification parameter (PID 234). The protocol and message formats are in conformance with SAE J1708 and SAE J1587.

Refer to Appendix B for additional detail regarding J1587 Software ID request / response message formatting.

**Vendor Implementation Specification**

For the CUSTOMER VLU system to be properly configured to support a J1939 or J1587 (J1708) compliant device, the following information must be provided in a vendor-supplied specification:

**J1939 Compliant Devices:**

1. Source Address on the J1939 network.
2. Specific detail for all PGNs supported (down to the individual parameters supported within the PGN).
3. Details for each fault the device is capable of generating (using the DM1 message). Specifically, the Source Address (SA), Suspect Parameter Number (SPN), Fault ID (FMI), OEM Description and OEM Flash Code or Fault Code, if it exists.

**J1587 Compliant Devices:**

1. MID on the J1587 (J1708) network.
2. Specific detail for all PIDs. Details for each fault the device is capable of generating (using the PID 194 message). Specifically, the MID, PID / SID, Fault ID (FMI), OEM Description and OEM Flash Code or Fault Code, if it exists.

**Appendix A – Reporting Faults Using DM1**

The DM1 message is used to report active faults for devices on the J1939 network and is described in paragraph 5.7.1 of J1939-73. Devices reporting more than one active fault at a time must use the Broadcast Announce Message (BAM) transport protocol as described in J1939-21 to format and send a DM1 message which spans multiple packets.

**Reporting a single active fault**

This message is broadcast when a fault occurs and then once per second thereafter; or upon request.

The 29-bit message ID field will contain a default priority of 6 (the upper 5 bits of the ID field contains the 3 bit priority, the reserved bit and the data page bit – together they form a value of 18 hex), a PGN value of 65226 (FECA hex), and the source address of the reporting device (the sender):

DM1 MESSAGE ID

|  |  |  |  |
| --- | --- | --- | --- |
| ID UPPER 5 BITS | PGN UPPER BYTE | PGN LOWER BYTE | SA BYTE |
| 18 (hex) | FE (hex) | CA (hex) | (sender) |

The data field format for reporting a single Diagnostic Trouble Code (DTC) is as follows (bytes 3 through 6 contain the DTC):

DM1 MESSAGE DATA

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 |
| Lamp Status 1 | Lamp Status 2 | DTC (SPN low bits) | DTC (SPN middle bits) | DTC (SPN upper 3 bits, FMI) | DTC (CM, occurrence count) |

This message is broadcast as soon as the fault goes active and once every second thereafter.

**Reporting multiple active faults**

Reporting more than one active fault requires the implementation of the BAM transport protocol.

This message is broadcast when a fault occurs and then once per second thereafter; or upon request.

In the following example a DM1 message is broadcast using the BAM transport protocol to report 2 active faults (DTCs).

The first packet transmitted will contain the transport protocol connection management ([TP.CM](http://TP.CM)) PGN in the message ID field (base value 60416, or EC00 hex), plus a global broadcast destination address (255, or FF hex), which together yield a PGN of 60671 (ECFF hex):

BAM (DM1) Connection Management Message ID

|  |  |  |  |
| --- | --- | --- | --- |
| ID UPPER 5 BITS | PGN UPPER BYTE | PGN LOWER BYTE | SA BYTE |
| 18 (hex) | EC (hex) | FF (hex) | (sender) |

The data field format for the connection management data packet is as follows:

BAM (DM1) Connection Management Message Data

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 | BYTE 8 |
| Control Byte- BAM (32 [20 hex]) | DM1 Message Size Low Byte (10 [0A hex]) | DM1 Message Size High Byte (0) | Number of Data Transfer Packets (2) | FF (hex) | DM1 PGN Low Byte (CA hex) | DM1 PGN Middle Byte (FE hex) | DM1 PGN High Byte (00 hex) |

The second and third transport protocol packets for this message transmission will have a message ID field which contains the Data Transfer (TP.DT) PGN (base value 60160, or EB00 hex), plus a global broadcast destination address (255, or FF hex), which together yield a PGN of 60415 (EBFF hex):

**BAM (DM1) Data Transfer Message ID (this will be identical for all data transfer packets)**

|  |  |  |  |
| --- | --- | --- | --- |
| ID UPPER 5 BITS | PGN UPPER BYTE | PGN LOWER BYTE | SA BYTE |
| 18 (hex) | EB (hex) | FF (hex) | (sender) |

The data field format for the data transfer packets is as follows - note the FF fill in the last bytes of the second (final) packet:

BAM (DM1) Data Transfer Message Data – Data Transfer Packet 1 of 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 | BYTE 8 |
| Packet Sequence Number (1) | DM1 Lamp Status 1 | DM1 Lamp Status 2 | DTC 1 (SPN low bits) | DTC 1 (SPN middle bits) | DTC 1 (SPN upper 3 bits, FMI) | DTC 1 (CM occurrence count) | DTC 2 (SPN low bits) |

BAM (DM1) Data Transfer Message Data – Data Transfer Packet 2 of 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 | BYTE 8 |
| Packet Sequence Number (2) | DTC 2 (SPN middle bits) | DTC 2 (SPN upper 3 bits, FMI) | DTC 2 (CM occurrence count) | FF (hex) | FF (hex) | FF (hex) | FF (hex) |

**REPORTING NO ACTIVE FAULTS**

This message is transmitted once when the reporting device transitions from having at least one active fault to having no active faults or upon request.

The 29-bit message ID field will contain a default priority of 6 (the upper 5 bits of the ID field contains the 3 bit priority, the reserved bit and the data page bit – together they form a value of 18 hex), a PGN value of 65226 (FECA hex), and the source address of the reporting device (the sender):

DM1 (no active faults) Message ID

|  |  |  |  |
| --- | --- | --- | --- |
| ID UPPER 5 BITS | PGN UPPER BYTE | PGN LOWER BYTE | SA BYTE |
| 18 (hex) | FE (hex) | CA (hex) | (sender) |

The data field format for the no active faults indication is a fixed pattern of data bytes:

DMI (No Active Faults) MESSAGE Data

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 | BYTE 8 |
| 00 | FF | 00 | 00 | 00 | 00 | FF | FF |

**Appendix B – Software ID by Request**

The following examples illustrate packet formatting for requests for the Software ID and the associated responses for both J1939 and J1587 interfaces:

J1939 Request for Software ID PGN 65242

The CUSTOMER VLU will issue the request with the following format:

The 29-bit message ID field will contain a default priority of 6 (the upper 5 bits of the ID field contains the 3 bit priority, the reserved bit and the data page bit – together they form a value of 18 hex), a Request PGN base value of 59904 (EA00 hex) plus the destination address for this directed request, followed by the source address of the requesting device. For example, if the destination address is 33 hex and the IVN is the requestor, the format would be:

Request Message ID Field

|  |  |  |  |
| --- | --- | --- | --- |
| ID UPPER 5 BITS | PGN UPPER BYTE | PGN LOWER BYTE | SA BYTE |
| 18 (hex) | EA (hex) | 33 (hex) | 41 (hex) |

The data field contains the requested PGN. The format is low byte, middle byte, and high byte as shown. Only three bytes are necessary in the data field. If additional bytes are sent, they should all be FF hex:

Request Message Data Field

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 | BYTE 8 |
| DA | FE | 00 | FF | FF | FF | FF | FF |

J1939 Response to Request for Software ID PGN 65242

The device should respond with the following format:

The 29-bit message ID field will contain a default priority of 6 (the upper 5 bits of the ID field contains the 3 bit priority, the reserved bit and the data page bit – together they form a value of 18 hex), the Software ID PGN (FEDA hex), followed by the source address of the responding device (33 hex in this example):

Response Message ID Field

|  |  |  |  |
| --- | --- | --- | --- |
| ID UPPER 5 BITS | PGN UPPER BYTE | PGN LOWER BYTE | SA BYTE |
| 18 (hex) | FE (hex) | DA (hex) | 33 (hex) |

The data field contains the PGN data value for Software ID. The format is as follows: Byte 1 = 01 hex, Bytes 2 through (up to) Byte 7 contain the ASCII hex values for the software or firmware version and the last byte contains an ASCII ‘\*’ (asterisk) indicating the end of the field. For the example shown here, the software version is “A21 .35”

Response Message Data Field

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 | BYTE 5 | BYTE 6 | BYTE 7 | BYTE 8 |
| 01 hex | 41 hex | 32 hex | 31 hex | 2E hex | 33 hex | 35 hex | 2A hex |

J1587 Request for Software ID PID 234

**Note: Packet checksums are not shown here but are required in accordance with J1708 / J1587.**

The CUSTOMER VLU will issue the request with the following J1587 packet format:

**Request Message using PID 0 (broadcast to all devices)**

|  |  |  |
| --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 |
| NN hex (CUSTOMER’s MID to be determined) | 00  (PID 0) | EA hex  (PID 234) |

**Request Message using PID 128 (request to a specific device)**

|  |  |  |  |
| --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4 |
| NN hex (CUSTOMER’s MID to be determined) | 80 hex  (PID 128) | EA hex  (PID 234) | (Destination device MID) |

J1587 Response to Request for Software ID PID 234

The device should respond with the following format:

Response Message Data Field

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| BYTE 1 | BYTE 2 | BYTE 3 | BYTE 4… | …BYTE N | BYTE N+1 |
| (Device MID) | EA hex  (PID 234) | (Software version character count) | (1st ASCII ID character) | (Last ASCII ID character) | 2A hex  (ASCII ‘\*’) |

### Appendix F *-* vdl Technology, Capabilities & Selectable Parameters (CUSTOMER’s Survey Results of User Defined Inputs)

<< Not Used >>

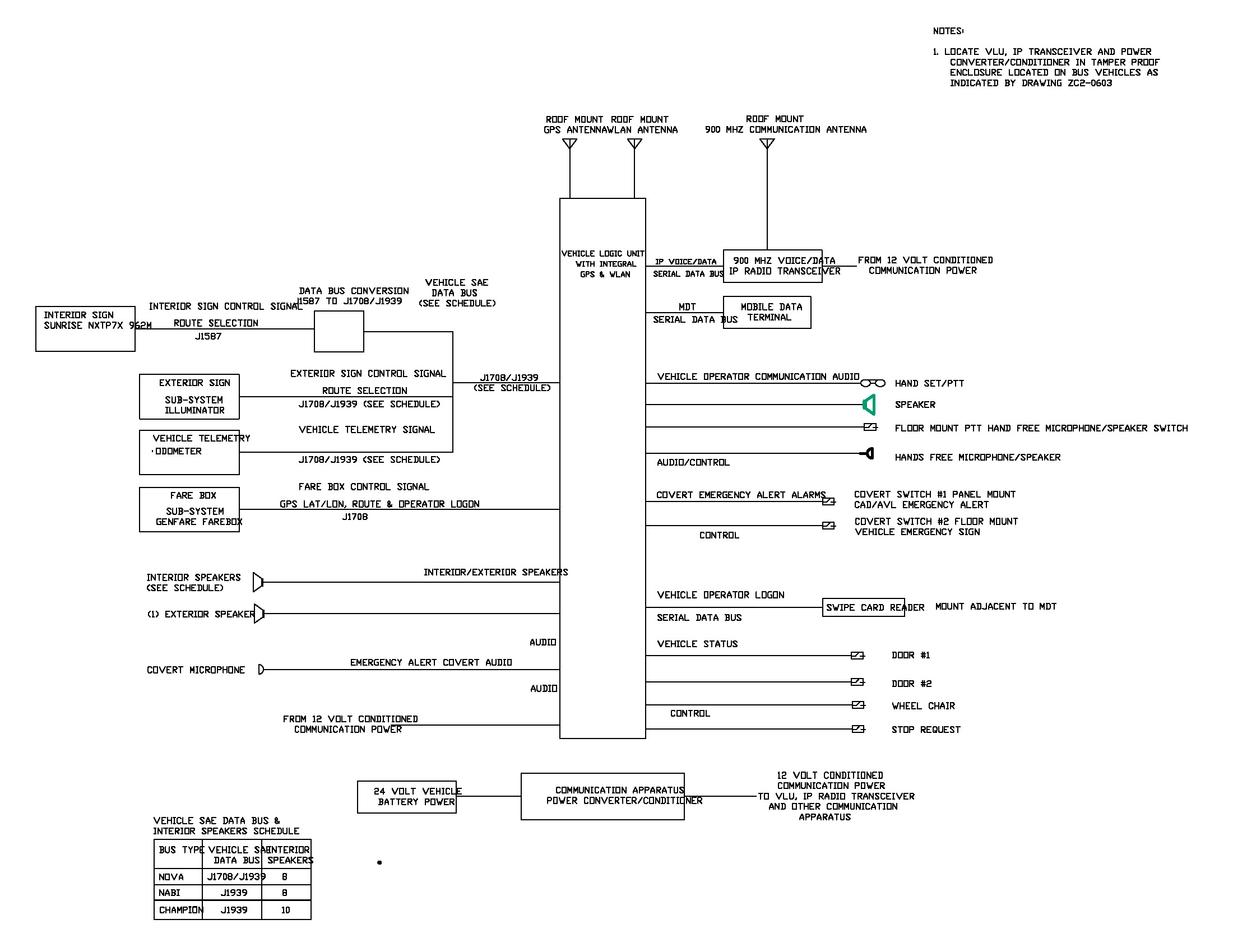
### Appendix G *-* vdl Technology, Capabilities & Selectable Parameters (VEHICLE J1939 DATA REQUIREMENTS)

| **VEHICLE J1939 DATA REQUIREMENTS** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **J1708** | | **J1939** | | | **Transmission** |
| **Parameter Group Label** | **Description/J1939 Name** | **MID** | **PID** | **SA** | **PGN** | **SPN** | **Rate** |
|  |  |  |  |  |  |  |  |
| Shutdown | **Drive System Protection System Timer State** |  |  | 0 |  |  |  |
| Shutdown | **Drive System Protection System Approaching Shutdown** |  |  | 0 | 65252 | 1109 | 1 sec |
| Shutdown | **Drive System Protection System has Shutdown Drive System** |  |  | 0 | 65252 | 1110 | 1 sec |
| Shutdown | **Drive System Protection System Configuration** |  |  | 0 | 65252 | 1111 | 1 sec |
|  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |
| Transmission Fluids 1 | **Transmission Oil Temperature** | 130 | 177 | 3 | 65272 | 177 | 1 sec |
| Cruise Control/Vehicle Speed | **Wheel-Based Vehicle Speed** | 128 | 84 | 0 | 65265 | 84 | 0.1 sec |
| Electronic Brake Controller 1 | **Anti-Lock Braking (ABS) Active** |  |  |  | 61441 | 563 | 0.1 sec |
| Electronic Brake Controller 1 | **ABS Fully Operational** |  |  |  | 61441 | 1243 | 0.1 sec |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |
| Air Suspension Control 2 | **Kneeling Request Right Side** |  |  |  | 53760 | 1748 | 0.1 sec |
|  |  |  |  |  |  |  |  |
| Lighting Data | **Back Up Light and Alarm Horn** |  |  |  | 65088 | 2392 | on request |
|  |  |  |  |  |  |  |  |
| Vehicle Position | **Latitude position of the vehicle** |  |  |  | 65267 | 584 | 5 sec |
| Vehicle Position | **Longitude position of the vehicle** |  |  |  | 65267 | 585 | 5 sec |
|  |  |  |  |  |  |  |  |
| Drive System | **ReGen Switches Status** | 128 | 40 |  |  |  |  |
| Electronic ReGen Controller 1 | **ReGen Enable - Brake Assist Switch** |  |  | 15 | 61440 | 571 | 0.1 sec |
|  |  |  |  |  |  |  |  |
|  | **Cab HVAC System Controller** |  |  |  |  | 3985 |  |
|  | **Operator Input Device for Cab Climate Control** |  |  |  |  | 1552 |  |
|  |  |  |  |  |  |  |  |
|  | **Door 1 Control Module** |  |  |  |  | 3988 |  |
|  |  |  |  |  |  |  |  |
| Tire Pressure Reference Information | **Tire Location** |  |  |  | 64953 | 3190 | on request |
| Tire Pressure Reference Information | **Reference Tire Pressure** |  |  |  | 64953 | 3191 | on request |
|  |  |  |  |  |  |  |  |
| Operator Wiper and Washer Controls Message | **Front Operator Wiper Switch** |  |  |  | 64973 | 2863 | 0.2 sec |
| Operators External Light Controls Message | **Turn Signal Switch** |  |  |  | 64972 | 2876 | 1 sec |
| Operators External Light Controls Message | **Hazard Light Switch** |  |  |  | 64972 | 2875 | 1 sec |
|  | **Headlamp 1 High Beam (left)** |  |  |  |  | 4011 |  |
|  | **Headlamp 2 High Beam (right)** |  |  |  |  | 4012 |  |
|  | **Headlamp Low Beam Left #1** |  |  |  |  | 2653 |  |
|  | **Headlamp Low Beam Right #1** |  |  |  |  | 2655 |  |
| Operators External Light Controls Message | **High-Low Beam Switch** |  |  |  | 64972 | 2875 | 1 sec |
| Vehicle Electrical Power 1 | **Charging System Potential** |  |  |  | 65271 | 167 | 1 sec |
| Vehicle Electrical Power 1 | **Battery Potential /Power Input 1** | 128 | 168 | 0 | 65271 | 168 | 1 sec |
|  |  |  |  |  |  |  |  |
| Time/Date | **Seconds** |  |  |  | 65254 | 959 | On request |
| Time/Date | **Minutes** |  |  |  | 65254 | 960 | On request |
| Time/Date | **Hours** |  |  |  | 65254 | 961 | On request |
| Time/Date | **Day** |  |  |  | 65254 | 962 | On request |
| Time/Date | **Month** |  |  |  | 65254 | 963 | On request |
| Time/Date | **Year** |  |  |  | 65254 | 964 | On request |
|  |  |  |  |  |  |  |  |
| CUSTOMER VLU | **Operator Login** |  |  |  |  |  |  |
| CUSTOMER VLU | **Manual Incident Trigger** |  |  |  |  |  |  |
| Odometer | **Mileage Odometer** |  |  |  |  |  |  |
| CUSTOMER VLU | **Route/Call Analysis** |  |  |  |  |  |  |
| Mutiplex/GPS | **Start/Stop Time** |  |  |  |  |  |  |
| Mutiplex/GPS | **Idling/Shut Down Time & Location** |  |  |  |  |  |  |
| Mutiplex/GPS | **Stop Request Activation** |  |  |  |  |  |  |
| Mutiplex/GPS | **Parking Brake Status** |  |  |  |  |  |  |
| Mutiplex/GPS | **Master Switch Position** |  |  |  |  |  |  |
| Mutiplex/GPS | **IO Controls or Parker Vansco Communications Fault** |  |  |  |  |  |  |
| Mutiplex/GPS | **Kneeling System Status** |  |  |  |  |  |  |
| Mutiplex/GPS | **Fire Suppression Status** |  |  |  |  |  |  |
| Mutiplex/GPS | **Equalizer 12V DC Potential** |  |  |  |  |  |  |
| Mutiplex/GPS | **Equalizer 24V DC Potential** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| NOTE: Parameter Group Labels shown as "Multiplex/GPS" will be "hardwired" inputs to the Multiplex | | | | | | | |
| system or the GPS system and broadcast to the J1939 bus. Labels shown as CUSTOMER VLU | | | | | | | |
| will be interfaced with the CUSTOMER Vehicle Logic Unit (VLU). | | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

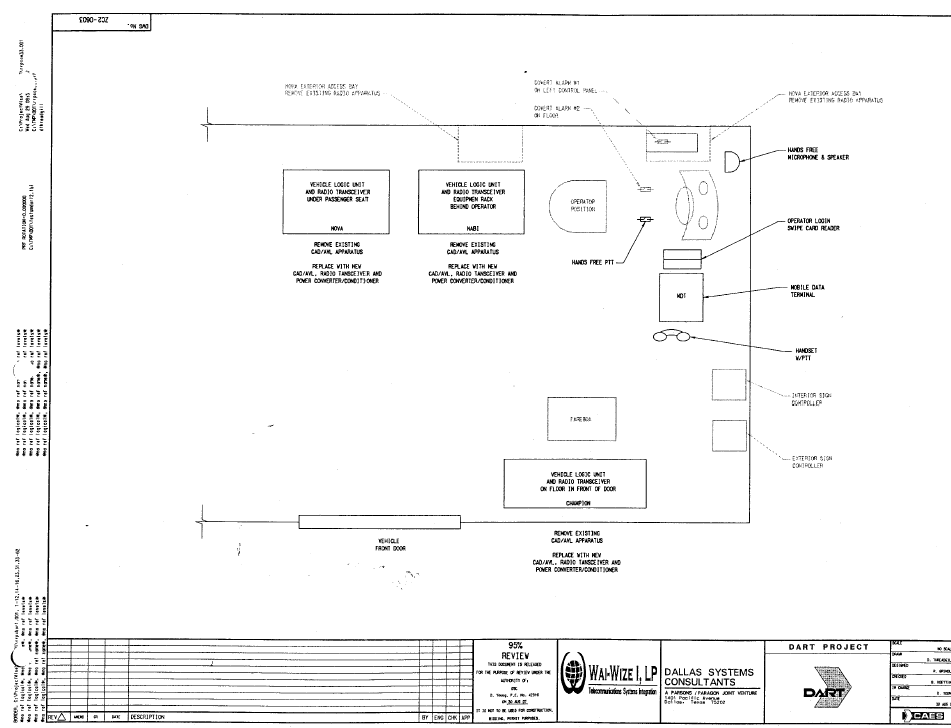
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### Appendix H *-* CUSTOMER’s Integrated Radio System (IRS) – Vehicle Logic Unit (VLU), Bus General Equipment Plan & Hardware Block Diagram {Sheet 1 of 2}

### 



### Appendix H-1 *-* CUSTOMER’s Integrated Radio System (IRS) – Vehicle Logic Unit (VLU), Bus General Equipment Plan & Hardware Block Diagram {Sheet 2 of 2}



***<<<< End of Specifications***