13.4.2 Salem test fittings shall be provided at all gauges plus at the air compressor control switch.

13.4.3 (deleted).

13.4.4 The above indications can be included in the Builder's integrated electronic display (if provided) in lieu of the above.

13.5 MAIN RESERVOIR

13.5.1 The main reservoir and air dryer system shall be subject to Metra design review and approval. **[CDRL C-13-04]**

13.5.2 A minimum of 400 l of main reservoir volume shall be provided on the trainset. Reservoirs shall comply with the requirements of 49 CFR 229.31. Reservoirs shall have an accessible drain hole at the bottom of each reservoir to facilitate draining of condensate.

13.5.3 The brake system of each truck shall have a separate R-Reservoir with a minimum volume of 80l.

13.5.4 Reservoirs shall be equipped with drain valves. Drain valves shall be located at the lowest point of the reservoir.

13.5.5 An aftercooler shall be provided in the air compressor system.

13.5.6 The air filter/dryer system shall meet the requirements as specified in APTA Standard APTA PR-M-S-011-99. A heater shall be included.

13.5.7 A safety valve set for a maximum of 160 psi shall be provided before the outlet of the compressor.

13.5.8 All check valves in the reservoir system shall be flange mounted.

13.6 AIR PIPING

13.6.1 Air piping shall be according to ASTM A-53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 316L or the equivalent 1.4404. Pipe Connection shall be according to ISO 8434 Metallic tube connections for fluid power and general use.. Contractor's standard piping and tubing shall be approved by Metra. **[CDRL C-13-05]**

13.7 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-13-01	Air Brake and Air Supply System

13.8 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-13-01	Air Brake System
C-13-02	Deadman Pedal
C-13-03	Air Compressor
C-13-04	Main Reservoir and Air Dryer

C-13-05	Air Piping

14 WARNING DEVICES

14.1 BELL

14.1.1 A bell (electric or pneumatic) shall be provided. The bell shall be mounted in a position to minimize snow and ice intrusion while still maintaining audible requirements. The location and design of the bell and bell controls shall be subject to Metra review and approval. **[CDRL C-14-01]**

14.1.2 Each driver's cab shall be equipped with two manual bell control buttons, reachable by the engineer and at the observer side.

14.1.2.1 Controls shall be arranged so that the bell may be operated manually in an active cab at any time.

14.1.2.2 The same apparatus panel to activate the bell shall be the same apparatus panel to deactivate it.

14.2 HORN

14.2.1 Horn sound levels must satisfy the requirements of FRA regulations 49 CFR 229.129. A minimum sound level of 96 dB(A) and a maximum sound level of 110 dB(A) at 100 feet forward of the locomotive in its direction of travel.

14.2.2 A low profile three-chime horn shall be provided. The horn(s) shall be located in a Metra approved location. The location and design of the horn and horn controls shall be subject to Metra review and approval. **[CDRL C-14-02]**

14.2.3. A horn heating system shall be provided. At a minimum, the center chime must be heated. The heating system for the horn assembly shall be subject to Metra review and approval.

14.2.3 The horn shall be activated by two (2) controls, one located on the engineer's console and the other on the observer's desk.

14.2.4 Horn assemblies with internal heating feature to prevent failure from ice or snow accumulations shall be provided.

14.3 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-14-01	Bell
C-14-02	Horn

15 TRUCKS

15.1 GENERAL REQUIREMENTS

15.1.1 Details of the design, arrangement, installation, and testing of the truck components and assembly shall be submitted to Metra for review and approval. **[CDRL C-15-01]** Truck system proposal shall include a basic general arrangement drawing, service history, and basic description of system function. **[PDRL P-15-01]**

15.1.2 Only trucks manufactured by a supplier with successful experience in railway passenger truck design and manufacture shall be acceptable. Final assembly needs not be done at an AAR certified shop however, manufacture of wheels and axles and their mounting shall be performed at AAR certified facilities. Trucks and components shall be based on a service proven design, which has operated in similar service in the United States. A technical evolution of the truck frame design is accepted under consideration of all track classes according to 49 CFR 213.9 and the requirements according to the standards EN 13749, EN 15085, EN 15827 and applicable CFR requirements. The Contractor shall submit the service history of the truck, noting any deviation for this application to Metra for review and approval, prior to selection of truck. **[CDRL C-15-02]**

15.1.3 The trucks shall provide a safe and secure support and guidance system, transmitting accelerating and braking forces to the car-body, and must provide comfortable riding quality at all speeds up to 100 miles per hour on track appropriately certified by FRA. The design, arrangement and equipment of the trucks shall be such as to prevent "hunting" or "nosing" at all speeds, and to minimize rocking of truck frame at critical speeds. **[CDRL C-15-05]**

15.1.4 The design safety concept shall be according to the standards EN 13749, EN 15085, EN 15827 and applicable CFR requirements. In the design of all truck parts, all forces and combinations of forces, including braking forces, must be taken into account. Multiplication of forces due to accelerations and shocks, and non-uniform distribution of vertical loading due to track irregularities and super elevation, must be considered according to best practice. The design center bearing load for both trucks shall be determined from the heaviest end of the trainset, using AW3 load, plus train supplies, less truck weight. To this dead weight must be added all dynamic loads and multiplying factors.

15.2 TRUCK FRAME

15.2.1 Truck frames shall be stress relieved, one piece cast, low alloy nickel structure, normalized and tempered, or welded steel fabrication of adequate cross sectional area at all locations. Junction of cross members to side members must be proportioned and shaped to eliminate stress points. Truck frame shall have as much strength and capability of resisting twisting and uneven distribution of loading as possible.

15.2.2 The truck frame shall be analyzed for static and dynamic loads and will be tested for static stresses and fatigue stresses. On-track testing of the truck frame and equalizer beam may also be required per the truck validation plan.

15.2.3 Design shall allow removal of wheelsets with traction motors or wheelsets with axle riding gear boxes using drop tables.

15.2.4 Axle-drive, end of-axle wheel-truing access provision, to allow wheel truing while the wheel set is attached to the car.

15.2.5 The truck frame shall provide a minimum life of 40 years based on proper performance of scheduled maintenance.

15.3 BRAKE RIGGING AND HANDBRAKE

15.3.1 Brake system shall be the builder's standard and service proven design to include tread or disc brakes, or a combination thereof.

15.3.1.1 Pneumatic application will apply brakes at all wheels
15.3.1.2 A suitable combination (as required) of disc or tread brakes shall be installed.
15.3.1.3 Self-aligning and adjusting brake rigging to correct clearances resulting from wear of brake pads, brake discs and wheel surface shall be provided.
15.3.1.4 Composition brake shoes/pads shall be used. Alternatively organic or sinter pads may be used.

15.3.2 Performance of a parking brake mechanism shall ensure that the vehicle can be safely parked at a 3% grade holding capacity, assuming the manufacturer's suggested friction coefficient for the brake pad. The hand brake shall be electrically operated, with indicator lamps near the brake unit and also in the cab. The design and placement of the handbrake and handbrake controls shall be subject to Metra design review and approval. **[CDRL C-15-03]**

15.4 TRUCK BOLSTER

15.4.1 Truck Bolster shall be a welded or cast steel structure. The junction of cross members to side members must be proportioned and shaped to eliminate stress points.

15.4.2 The bolster shall include an integral central bearing between the bolster and truck frame. Two piece locking pin shall be utilized between the truck frame and bolster. Vertical and Horizontal wear liner shall be a polymer material with previous service history and excellent maintenance performance.
If no vertical and horizontal wear liner are used the vertical and lateral suspension is given by air spring system. The lateral suspension is limited by progressive lateral rubber bumper in parallel to the air springs. The rotation is given by the air springs and pivot center bearing between frame and bolster.

15.4.3 The first truck bolster shall be tested as described in Section 22.2.8.2. On-track testing of the bolster may also be required per the truck validation plan.

15.5 SIDE BEARINGS

15.5.1 Truck frame shall have side bearing pads located between the truck frame and bolster that are provided with a replaceable steel liner. An air gap is specified between the bolster and steel liner to limit lean in extreme conditions and does not contact during normal service. Side bearing pads provide a safety or hard stop for extreme cases of car-body lean. Alternatively, the lateral suspension is limited by progressive lateral rubber bumper in parallel to air springs.

15.6 WHEELS/AXLES/GEARS

15.6.1 Gear ratio shall provide for operation up to 90 mph minimum and the gear seat on axle shall be tapered.

15.6.2 Axles shall be supplied to the latest revision of AAR Specification M-101, grade "F" material or EN 13261. End-of-axle access shall be provided for wheel truing operations.

15.6.3 New wheels shall be 870 mm, 33" or 36" diameter, wrought steel, multiple wear, heat-treated, curved plate design conforming to AAR specification M-107/M208, latest revision for Class B wheels. Wheels should have sufficient material to allow multiple wheel truing operations. Mill scale shall be removed from the entire wheel so that inspection can be made before application. The wheel profile shall be a narrow flange APTA 220 wheel profile as specified in APTA PR-M-S-015-06 latest revision, based on AAR-1B (AAR S-669), 1:20 taper, modified for 5.5 inch wheel width. Wheels shall be balanced to the design requirements in accordance with the procedures specified in recognized industry standards

15.6.4 Before assembling wheel and axle sets, the pairs of wheels must be matched as to tape size according to EN 13260, or AAR Wheel and Axle Manual, and all operations of boring wheels, assembly, and pressing same on axle, and press tonnages obtained, must be in accordance with recommendations in EN 13260, or AAR Wheel and Axle Manual.

15.6.5 Wheels must be statically balanced to the requirements from EN 13262, or at minimum to with 1.3 Lbs at outside rim diameter and the amount of imbalance to be marked or stenciled on the back of rim face at point of maximum imbalance. The contractor shall follow APTA PR-M-S-019-17 latest revision for the back-to-back wheel measurement.

15.6.6 Radial, plane and parallelism for the mounted wheels shall be per AAR requirements. In the absence of such requirements the following shall apply: Radial - .008", Plane - .015", Parallelism - 0.150".

15.6.7 Bearing press charts shall be provided with each mounting wheelset report in addition to the reporting requirements specified in the AAR Wheel and Axle Manual. Alternatively, the reporting requirements from EN 13260 can be used.

15.7 JOURNAL BEARINGS

15.7.1 Roller bearing races, fingers, seal rings, cones, spacers and other parts placed on axles must be properly assembled or pressed in place, in accordance with bearing manufacturer's and AAR recommendations. Alternatively, service proven tapered bearing units (TBUs) from approved suppliers can be used.

15.7.2 Journal bearings shall have not less than a ninety percent (90%) probability of an expected life of at least the equivalent of 1 million miles (1.62 million km) acc. ISO 281. The Contractor shall confirm the size by an approved analysis, in conformance with AAR size, weight, and speed relationship or appropriate EN standards.

15.8 SUSPENSION SYSTEM

15.8.1 The suspension system shall be consistent with the overall performance requirements of the trainset. The Contractor shall demonstrate through test results or simulations that the interfaces and integration of the system has been fully and successfully accomplished and that its dynamic performance under all operating conditions and speeds is in accordance with the requirements of this Specification and the intended services. If simulation is to be used for the strength assessment, the Contractor shall demonstrate the correlation between the numerical strength assessment and the results of the laboratory testing according to EN 13749.

15.8.2 At a minimum, each truck shall be provided with two shock absorbers to control the vertical motion of the truck bolster

15.8.3 Wheel Load Equalization

15.8.3.1 The suspension system shall meet Class R load equalization requirements per latest revision of APTA Standard SS-M-014-06.

15.8.4 Static Lean Response

15.8.4.1 The trainset and suspension system shall meet static lean requirements as follows:

15.8.4.1.1 For maximum cant deficiency a worst-case wheel load no less than 60% of the static wheel load (see 49CFR Section 213.57 and 49CFR Section 213.329).

15.8.4.1.2 (deleted)

15.8.5 Track Dynamic Forces

15.8.5.1 Track dynamic (P2) forces shall not exceed 82,000 lbs for a 0.5 degree dip angle and all speeds up to the operating speed limit. The calculation is to consider nominally stiff concrete tie track and to use the British Rail Equation (as defined in British Railways Board Group Standard GM/TT0088 Issue 1, Rev. A).

15.8.5.1.1 The specific equation to be used is as follows:

$$P_2 = P_0 + 2\alpha v\sqrt{\frac{m_u}{m_u + m_t}}\left(1 - \frac{\pi c_t}{4\sqrt{k_t(m_u + m_t)}}\right)\sqrt{k_t m_u}$$

Where:

P_0 Static wheel load in pounds
α Dip angle in radians
v Vehicle speed in inches/ second
m_u Unsprung mass per wheel in lbf/in/ sec2
m_t Track mass per wheel in lbf/in/ sec2
c_t Track damping per wheel in lbf/in/sec
k_t Track stiffness per wheel in lbf/ in
Track parameter values are as follows:
α 0.0085 Total dip angle in radians based on '/2 degree on both sides of the dip
m_t 1.1335 Track mass per wheel in lbf/ in/ sec2 for nominally stiff concrete tie track
c_t 671 Track damping per wheel in lbf/in/ sec for nominal track conditions (from literature)
k_t 392,900 Track stiffness per wheel in lbf/in for nominally stiff concrete tie track (corresponds to track modulus of 5,100 lb/in/in, assuming a track deflection of 0.084 inches under a 33,000 pound wheel load)

15.8.5.1.2 Calculation of P_2 forces using builder proposed alternative values in the British Rail Equation and resulting change in the value of P_2 forces may be considered by the Customer upon approval of justification for such changes by the Customer and that such calculations are also approved by the owner of the right-of-way or his designated representative.

15.8.6 Dynamic Response on FRA Class 1 through Class 5 Track

15.8.6.1 Track-worthiness of the suspension system shall be verified through test results or simulations following the requirements of EN 14363.

15.8.6.1.1 (deleted)
15.8.6.1.2 (deleted)
15.8.6.1.3 (deleted)
15.8.6.1.4 (deleted)
15.8.6.1.5 (deleted)
15.8.6.1.6 (deleted)

15.8.6.2 Test or analysis is to consider speeds up to 90 mph (where appropriate). Limit values are to be based on criteria defined in EN 14363.

15.9 TRUCK-TO-CAR ATTACHMENT MECHANISM

15.9.1 The truck design shall follow EN 13749. The arrangement shall provide for lifting of trucks when the car body is lifted without disengagement of the mechanism.

15.9.2 Entire mechanism shall be in accordance with FRA Regulation 49 CFR Part 238 and APTA Standard PR-CS-S-034-99, latest revision, Section 5.6. Alternatively, a solution in accordance with 49 CFR 238,201(b) and EN 13749 may be proposed.

15.10 TRUCK GROUNDS

15.10.1 A Metra approved flexible ground strap system shall be provided between the car-body and each truck frame. The design and placement of truck ground strap shall be subject to Metra review and approval. **[CDRL C-15-04]**

15.10.2 Minimum Clearance of Truck Parts according to CFR49 229.71 above top of Rail (worst case): 2-1/2" apart from wheel mounted or adjacent equipment like wheel mounted brake discs, brake pad holder or brake pads.

15.11 AAR S920 COMPLIANCE

15.11.1 The Contactor shall comply with AAR S920 (AAR CID) for wheels. Scanned Data shall be provided with each car history book electronically.

15.12 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-15-01	Truck System

15.13 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-15-01	Truck Design Review
C-15-02	Service History of Truck
C-15-03	Handbrake
C-15-04	Truck Ground
C-15-05	Ride Quality Simulation or Test Report

16 CAB CONTROL STATION

16.1 GENERAL REQUIREMENTS

16.1.1 An operating station shall be located on the lead end of all cab control cars. It shall have an Engineer's position on the right side (when looking out the windshield) and an observer's position on the left side.

16.1.2 The control station shall conform to the FRA and AAR standards for cab arrangements, to the greatest extent possible, considering the requirements of this specification.

16.1.3 The Engineer's operating controls shall be arranged in and on a desk-top console to the front of the engineer's seat and immediately below the windshield. All switches, circuit breakers and alike shall be arranged to permit a one man operation from the engineer's position. Details of the design of the cab, arrangement of the cab, and the locomotive controls, to include a mock-up of the cab, shall be submitted to Metra for review and approval. **[CDRL C-16-01]**

16.2 CAB SEATS

16.2.1 The control cab accommodate an Engineer and two seated Observers.. The seats shall comply with the requirements of APTA Standard PR-CS-S-011-99, latest revision and FRA Regulations 49 CFR Part 238.103 and 49 CFR Part 229.119. The cab seat design and layout shall be subject to Metra review and approval. **[CDRL C-16-02]**

16.3 AIR BRAKE EQUIPMENT

16.3.1 The air brake system shall have a penalty system linked to PTC, alerter function and overspeed.

16.3.2 Recovery from an emergency brake application shall only be possible after standstill. There shall be no delay on recovery from a penalty application except for a triggered emergency brake application via the penalty system..

16.3.3 Equipment to be provided as follows:

16.3.3.1 One (1) desk top electronic brake valve
16.3.3.2 One (1) dual gauge for MRE and Brake Pipe
16.3.3.3 One (1) dual gauge for brake cylinder and park brake cylinder pressure
16.3.3.4 (deleted)
16.3.3.5 One (1) emergency brake push button accessible for the operator and observer
16.3.3.6 One (1) alerter foot panel
16.3.3.7 (deleted)
16.3.3.8 Emergency brake shall trigger a traction cut-off.

16.3.4 (deleted)

16.3.5 (deleted)

16.3.6 "Deadman" feature shall be provided with appropriate sealable cutout switch.

16.4 CONTROL EQUIPMENT

16.4.1 A master Electro-Mechanical controller shall be provided in the control station to permit forward or reverse control of the train.

16.4.2 Power Knock/Out (PKO) will occur in response to emergency or penalty brake application. Automatic unloading and return to idle speed of engine or unloading of locomotive traction power without affecting engine speed, as appropriate to head end power supply requirements, will occur in the event that emergency brake application is made, or a service application is instituted through the safety control, overspeed, train stop or speed control systems. The propulsion system will receive the PKO signal from the brake system and immediately remove traction power. Also, a light shall be provided to indicate when the "PC" switch is open. Visual indication of the Power Knock/Out shall be displayed on the TOD (Train Operator Display)

16.4.3 Equipment to be provided as follows:

16.4.3.1 One (1) cab makeup switch.
16.4.3.2 One (1) attendant call switch (pushbutton or spring return switch);
16.4.3.3 One (1) Power Trainline Control (TLC) Reset

16.5 SPEED INDICATOR/ALERTER/EVENT RECORDER

16.5.1 A speed indicator shall be provided. The indicator shall be mounted in the lower console in the general line of sight, while facing forward.

16.5.2 The vehicle control unit (VCU) and the monitoring control unit (MCU) shall include multiple overspeed (underspeed) settings.
1. General Overspeed shall be set for 82 MPH and underspeed set for 3 MPH.
2. Overspeed PTC Cut Out 40mph, if there is not ATC (Overspeed 79mph) installed or block signal (Overspeed 59mph) system in place..

16.5.3 An event recorder shall be installed to record operating parameters of the car to interface with the PTC event recorder. The event recorder shall be fully compliant with 49 CFR Part 229.135.

16.5.4 The following parameters, at a minimum, shall be measured:

CHANNEL	TYPE	DESCRIPTION
1	Digital	BCP < 15 PSI
2	Digital	Manual Reset
3	Digital	Equalizing Reservoir
4	Digital	Not used
5	Digital	Bell
6	Digital	Horn
7	Digital	Self Test
8	Digital	Override Switch
9	Digital	Radio

10	Digital	Gen. Field
11	Digital	Throttle Sol. A
12	Digital	Throttle Sol. B
13	Digital	Throttle Sol. C
14	Digital	Throttle Sol. D
15	Digital	Forward
16	Digital	Reverse
17	Digital	Not used
18	Digital	Lift Deployed Override
19	Digital	Alerter Penalty
20	Digital	Osc. Headlight
21	Digital	Lift Deployed Signal
22	Digital	Door Closed Light
23	Digital	Train Control Penalty
24	Digital	Cab Signal Green
25	Digital	Cab Signal Yel/Grn
26	Digital	Cab Signal Yellow
27	Digital	Cab Signal Red/Yel
28	Digital	Not used
29	Digital	Not used
30	Digital	Not used
31	Digital	Not used
32	Digital	Not used
1	Analog	Brake Cylinder Pres.
2	Analog	Brake Pipe Pressure
3	Analog	Headlight Voltage
4	Analog	Ditch light on
5	Analog	Ditch light Flash
6	Analog	Ditch light Flash Auto
7	Analog	Not used
8	Analog	Not used
1	Frequency	Speed
2	Frequency	Not Used
3	Frequency	Not Used
4	Frequency	Not Used

16.5.5 An alerter system shall be provided which monitors the action of the operator and is recorded to the event recorder. If the alerter is not reset, a visual and an audible warning shall be made on the systems alarm panel (flashing visual light and increasing level of audible alarm). After the initial allowance time of 20 seconds upon system activation, the reset time shall inversely relate to speed. The alerter penalty application shall be capable of reset with a "running release". The details of the alerter system shall be submitted to Metra for review and approval. **[CDRL C-16-03]**

16.5.6 The conditions for resetting the alerter shall be submitted to Metra for review and approval and consider the following actions. [CDRL C-16-03]:

16.5.6.1 Master Controller Movement
16.5.6.2 Horn Use
16.5.6.3 Change in Direction of Travel
16.5.6.4 (deleted)
16.5.6.5 (deleted)
16.5.6.6 Alerter Reset Button
16.5.6.7 Bell Use

16.5.6.8 Change of State of the Headlight
16.5.6.9 Radio Use

16.5.7 A dedicated cutout function, with seal, shall be provided in a visually accessible location to cutout the alerter function in case of failure.

16.5.8 Alerter reset intervals shall be speed dependent; as vehicle speed increases, the alerter must be acknowledged more frequently. Per 49 CFR Part 229.140, alerter warning timing cycle interval shall be within 10 seconds of the calculated setting utilizing the formula (timing cycle specified in seconds = 2400 ÷ track speed specified in miles per hour). At speeds below 20 mph, the interval shall be between 110 seconds and 130 seconds.

16.5.9 The reset timing shall be as follows:

SPEED (MPH)	TIME (SEC.)
0.5-1.9	120
2.0	120
10	120
20	120
30	80
40	60
50	48
60	40
70	35
80	30

16.5.10 The following ditch light operating modes are controlled by solid state relays which are activated either by PTC, the train control system, or horn/bell activation:

16.5.10.1 Continuous
16.5.10.2 Flashing
16.5.10.3 Flashing after horn/bell.

16.6 CAB SIGNAL SYSTEM

16.6.1 (deleted)

16.6.1.1 (deleted)

16.6.1.2 (deleted)

16.6.1.3 (deleted)

16.6.2 (deleted)

16.6.3 (deleted)

16.6.4 (deleted)

16.6.5 (deleted)

16.6.6 (deleted)

16.6.7 (deleted)

16.7 POSITIVE TRAIN CONTROL

16.7.1 The Contractor shall propose to integrate and install the Wabtec I-ETMS Positive Train Control System kit. The PTC system components shall be reviewed and agreed between Metra, Wabtec and Stadler. The PTC components shall be drop shipped by Metra within four weeks of start of final assembly. The Contractor shall be responsible for all ancillary equipment and materials needed to complete the installation of the PTC system. Contractor will be responsible for the successful completion of the on-board diagnostic testing prior to delivery to Metra. The Contractor shall work with Metra to determine the best locations for PTC equipment and submit a final design for review and approval by Metra. **[CDRL C-16-05]**

16.8 CAB DIGITAL VIDEO RECORDING SYSTEM

16.8.1 The Contractor shall propose a new CDVRS system. The Contractor will provide its Cab Digital Video Recording System kit, with LDVR, microphones and cameras. The contractor shall comply with all applicable FRA requirements in effect at the time the proposals are submitted. In addition, the contractor will be required to meet or exceed language contained in 49 CFR 229.136. The Contractor shall be responsible for all ancillary equipment and materials needed to complete the installation of the CDVRS. Contractor shall be responsible for the successful completion of the on-board diagnostic testing prior to delivery to Metra. The Contractor shall work with Metra to determine the best locations for CDVRS equipment and submit a final design for review and approval by Metra. **[CDRL C-16-06]**

16.8.2 The CDVRS shall be composed of one central recorder, two (2) forward facing cameras, two (2) platform-facing cameras, one (1) cab-camera to cover operator control panels and one (1) cab-camera facing towards the operator (total six (6) cameras per cab), two exterior mounted microphones, one cab mounted microphone, solid state drive storage memory, crash hardened memory and all applicable interconnections. The CDVRS system shall be powered from a separate low voltage circuit breaker (on the breaker panel). A terminal board panel will be applied in a dry location near the central recorder for all CDVRS (power and signal) connections to be made. Hardware is to exhibit the smallest area footprint inside the cab cars and use the least mounted hardware as possible. The inputs and outputs of the DVR are to exhibit railroad grade connections. The design and arrangement of the CDVRS shall be approved by Metra prior to build of the first cab car.

16.8.3 The DVR recorder shall be a digital Internet Protocol (IP) based system and support digital IP cameras. The recorder shall have no less than 8 IP video channel inputs. The recorder shall have no less than 3 audio channel inputs. The DVR recorder video channels shall be used to capture and record video from multiple connected cameras simultaneously. The recorder audio channels shall be used to capture and record bell sounds, horn sounds, and have the ability to record cab compartment audio from multiple connected microphones simultaneously. The DVR recorder shall be capable of simultaneous playback, remote access, and recording. A removable hard drive shall be incorporated into the DVR recorder unit. The removable drive shall have security measures to allow only authorized personnel to remove the drive. The DVR recorder shall have a minimum of 1TB solid state storage capacity and the capacity to record at least 12-hour continuous recording capability per 49 U.S.C 20168(b)(1) and the recordings must beaccessible for review during an accident or incident investigation per 49 U.S.C 20168(b)(3). The hard drive capacity shall be sized to archive not less than 10 calendar days of video. The DVR recorder shall have Wi-Fi capabilities for ease of downloading in the case of accident or incidents when the DVR cannot be safely accessed in the rolling stock. The DVR recorder shall have crash and fire protections for any in-cab image recordings that are stored in the cab car operating compartment per 49 U.S.C 20168(b)(2). Frame rates and resolutions shall be customizable for each camera and be made accessible by Metra. The recorder shall feature

video motion detection. Video motion detection sensitivity shall be adjustable, customizable, and shall be capable of being enabled or disabled by Metra. The DVR system shall have the ability to utilize GPS data for location data and time synchronization. The DVR shall interface, access and download existing event recorder data. The recorder shall have a power input for all voltage ranges experienced by its power connection to the trainset and shall feature overvoltage and transient protection. The DVR recorder shall be capable of normal recording operations during momentary power losses, defined as 1 second or less, without: sustaining data loss, causing the DVR to reset due to momentary power loss, recording failure due to momentary power loss, or the DVR recorder entering a fault state requiring maintenance due to momentary power loss. The DVR recorder shall have a "self-test" and visual indicator system that indicates the system is properly functioning and recording. The visual indicator system shall alert personnel upon failure of any camera, hard drive, or other type of fault.

16.8.4 The two (2) forward facing cameras shall be capable of clearly recording railroad signal aspects in all types of weather, day, or nighttime conditions. The forward facing cameras shall be used to record the right of way, incidents, and railroad signal aspects of wayside signals. The cameras shall be aimed parallel to the centerline of tangent track within the gauge. The railroad signal aspects (colors) shall be clearly discernible during video playback. The cameras shall be a high definition digital IP type camera. The camera shall be powered by Power over Ethernet (PoE). The forward facing camera shall feature a dual lens, one for wide view, and one for narrow view. The focal length of the wide lens shall be 6mm. The focal length of the narrow lens shall be 16mm. Alternative focal lengths may be considered. The camera shall be mounted inside the cab, in a Metra-approved enclosure. The camera shall be adjustable to allow for camera positioning.

16.8.5 The platform cameras shall be a high definition digital IP type camera. The camera shall be powered by PoE. The focal length shall be determined during the design review. The camera shall be mounted outside the cab near the wind deflector on the observer's side in a high position close to the roof in order to get an optimal view of the vehicles side, boarding platform area and door indicator lamps. The camera will be able to resist all weather conditions in a weather-proof enclosure and include an automatic heating operation between a configurable temperature range. Additional car body cameras along the vehicle may be considered.

16.8.6 Two cameras shall be "inward facing" and used to record the cabin compartment of a cab car. Each inward facing camera shall be adjustable to allow for camera positioning. Each inward facing camera shall be a high definition digital IP type camera. Each inward facing camera shall be powered by PoE). The inward facing cameras shall be capable of recording black and white, as well as color. The settings shall be made accessible and adjustable to Metra. Each inward facing camera shall have 1 lens. Each inward facing camera shall have an adjustable lens. The camera lens focal length shall be set at 2.5mm or Metra-approved alternative. Each inward facing camera shall be housed in a compact vandal resistant enclosure. The inward facing cameras shall be suitable for indoor and outdoor installations. The inward facing cameras shall be capable of recording in any weather, day, or nighttime conditions. Each inward facing camera shall include an Infrared illumination (IR) feature for night vision video capture capability which can be enabled or disabled by Metra.

16.8.7 The dedicated microphones will have a "quick-disconnect" threaded, environmental-rated circular connector. The contractor will use the appropriate mating connector as well as non-metallic flexible ½" conduit, ½" NPT connectors and UNEF circular connector adaptor for the final two (2) feet of conduit connection to each microphone. Each dedicated microphone shall be rated for exterior outdoor use. One dedicated microphone will be mounted within three (3) feet of the bell. A new rigid metal ½" conduit will be run from the recorder location to the location of the microphone. The second dedicated microphone will be mounted on the roof within three (3) feet of the air-horn. A new rigid metal ½" conduit will run from the recorder location to the

location of the microphone. The roof microphone and associated conduit will not interfere with any removable roof panels. A third microphone will be mounted in the cab and shall be capable of recording cab compartment audio. This microphone shall be capable of being enabled or disabled by Metra.

16.8.8 In addition to the solid state hard drive storage media, a separate crash hardened memory module shall be priced for use with the DVR system. The crash hardened memory module may be internal or external. The crash hardened memory shall be sized to archive 12 hours of video. The DVR shall be already configured to accept crash hardened memory with "plug and play" functionality. The crash hardened memory module shall be a field replaceable component by Metra personnel without requiring the assistance of the contractor. The crash hardened memory module shall be upgradeable in the future to higher capacities.

16.8.9 Crash hardened memory module supplied shall be DOT certified to FRA 49 CFR Part 229.

16.8.10 The solid state hard drive shall be mechanically and functionally uniform and interchangeable across all cab compartment DVR systems defined in this specification. The hard drive shall be upgradeable in the future to higher capacities.

16.8.11 The crash hardened memory module shall be mechanically and functionally uniform and interchangeable across all cab compartment DVR systems defined in this specification.

16.8.12 On the video playback, The DVR system shall display a time and date stamp on all downloaded data. The time shall be synchronized with the time clock used by the event recorder. On the playback software, the system shall display event recorder data concurrent with video downloads. A minimum number of 4 event recorder channels shall be recorded: speed (SPD), Brake Pipe Pressure (BPP), Brake Cylinder Pressure (BCP), and Throttle (THR). The DVR system shall include computer software that allows for downloading and onboard viewing of video directly from the DVR recorder without removing the hard drive. The software shall allow the user to specify specific dates and times in order to control the length of the video clips downloaded. When downloading a video/audio clip, the user shall have the ability to select or deselect which video and audio channels are to be downloaded. The software shall have the capability to export all video and audio channels (including dedicated audio channels) into 1 file with all video and audio channels synchronized. Each audio/video clip shall contain at minimum a time stamp with date, time, name of DVR system, and associated video channel names that are overlaid onto the image and synchronized with video and audio. Upon starting the software, the main screen shall automatically (and without user interaction) display in real time live video viewports of all the cameras simultaneously. The viewports of all the video channels shall be visible simultaneously and without obstructions to the user on the main screen. The user shall not be required to make any clicks, minimize or maximize windows to cycle through to view video camera channels. The DVR system shall include computer software allowing for video downloads for a hard drive removed from the DVR recorder that is connected to a laptop or desktop computer. All computer software supplied to Metra by the Contractor shall include an unlimited use license agreement for unlimited installations and use. The ability for Metra personnel to install and configure all supplied software without contractor assistance or interaction shall be required. The software interface design shall be subject to Metra approval as part of **[CDRL C-16-06]**.

16.9 CONTROL CONSOLE AND CONTROL ARRANGEMENT

16.9.1 A desk top console and a console above the windshield shall be provided. The consoles shall be of non-reflective material. The console shall be readily removable to permit access to mounted components, wiring and piping. The console shall not loosen during normal

operations, move, or creep. No recesses, crevices or joints, which shall permit the incursion or accumulation of dirt, dust, or liquids, shall be permitted.

16.9.2 It is desired that the console surface shall be of one-piece construction. As an alternative, the console may have separately removable inserts to contain and enclose the various controls and indications.

16.9.3 The console shall not interfere with the Engineer's vision in any direction, nor with replacement of or maintenance to the windshield or other appurtenances. It shall provide a clear view of all indications and ease of reach and manipulation of all controls and switches.

16.9.4 Controls:

16.9.4.1 Master Controller, with single throttle handle with traction and brake function
16.9.4.2 Direction lever with the positions "Forward", "Neutral" and "Reverse"
16.9.4.3 Park brake push button and indicator lamps, which show the park brake status
16.9.4.4 Sand operating push button
16.9.4.5 Bell operating button
16.9.4.6 Horn Operating switch
16.9.4.7 Alerter reset button
16.9.4.8 Low beam/high beam push button combined with headlight/ditch light control on the TOD
16.9.4.9 Ditch light selector on the TOD
16.9.4.10 (deleted)
16.9.4.11 PA/IC control panel
16.9.4.12 Cab signal cutout switch
16.9.4.13 ADA Lift over-ride isolating switch or push button
16.9.4.14 Desk light switch
16.9.4.15 Radio Control Head
16.9.4.16 Attendant Call Switch
16.9.4.17 (deleted)Engine RUN/STOP Switch
16.9.4.18 Gage Light shall be controllable on the TOD
16.9.4.19 Gage Light shall be adjustable on the TOD
16.9.4.20 Power mode on the TOD
16.9.4.21 Cab activation key switch
16.9.4.22 Defroster control on the TOD
16.9.4.23 (deleted)
16.9.4.24 (deleted)
16.9.4.25 Rear Warning Light Control on TOD
16.9.4.26 Door Mode Indicator Button
16.9.4.27 (deleted)
16.9.4.28 Video System Control on PIS Panel
16.9.4.29 (deleted)
16.9.4.30 (deleted)
16.9.4.31 (deleted)
16.9.4.32 Train Radio Circuit Breaker
16.9.4.33 Video System Circuit Breaker
16.9.4.34 Train Control reset button on TOD
16.9.4.35 Train Control acknowledge button on TOD

16.9.5 Indicators:

16.9.5.1 Speed indicator
16.9.5.2 Air Gages

16.9.5.3 Ground fault indication on TOD
16.9.5.4 PCS Open indication on TOD
16.9.5.5 Wheel Slip light
16.9.5.6 Door Closed light
16.9.5.7 Lift Deployed light
16.9.5.8 Lift Override Switch Activation shall be Displayed on the TOD
16.9.5.9 PTC Display
16.9.5.10 The alerter push button shall visually indicate the alerter status combined with an acoustic tone.
16.9.5.11 Battery Charge Status Tri-Color (G-Y-R) Light on the TOD;

16.9.5.12 Indicator light test function on the TOD

16.10 BUZZERS

16.10.1 An approved high tone buzzer shall be furnished in the control console. The trigger for the buzzer shall be part of the final design for review and approval by Metra.

16.10.1.1 (deleted)
16.10.1.2 (deleted)
16.10.1.3 (deleted)
16.10.1.4 (deleted)
16.10.1.5 (deleted)
16.10.1.6 (deleted)

16.10.2 An override circuit shall be provided to allow the engineer to silence a continuous warning.

16.11 MISCELLANEOUS CAB EQUIPMENT

16.11.1 Equipment to be provided as follows:

16.11.2 Sun visors shall be provided for the windshield and the side windows. It shall be mounted above the windshield or side window. The visor shall provide coverage for the 5th and 95th percentile fields of view based on the ergonomic study.

16.11.3 An electro-static chest type cooler for bottled water shall be mounted in the control station within reach of the engineer's position. Water cooler shall be equipped with a drain to the outside of the car.

16.11.4 Two (2) single cup holders shall be provided, one the operator's side and one on the observer's side.

16.11.5 Two (2) sun visors (one over each sliding sash) shall be provided.

16.11.6 A sliding table with an integrated spring-clip holder shall be provided close to the left observer seat. The operators writing pad shall be equipped with a spring clip.

16.11.7 One (1) stainless steel enclosure with keyed lock for the storage of reverser handles.

16.11.8 A total of two (2) cab card holders shall be provided in the cab. A 9 inch x 12 inch card holder, and a 3-slot holder shall be applied in an approved location on the operator's side cab door.

16.11.9 A waste container, capable of holding a plastic liner, shall be provided in the cab behind the operator.

16.11.10 One (1) paper towel holder shall be provided in the cab.

16.11.11 One dry chemical type fire extinguisher shall be applied in an approved location in the cab.

16.11.12 One Emergency Response Book Holder per Metra Drawing M-524 shall be provided on the back wall of the cab.

16.12 WINDSHIELD WIPERS

16.12.1 One (1) operated windshield wiper system (motor and arm assembly) shall be located at each window in front of the control station. An electric windshield wiper system is the Metra preferred option. The windshield wiper system proposed shall be subject to Metra review and approval. **[CDRL C-16-09]** If pneumatic, noise from the motor's exhaust shall be reduced in an approved manner. The wipers shall operate satisfactorily at speeds up to 100 mph in a thirty-five (35) mph opposing head wind. The wipers shall have a parallel motion covering the full width of the glass and utilizing the largest blade that can be accommodated. Each wiper assembly should contain a lever that allows manual operation of wiper by operator in cab in the event of electric failure.

16.12.2 A windshield wiper control switch shall be provided. The wiper operating mechanisms shall be easily accessible, and the controls located in the operating compartment. The mechanism shall provide for variable speed and for a "park" position. The park position shall be approved by Metra. The wiper shall return to the park position each time the wiper system is turned off regardless of the position of the wiper blade.

16.13 REAR VIEW MIRRORS

16.13.1 A rear view mirror shall be provided at the front of the sliding sash cab windows on each side of the cab control car.

16.14 PILOT

16.14.1 At the lead end of cab control cars, a body mounted, high profile, snow plow type pilot of Metra approved design, shall be provided. **[CDRL C-16-10]** The pilot shall be securely attached to the car structure and shall be adjustable for height. The design of the pilot shall accommodate and afford maximum protection for the cab signal receivers and TRAINLINE junction boxes.

16.15 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-16-01	Cab Control – Design and Arrangement of Cab Car
C-16-02	Cab Seating
C-16-03	Alerter Operation
C-16-04	(deleted)
C-16-05	Wabtec IETMS System
C-16-06	Cab Digital Video Recording System
C-16-07	(deleted)
C-16-08	(deleted)

C-16-09	Windshield Wiper System
C-16-10	Pilot Design

17 PROPULSION

17.1 TRACTION MOTORS

17.1.1 The AC traction motors shall be the builder's current production, proven motor, with roller support bearings (if applicable). Adequate traction motor cooling air shall be provided for repetitive high-load start, quick stop operation. The traction motor design shall be submitted to the Contracting Authority for review and acceptance. **[CDRL C-17-01]** AC type traction motors shall be designed for North American Passenger Service. A proposal shall be submitted for the prime traction system. **[PDRL P-17-01]**

17.1.1.1 If the traction motor is axle hung, sealed-grease lubricated insulated bearings, tapered roller or equivalent shall be incorporated.

17.1.1.2 Class H or better insulation with vacuum/ pressure impregnation of all coils, armature, field or stator.

17.1.1.3 Fitted with disconnect cable leads.

17.1.1.4 Properly baffled to prevent blowing of sand and debris from rails, and to prevent motors from inhaling non-filtered cooling air, rain or snow.

17.1.1.5 The traction motor testing shall be performed in accordance to IEC 60349-2 prior to use in first vehicle.

17.1.1.6 Motors shall be cooled with clean air supply (if required) using inertial air filters or filter grids as approved by the Customer.

17.2 DYNAMIC BRAKES

17.2.1 Single-handle blended brake control shall be provided and controlled by the automatic brake handle position. The trainset shall be equipped with the builder's dynamic brakes, which shall be automatically blended with the friction braking when the dynamic brakes separately are not capable of applying the requested braking efforts. The dynamic brake system design shall be submitted to The Contracting Authority for review and acceptance. **[CDRL C-17-02]**

17.2.2 The service brake will be applied in priority using the dynamic brakes and friction brake will be added if necessary to reach the specified service brake rate.

17.2.3 Normal blended braking shall be "dynamic priority" where friction braking is used to supplement dynamically braking to produce the braking effort called for. Emergency braking shall be "friction priority", where a small fixed amount of dynamic braking shall be used only to supplement the braking effort called for.

17.2.4 To the extent that either the train or locomotive auxiliaries are demanding power, dynamic braking energy recovered and used to supply those power demands is a desirable feature. If the total energy exceeds the auxiliary power and HEP demands, the surplus energy may be stored in a supplemental energy storage device (if proposed) such as a supercapacitor bank or is dissipated as heat by the dynamic brake grid resistors.

17.2.5 (deleted)

17.2.6 (deleted)

17.2.7 (deleted)

17.2.8 (deleted)

17.2.9 Blended brake shall be nullified at speeds below 4-5 mph. The trainsete shall not transfer into blended or dynamic brake when it is at a standstill.

17.2.10 Wheel slide detection and correction shall be employed in conjunction with dynamic and pneumatic brake.

17.3 BATTERY PRIME MOVER

17.3.1 The batteries shall be of a reliable, if possible rail service proven design, with adequate power to meet or exceed established performance standards on the Metra system as described elsewhere in this Specification. Prior applications, other than rail service, may be considered but are subject to approval by The Contracting Authority's Mechanical Department. Battery design shall be optimized to allow for the lowest possible life-cycle costs and ease of maintenance. A proposal shall be submitted for the prime mover system. **[PDRL P-17-02]** Details of the design of the prime mover shall be submitted to The Contracting Authority for design review and approval. **[CDRL C-17-03]**

17.3.2 PROPULSION BATTERY **[CDRL C-17-04]**

17.3.2.1 A Li-Ion Battery propulsion battery shall be provided. Useable energy will vary based on duty cycle.

17.3.2.2 Maximum Battery discharge power shall exceed power to meet current Metra schedule

17.3.2.3 Battery and support structure to be designed for shock and vibration per IEC 61373 on branch level per IEC 62689

17.3.2.4 Battery assembly shall be protected by a hood structure with access for inspection, if not protected by the car body structure. The battery shall be protected in case of crash conditions.

17.3.2.5 Carbody or roof battery assembly shall be removable by crane or forklift.

17.3.2.6 (deleted)

17.3.2.7 General (typical) battery duty cycle assumed to be 6 days/week operation, 6 charge/discharge cycles per day (single trips on the Rock Island district blue island branch line). The auxiliary consumption considering an average loading AW1 and an external temperature of 15°C.

17.3.3 PROPULSION BATTERY CONTROL **[CDRL C-17-05]**

17.3.3.1 A Battery Management System (BMS) shall be included for each battery pack.

17.3.3.2 A master BMS shall be responsible for interfacing with Locomotive Control System.

17.3.3.3 Battery Voltage, Current and Temperature Monitoring shall be provided

17.3.3.4 When charging or discharging, protect the traction battery in the event of over/under voltage, over temperature, and over current.

17.3.3.5 Diagnostic data shall be made available from the BMS to be used for monitoring of the battery from the vehicle control and visualized on the operator's display. The battery state of charge will also be visible on the outside of the trainset.

17.3.4 PROPULSION BATTERY CHARGING **[CDRL C-17-06]**

17.3.4.1 Battery charging may be performed by an overhead DC power source (FAST CHARGE) to connect by way of pantograph

17.3.4.2 Typical Battery charge duration dependent on charge power available.

17.3.4.3 Wayside 480VAC power connections shall power an onboard battery charger to charge the traction battery and other auxiliary devices if applicable.

17.3.5 DC FAST CHARGE PANTOGRAPH **[CDRL C-17-07]**

17.3.5.1 A dedicated charging station that compliments the trainset design shall be proposed to recharge the batteries as quickly and safely as possible to quickly return the trainset into service.

17.3.5.2 DC Fast Charging via DC Catenary source.

17.3.5.3 Electric or air operated pantograph operation to be provided.

17.3.6 Proposer shall determine a trainset battery charging performance to be such to minimize down time between revenue service runs.

17.3.7 BATTERY THERMAL CONDITIONING **[CDRL C-17-08]**

17.3.7.1 A thermal conditioning unit shall be provided for e ach battery subassembly

17.3.7.2 Coolant shall be prevented from freezing in the specified temperature range

17.3.7.3 The cooling system is linked to the Battery Management System (BMS) with sensors to monitor coolant temperature and pressure. Alternatively, the link may be done by SW only and managed by the vehicle control. There may be no direct cables, or sensors between the BMS/Battery and the BTMS (battery thermal management system) responsible for the cooling function of the traction battery.

17.3.7.4 Coolant drain and refilling apparatus shall be located on the PowerPack.

17.4 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-17-01	Traction System
P-17-02	Prime Mover System

17.5 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title

C-17-01	Traction System
C-17-02	Dynamic Brake System
C-17-03	Prime Mover System
C-17-04	Propulsion Battery
C-17-05	Propulsion Battery Control
C-17-06	Propulsion Battery Charging
C-17-07	DC Fast Charge Pantograph
C-17-08	Battery Thermal Conditioning

18 AUXILIARY POWER SYSTEM

18.1 GENERAL REQUIREMENTS

18.1.1 A proposal shall be submitted for the auxiliary power system or equivalent to power the passenger compartment areas. **[PDRL P-18-01]**

18.1.2 Design details, software documentation and electrical schematics for the auxiliary power system shall be submitted to The Contracting Authority for design review and approval. **[CDRL C-18-01]**

18.1.3 The control system shall incorporate fault monitoring, diagnostics and control of the inverter. An external communication port for the purpose of programming and diagnostic communication shall be provided. No 480 VAC empty receptacle shall be energized.

18.1.4 Controls shall be provided in the cab. The below indicators and/or controls may be replaced with indications on the builder's integrated electronic display (if provided). Design of the Auxiliary System Power controls shall be submitted to The Contracting Authority for design review and approval. **[CDRL C-18-02]** The following features shall be included:

18.1.4.1 The start, stop and emergency shut-off procedures and sequences shall be described.

18.1.4.2 Status indicator lamps or display.

18.1.4.3 (deleted)

18.1.4.4 If applicable, a selector switch or control for consist configuration relative to desired energized receptacles. (Coupled to B-end, etc.)

18.1.5 Displays or meters indicating frequency, voltage and amperage of the 3x480V power supply.

18.1.6 Auxiliary Power Supply ground fault detection system to identify an electrical ground in the train power circuit. A ground occurring in the circuit shall result in an indicator light as notification of the condition. An audible alarm is not required. A ground occurring in one phase of the train power trainline circuit shall lead to the disconnection of the corresponding load.

18.1.7 A wayside layover interlock is required to prevent connecting to wayside power while the trainset is actively powering the train or vice versa. The control system shall be designed to prevent application of power to trainlines if the trainlines are already energized from another source of 3-phase power, such as another locomotive or shore power.

18.1.8 An Inverter Backup Mode feature is desirable to allow for system reconfiguration from the propulsion to provide Train Power in the event of an Auxiliary Power System inverter failure. In such cases, appropriate controls for this transfer and corresponding fault indicators shall be provided.

18.1.9 The aux system can be activated/deactivated manually via the display from the drivers cab for the whole trainset from an active cab.

18.2 PROPOSAL DELIVERABLES REQUIREMENT LIST

P-18-01	Auxiliary Power System

18.3 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-18-01	Auxiliary Power System
C-18-02	Auxiliary Power Controls