LAX Landside Access Modernization Program

APM Operating System Supplier Eligibility Determination Process

Attachment 3
Select Draft Project Technical Performance Provisions

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3.3 OPERATING SYSTEM TECHNOLOGY MATURITY

This section identifies the criteria that will determine the state of technical maturity of the Contractor's Automated People Mover (APM) Operating System technology. The technical maturity is a measure of the degree of the technology's readiness for deployment for the project and can range from the highest level of maturity, i.e. service-proven as defined in TP 3.3.1, to a lesser level of maturity as defined in TP 3.3.6.

Definitions used in this TP 3.3 are as follows:

Major Subsystems - Those subsystems that comprise the most important functional elements of the APM Operating System technology. For the purposes of this TP 3.3, the Major Subsystems are:

A. Vehicles - Refer to TP 9.

B. Power distribution - Refer to TP 10.

C. Automatic train control - Refer to TP 11.

D. Power rail (and signal rail, if appropriate) and vehicle power collector assemblies and interface - Refer to TP 10.1.4 and TP 9.8.3.

E. Vehicle running gear/guidance assemblies and interface - Refer to TP 9.9 and TP 13.1.

F. Vehicle/train switching - Refer to TP 13.7.

G. Reserved

APM Operating System Technology - The Major Subsystems, when appropriately and successfully combined with other APM System components to form an integrated, functioning whole, constitute the APM Operating System technology.

Technology Modification - With respect to a Major Subsystem of the Contractor's existing service-proven APM Operating System technology, the term technology modification means a changed design for the major subsystem. The change may be progressive, as evidenced by incremental changes to a previous design and/or a previous generation of the subsystem, or a new subsystem to be used as a replacement for a Major Subsystem in a first-time implementation as part of this Project. A radical design change or incorporation into the APM Operating System technology of technically immature (without analysis, performance and test data documentation) or experimental processes, components, or materials do not qualify as a technology modification.

3.3.1 Service-Proven APM Operating System Technology

Except as otherwise provided in TP 3.3.1.1 and TP 3.3.1.2 below, the Contractor's APM Operating System technology, including its Major Subsystems shall have been successfully proven in current, daily, year-round passenger service operation for a period of approximately two years. Successful operation of the APM Operating System shall be determined by the Owner to be attainable by the Contractor based on documented evidence that the proposed APM Operating System technology can meet the Owner specified operational performance and the system service availability requirements.

Successful passenger service operation, for the purpose of qualifying the Contractor's APM Operating System technology under TP 3.3.1, means that an owner or owners of the Contractor's APM Operating System technology, that is offered by the Contractor to comply with the requirements of these "Select Draft Project Technical Performance Provisions", is satisfied that such APM Operating System technology has met original expectations as indicated by a letter from the senior management executive(s) of the system owner(s). Additionally, the Contractor shall provide evidence, from at least one passenger service-proven application, documenting that the APM Operating System technology is technically mature and has been satisfactorily and appropriately integrated into a functional whole. Documented evidence shall clearly show that the preceding features and components are capable of satisfying the requirements of these "Select Draft Project Technical Performance Provisions".

3.3.1.1 Use of Technology Modifications

In determining compliance with the service-proven requirement of TP 3.3.1, the Owner will permit Technology Modifications to be implemented as part of the APM Operating System, but only under the following conditions:

A. No more than one Major Subsystem and one Technology Modification shall be accepted.

B. Integrated operation of the replacement subsystem in a similar APM Operating System technology shall have been successfully proven in current or seasonal passenger service operation for approximately two years. Further, such passenger service shall approximate the APM System operations specified in these "Select Draft Project Technical Performance Provisions".

C. The Contractor presents design documentation as evidenced by analysis, performance and/or test data documentation, that the replacement subsystem has been integrated into the Contractor's APM Operating System technology design.

D. The Technology Modification meets all other requirements of these "Select Draft Project Technical Performance Provisions".

Any Technology Modifications that do not meet the criteria specified above will be carefully evaluated, and may be ruled unacceptable by the Owner.

3.3.1.2 Requirements for Replacement Subsystems

In determining compliance with the service-proven requirement of TP 3.3.1, the Owner will permit a Major Subsystem, as defined TP 3.3 above, to be replaced with another in a first time implementation as part of the APM Operating System, but only under the following conditions:

A. No more than two Major Subsystem replacements shall be accepted.

B. Integrated operation of the replacement subsystem in a similar APM Operating System technology shall have been successfully proven in current or seasonal passenger service operation for approximately two years. Further, such passenger service shall approximate the APM Operating System operations specified in these "Select Draft Project Technical Performance Provisions".

C. The Contractor presents design documentation as evidenced by analysis, performance and/or test data documentation, that the replacement subsystem has been integrated into the Contractor's APM Operating System technology design.

D. The replacement subsystem meets all other requirements of these "Select Draft Project Technical Performance Provisions".

Any replacement subsystem that does not meet the criteria specified above will be carefully evaluated, and may be ruled unacceptable by the Owner.

3.3.1.3 Evaluation of Technology Modifications

All Technology Modifications will be carefully evaluated by the Owner. Any Technology Modification that does not meet the criteria specified in TP 3.3.1.1 above may be ruled unacceptable by the Owner.

Additionally, the Owner will evaluate issues related to the integration of multiple Technology Modifications to assess the technical and schedule risk associated with their simultaneous deployment.

The provisions of this TP 3.3.1.3 shall be in addition to the provisions of TP 3.3.1.1 and TP 3.3.1.2.

3.3.2 Not Used

3.3.3 Not Used

3.3.4 Not Used

3.3.5 Not Used

3.3.6 Non-Service Proven Technology

The Owner may make exceptions to any of the requirements of TP 3.3.1 and accept an APM Operating System technology that is not service-proven when, in the Owner's sole opinion, such exception(s) do not introduce unacceptable product development, deployment and other risks to the project, taking the following into consideration:

A. Contractor's successful proven experience in designing, supplying and installing applications of new APM Operating System technologies that do not meet the service proven requirements of TP 3.3.1.

B. The sufficiency of the Contractor's proposed Project Management Plan, as applicable for the design, supply and installation of any Technology Modifications that do not meet the requirements of TP 3.3.1.

C. The qualifications and experience of participating personnel, as indicated on their resumes, in designing, supplying and installing new APM Operating System technologies that do not meet the requirements of TP 3.3.1.

D. The extent of documented design, analysis, qualification testing and/or test track operations of any technology modifications.

E. The Contractor's proposed plan and schedule for qualification testing the technology modifications for this Project, prior to their scheduled deployment for passenger service.

F. Available manufacturing facilities sufficient to produce and supply the APM Operating System within the Contract Time specified in these “Select Draft Project Technical Performance Provisions”assuming that Notice to Proceed would occur in or about the 1st quarter of 2018, with the APM Operating System ready and capable of transporting passengers no later than the 1st quarter of 2023. Facilities shall include a fully-equipped manufacturing plant with adequate and available production capacity and test facilities to fully test all critical subsystems as full-scale production units.

5.1 PASSENGER SERVICE CHARACTERISTICS

5.1.2 Headway

Headway is the elapsed time between the same part of consecutive trains operating in the same direction on the same guideway, measured at any given point on the guideway. During all normal operations, all trains on the same route shall operate at continuously and nominally equal headway and all trains on different routes that share a common guideway track section shall also operate at continuously and nominally equal headway.

Special case definitions of headway are:

Safe Separation Headway - A two-train minimum headway based on ATC, braking, etc., that allows the following train to stop safely without a collision with the lead train. This is part of the Automatic Train Protection (ATP) subsystem design in accordance with TP 11.1.2. Operations based on minimum safe separation headway will allow a given train's velocity versus distance profile to influence the velocity versus distance profile of following trains.

Non-Interference Headway - The minimum sustainable headway that does not result in any given train's velocity versus distance profile influencing any other train's velocity versus distance profile, regardless of the number of routes that may be in simultaneous operation (i.e., no inter-train performance interference). For purposes of this definition, all external interferences such as passenger-induced delays are assumed to not be present.

Minimum Operational Headway - The minimum operational headway involves multiple trains, station stops, normal disturbances, passenger interference, etc., and is for operational planning to “ensure” smooth normal operations without train bunching and unscheduled stopping on the guideway. The minimum operational headway shall not be less than 115 percent of the non-interference headway, and not less than 120 seconds.

Operational Headway - The headway determined appropriate for planned scheduled operations to meet passenger demand.

The safe separation headway and the non-interference headway shall be used for carrying out APM Operating System design but shall not be used in defining APM Operating System performance such as the operational headway, line capacity and trip time.

Non-interference headway for the Ultimate System shall be proven by the Contractor by simulation and subsequent test demonstrations on the APM Operating System. The simulation methodology and results shall be documented and submitted by the Contractor. The test demonstration shall be according to a procedure accepted by the Owner and shall involve maximum length trains launched and separated by the non-interference headway being demonstrated. The trains shall be required to complete all route circuits at least twice and each test demonstration shall not be less than one-hour duration. Station dwells shall be the nominal dwells specified in TP 5.1.3.

The operational headway shall be used to calculate the Ultimate System line capacity (TP 5.1.5) and fleet size (TP 5.1.6). The operational headway shall not be less than the minimum operational headway.

The Contractor shall design the APM Operating System such that the specified Ultimate line capacity can be met with an operational headway as specified in TP 5.1.2.3.

5.1.2.3 Ultimate System Maximum Operational Headways

For the Ultimate System, the operational headway required to meet the specified capacities shall not exceed the following values for the specified period:

Night Mode Period: TBD

Off-Peak 1 Period: TBD

Peak Period: 134 seconds

Off-Peak 2 Period: TBD

5.1.3 Station Dwell Time

Station dwell time is the time during which the train is stopped in the station, beginning at the time train doors are commanded to open and ending at the time train doors are closed and locked. The dwell time for trains at each station shall be a minimum of 10 seconds adjustable in one second increments up to a maximum of 60 seconds. Within this 50 second range, station dwell times shall be automatically adjustable by the Automatic Train Supervision (ATS) subsystem to achieve proper train spacing on the route, or manually adjusted by the Central Control Operator (CCO) to provide dwell times that are appropriate for specific, short-term patronage or other conditions.

Nominal station dwell times for each station shall be calculated for all operating periods by the Contractor on the basis of the following criteria, which shall all be satisfied:

A. Vehicle loaded to normal capacity, as defined in TP 9.3.

B. For the Ultimate System, the percent of the total number of passengers on each vehicle loaded to normal capacity deboarding and boarding at each station location is defined in Table 5.1.3-1 below.

Table 5.1.3-1 – Percent of passengers boarding and deboarding at each station

Passengers Boarding and Deboarding	West	Center	East	West ITF	East ITF	ConRAC
Ons	45%	30%	35%	30%	20%	35%
Offs	35%	25%	30%	35%	30%	45%

C. Vehicle door size shall represent actual dimensions of the specific technology employed by the Contractor.

D. The passenger load/unload rate specified in TP 9.10.1 shall be used.

E. A time allowance that represents actual equipment performance allowance shall be included for all ATP interlock functions, plus door unlocking/opening and closing/locking times; this time allowance does not include door fully-open time. This allowance may not exceed ten seconds.

F. In any case, dwell times shall not be less than 35 seconds at the West ITF station, 30 seconds at the East CTA Station, and 25 seconds at the Center CTA and East ITF Stations.

G. At the West CTA and ConRAC stations, deboarding and boarding occurs from different platforms. Under normal operations, the dwell times at the West CTA and ConRAC stations shall not be less than 45 seconds; boarding doors shall be commanded to open no sooner than 10 seconds after the deboarding doors have opened.

These calculated nominal station dwell times shall be used to determine the operational headways of TP 5.1.2 and the round trip time requirements of TP 5.1.4.

5.1.4 Travel and Round Trip Times

Travel time between sequential stations on a route is the time a train takes to travel from one station to the next, beginning at the time train doors are closed and locked at the originating station and ending at the time the train is stopped and the doors are commanded to open at the destination station. Station dwell times are not included in travel times.

The round trip time is the time a train takes to complete one circuit around its route. Round trip time consists of the sum of all travel times and station dwell times on a route.

For determination of the travel times and round trip time, the Contractor shall assume station dwell times as defined in TP 5.1.3 and trains loaded at the AW1 weight specified in TP 9.2.

5.1.4.2 Ultimate System Round Trip Time

For the Ultimate System, the round trip time for all trains shall not exceed 1,200 seconds.

5.1.5 Line Capacity

Line capacity is the number of passengers per hour per direction (pphpd) that can be carried past a given point on each independent route by trains operating on that route.

All of the line capacities specified in this TP 5.1.5 shall be provided by trains that are:

A. Reserved.

B. Operating at the operational headway specified in TP 5.1.2.

C. Operating with station dwell times calculated as specified in TP 5.1.3.

D. Are loaded at the normal capacity as specified in TP 9.3.

5.1.5.3 Ultimate System Line Capacity

The Ultimate System shall provide the following line capacity:

Night Mode period operations minimum capacity:	TBD
Off Peak 1 period operations minimum line capacity:	TBD
Peak period operations minimum capacity:	5,515 pphpd
Off-Peak 2 period operations minimum capacity:	TBD

5.1.6 Fleet Size, Train Length and Spare Vehicles

The Contractor shall provide a fleet of vehicles sufficient to meet all requirements of the Ultimate System in accordance with the following requirements.

5.1.6.1 Peak Period Operating Fleet for the Ultimate System

The headway requirements of TP 5.1.2, the round trip time requirements of TP 5.1.4, and the line capacity requirements of TP 5.1.5 shall be used by the Contractor to establish the length of trains (number of entrained vehicles) and the operating fleet size of the Ultimate System so that all APM Operating System requirements are met.

During Peak period operations, the operating fleet shall include one spare train(s) in standby mode, equipped and functioning with no faults and ready for passenger-carrying service. The spare train(s) shall be located to replace a failed train on the line within the Departure Test area just outside the M&SF.

5.1.6.2 Spare Vehicles for the Ultimate System

In addition to the peak period operating fleet of trains specified in TP 5.1.6.1, the Contractor shall provide sufficient spare vehicles for the Ultimate System to meet APM Operating System service availability and maintenance requirements and as follows. The number of spare vehicles shall be such that:

A. The average annual vehicle mileage is minimized;

B. The number of spare vehicles is at least ten percent of the peak period operating fleet, rounded up to a whole number, where the spare train(s) in hot standby mode is (are) included in the peak period operating fleet.

C. The minimum number of spare trains, in hot stand-by mode, shall be one. Such train length shall be no less than the maximum length train operating during the peak period.

5.1.6.3 Fleet Size to Meet Ultimate System Line Capacity

The headway requirements of TP 5.1.2, the round trip time requirements of TP 5.1.4, the line capacity requirements of TP 5.1.5, and maximum length train shall be used by the Contractor to determine the fleet size necessary to meet the Ultimate System line capacity requirements in accordance with the same requirements as specified in TP 5.1.6.1 and 5.1.6.2.

5.1.6.4 Maximum Length Train

Based on the determination of the required train lengths (number of entrained vehicles) for the Ultimate System, the Contractor shall establish the maximum length train. All facilities and equipment provided by the Contractor for the APM Operating System shall be sized to accommodate a maximum length train. Station platforms in the Preliminary APM Project Layout Plan have been designed to accommodate up to a Maximum Length Train, not to exceed 175 feet from front coupler to rear coupler.

5.1.6.5 Train Composition

All trains supplied by the Contractor and operated in the APM System shall have the capability to operate with multiple train lengths including concurrent operations of any combination of trains of different lengths from smallest operating units to maximum length trains. While preferred operational configuration is in a counter-clockwise mode, it shall be possible to operate in a clockwise mode without any impacts on the line capacities, headways or the round trip times.

5.2 APM OPERATING SYSTEM OPERATING MODES

Operating modes shall include at least: (1) normal operating modes for standard peak, peak-day, off-peak service and on-demand and (2) failure operating modes for failure management and unscheduled wayside maintenance-related operations. The APM Operating System, using the maximum length trains, shall operate in all of these modes as specified in this TP 5.2.

5.2.1 Normal Operating Modes

All normal operating modes shall be fully automatic, regulated operations. In these modes, the headway shall be automatically regulated. Actual station dwell times shall normally be determined by the Automatic Train Operation (ATO) subsystem and shall be based on the nominal dwell times of TP 5.1.3. Dwell times shall be adjustable by the CCO through the use of associated manual overrides as specified in TP 11.3.3.2. When normal movement of any train is impeded for any reason, including manual intervention, the ATS subsystem shall automatically, without CCO intervention, re-establish regulated operation by adjusting train speeds and/or station dwell times. Current dwell time values shall be displayed to the CCO.

5.2.1.3 Pinched Loop Mode

The normal operating mode shall be the pinched loop operating mode, with trains operating between the two end stations (West CTA Station and ConRAC Station). In the pinched-loop mode, trains shall operate in a counter-clockwise direction when viewed from above, with forward operations on the right-side lane of the dual-lane guideway. They shall depart the West CTA Station and proceed along the south guideway traveling east. As the trains enter intermediate stations, they shall stop on the south side of the station platforms to allow passengers to deboard and board. As trains approach the ConRAC Station, they shall normally enter the station through the guideway crossover and berth on the north side of the center-platform station platform. After processing passengers at the ConRAC Station, trains shall reverse direction, exit the station and retrace the trip, this time on the north guideway, traveling west. As the trains enter intermediate stations, they shall stop on the north side of the station platforms to allow passengers to deboard and board. On the return trip, the trains shall enter the West CTA Station through the crossover, berthing on the south track side of the station platform. After processing passengers at the West CTA Station, trains shall reverse direction and repeat the trip. Pinched loop operation shall be possible between any two of the four end platform berthing positions.

5.2.1.5 Synchronized Double Shuttle Mode

Synchronized double shuttle mode shall be selectable as the normal mode of APM Operating System operation. This mode shall be a fully automated and regulated operation under ATC system control. In this mode, the two trains depart from opposite end stations at approximately the same time and arrive at the destination station at approximately the same time. Normally, dwell times at the stations are set by the ATC system to be equal. If the normal movement of either train is impeded for any reason for longer than 30 seconds, the APM Operating System shall automatically, without human intervention, revert to the unsynchronized double shuttle mode, with the two vehicles operating independently of each other. As soon as the impeded train again proceeds normally and under ATC control, provided that no other operating mode has been initiated by the Central Control Operator, the APM Operating System shall automatically revert to the synchronized double shuttle mode as quickly as practicable. Synchronization shall be reestablished by the ATC system by adjusting vehicle dwells. The time period during which the APM Operating System was operated in the nonscheduled unsynchronized mode shall be automatically counted as downtime. Wherever synchronized double shuttle mode is called out, it shall refer to the above specified normal mode of operation. Synchronized double shuttle mode shall be initiated by the CCO, who shall select the two end stations to be served.

5.2.2 Failure Operating Modes

The Contractor shall provide at least the following failure operating modes primarily for failure management purposes and for unscheduled maintenance of the wayside. Each failure operating mode shall be a fully automated and regulated operation which does not require manual intervention while operations are underway. All trains operating automatically in these failure operating modes shall be fully protected by the ATP subsystem (irrespective of the CCO actions) in accordance with TP 7.1.1 and TP 11.1. The Contractor shall use one or any combination of these failure modes to continue service when a section of the line is blocked due to failure, or if a switch or station is inoperative.

5.2.2.1 Skip-Stop Mode

The skip-stop mode shall be fully automated, regulated operation that may be used during failure mode operations as defined in TP 5.2.2. The specific skip-stop routes shall be programmed into the ATS/ATO software. This failure mode shall be from the West CTA Terminal station to the ConRAC station by-passing one or more of the other stations. The station or stations to be skipped shall be selectable by the CCO.

5.2.2.2 Shuttle Modes

In this mode, the APM Operating System shall be operated as a dual lane or single lane shuttle, where a single train remains on a particular lane and shuttles back and forth between two stations. The shuttle modes may be used individually or in combination with other failure modes to provide connecting service around a blockage or to connect two short turnback operations.

Shuttle mode operation shall be initiated by the CCO, who shall select the two end stations to be served.

5.2.2.3 Single-Tracking Mode

In single-tracking mode, one or more sections of the guideway are excluded from the routes, and trains shall automatically be directed to by-pass such section or sections. This will result in bi-directional traffic on certain single lane guideway sections.

Single-tracking mode shall be initiated by the CCO, who shall select the route trains shall follow.

The ATC system design shall provide for the operation of single tracking on any single lane guideway section that the crossovers shown on the Preliminary APM Project Layout Plan will allow.

5.2.2.4 Short Turnback Mode

In this mode, portions of the APM Operating System between two crossovers shall be temporarily set up and operated as truncated routes.

Short turnback mode operation shall be initiated by the CCO, who shall select the two end stations to be served.

The ATC system design shall provide for the operation of all possible short-turnback routes that the crossovers shown on the Preliminary APM Project Layout Plan will allow.

5.2.2.5 Other Failure Operating Modes

It shall be possible to operate pinched-loop, dual lane shuttle and single lane shuttle modes between the West CTA station and the ITF East station, in the event that the ConRAC station is out of service and between the ConRAC and the Center CTA stations in the event the West CTA Station is out of service. It shall also be possible to operate pinched-loop, dual lane and single lane shuttle modes between the West CTA station and ConRAC station with by-passing one or more of the other stations. See TP 5.2.2.1.

6.3.1 Exterior Noise

The exterior noise level generated by the APM System, with all contributing noise sources in operation, shall not exceed the levels specified in TP Table 6.3.1-1 measured in still air in the environment along the System. Should the required noise levels not be met, the Contractor, at its own cost, shall design and install additional noise mitigation measures at the source, on the guideway, or off the guideway along the alignment such that the noise levels are not exceeded. Such mitigations shall be subject to Owner review and acceptance.

With the exception of the aforementioned noise levels, all other requirements of Section 2.2.1, Exterior Airborne Noise, ASCE 21-05, shall be met. The design of any barrier-type noise reducing devices along the guideway shall be subject to the review and acceptance by the Owner.

Noise emanating from any maintenance and support equipment and any MRV or similar vehicle shall meet all exterior noise requirements, and the use and functions of these vehicles shall have appropriate noise muffling devices, particularly considering their normal use for maintenance during night periods.

All noise measurements are to be taken with a train on which there are no more than three test/observation personnel and necessary equipment. All auxiliary systems, including air conditioning, compressors, and pumps shall be operating. Exterior noise levels shall be measured using the instrumentation and settings specified in the referenced Section 2.2.1, Exterior Airborne Noise, ASCE 21-05 and TP Table 6.3.1-1.

Exterior noise measurements shall be made in each station and on an open section of elevated guideway. In the latter case an open section of elevated guideway in the APM System shall be chosen that best represents a free field environment where reflections and any ambient noise will be the least within the APM System. A maximum length train shall be operated with all auxiliaries in operation, including the air conditioning compressors and fans and any air compressors. At least three runs shall be made for each case and data taken for at least the following cases: (1) train operated at maximum cruise speed; (2) train accelerating from zero speed at its maximum acceleration rate to the maximum cruise speed; and (3) train decelerating to zero speed at the maximum service deceleration rate from the maximum cruise speed. Other runs may be made for slower speeds and/or train operating conditions, as applicable for certain sections of the line. The Contractor shall then perform a noise analysis over the entire APM System guideways to determine compliance with the noise limits specified in TP Table 6.3.1-1. The Contractor shall make site-specific noise measurements at locations where special noise mitigation is provided and where noise limits are analyzed to be exceeded.

TP Table 6.3.1-1 EXTERIOR NOISE LIMITS

Condition		Maximum dBA Level	Measurement Location
A.	Maximum length train entering and leaving station Elevated	(slow response) 76	In the station, 5 feet from the platform edge and 5 feet above the station floor.

B.	Maximum length train stopped in station	(slow response) 74	In the station, 5 feet from the platform edge and 5 feet above the station floor, with vehicle doors and platform doors fully open.
C.	Maximum length train traveling along the entire guideway under any normal velocity, acceleration, and deceleration operating condition	(fast response) 76	At any point* on a cylindrical envelope co-axial with, and 50 feet from, the centerline of each guideway lane (track), whichever is closer.
D.	Maximum length train traveling at 10 mph	(fast response) 74	At any point* on a cylindrical envelope co-axial with, and 50 feet from, the centerline of each guideway lane (track).

* Acceptance test points shall be limited and proposed by the Contractor within its prepared *Test Procedures*, subject to acceptance by the Owner.

7.1.1 Safety Principles and ATC System Fail-Safe Design

The APM Operating System shall be designed and implemented in accordance with the requirements of Section 3.2, Safety Principles, American Society of Civil Engineers (ASCE) 21-05.

All safety critical elements of the ATC system shall be designed and implemented in accordance with the requirements of Section 3.3, ATC System Fail-Safe Design, ASCE 21-05.

9 VEHICLE

The terms, “car”, “vehicle” and ‘train” are used extensively in this section, they are defined as follows:

A. **car** - An individual passenger-carrying unit which may be a vehicle or may be coupled with other car(s) to become a vehicle.

B. **vehicle** - A single car, or multiple cars when coupled together, that can operate independently in full compliance with all requirements including but not limited to redundancy. A vehicle can also be coupled with one or more vehicles to form a train.

C. **train** - A set of one or more APM Operating System vehicles coupled together and operated as a single unit. For this Project, the APM Operating System shall have the capability to operate with multiple train lengths including any combination of different length trains at the same time.

Vehicles shall be automatically controlled and operate normally without a driver. Multiple or single-vehicle trains shall be used as necessary to meet APM Operating System requirements. All vehicles provided for the APM Operating System fleet shall be essentially identical and shall operate interchangeably in any train and on any part of the APM Operating System.

All trains shall be 1) configured with the same types of vehicles, 2) be of equal length but it shall be permitted and possible to concurrently operate any combination of trains of different lengths at the same time in any operating mode, and 3) the maximum length train shall not exceed the station platform length available after all circulation and other requirements (overrun distance, etc.) are met.

9.1 DYNAMIC ENVELOPE AND CLEARANCES

9.1.1 Vehicle Dynamic Envelope

The vehicle dynamic envelope shall be defined in accordance with Section 7.2, Vehicle Dynamic Envelope, of ASCE 21.2-08, except that the risk of any part of a vehicle extending outside its dynamic envelope shall not be assessed to be either “unacceptable” or “undesirable” as defined in Table 3-1, Risk Assessment, of ASCE 21-05.

The worst-case vehicle dynamic envelope at any location along the guideway shall be used to calculate the clearance requirements of TP 9.1.2.

9.1.2 Clearance Requirements

The APM System shall be designed and installed so that the vehicle dynamic envelope is separated from all stationary equipment and structures by at least four inches.

Appropriate clearance shall be provided between the vehicle and other APM System equipment and structures, including power rails and undercar equipment, to ensure proper and safe operation.

The minimum horizontal clearance between worst-case combinations of vehicle dynamic envelopes on adjacent guideways shall be 12 inches, reflecting all effects of super elevation and guideway curvature.

Specifically excluded from these clearance requirements are the platform gap and the horizontal distance between the station platform doors and vehicle doors, which shall be as specified in TP 9.10.4. Contact between the vehicle side and the platform edge may be permitted in extreme failure conditions as long as the Owner approved protective features such as, prohibiting unsafe vehicle tilting in the event of failure and making the sides of the vehicles that might contact the platform edge strip strong enough to withstand such contact without being damaged, are provided.

The minimum clearance between the outside of the guideway to adjacent structure is indicated on the Preliminary APM Project Layout Plan.

9.2 VEHICLE SPACE AND WEIGHT ALLOCATIONS

The following are vehicle passenger area and weight allocations for the purposes of these Technical Performance Provisions.

Total passenger area shall be all of the area available to and intended for seated and standing passengers. Standee floor area is defined as the area available to standing passengers and is equal to the total passenger area less 4.5 ft^2 for each fixed seat position. For calculating the number of seat positions on benches, 18 inches of bench width and no more than 24 inches of bench depth shall be allocated for each seat position. In determining the standee floor area, the area available to standing passengers shall be limited to space within the car; space in between cars such as gangways shall not be considered.

Vehicle allocated weights are defined as follows:

<u>AW0</u> - The weight of an empty vehicle, ready to be operated.

<u>AW1</u> - The vehicle design weight, calculated by adding AW0 with the product of 160 pounds per passenger multiplied by the design capacity (See TP 9.3).

<u>AW2</u> - The maximum vehicle weight or “crush load”. This weight shall be calculated by adding AW0, 107 lbs/ft^2 of standee floor area, 160 pounds for each fixed seat position, and 36 lbs/ft^2 of interior plan area not included in the total passenger area. This definition shall apply for references to AW2 in the ASCE APM Standards.

<u>AW3</u> - This weight, as defined in Section 7.1, Vehicle Capacity and Load, ASCE 21.2-08, shall be AW2 as defined above. All references to AW3 in the ASCE APM Standards shall be interpreted to be AW2 as defined above.

9.3 VEHICLE CAPACITY

The vehicle passenger capacity shall be determined based on the vehicle passenger area definitions of TP 9.2 and the provisions of this TP 9.3. Flip up and stowable seats shall be prohibited.

For the purposes of these Technical Performance Provisions, the following definitions of vehicle capacity shall be used:

<u>Seating Capacity</u> - Seating capacity is the number of seat positions provided for passengers (not including wheelchair passengers). Each vehicle shall have a seating capacity of at least 10 percent and not more than 15 percent of the normal capacity.

Design Capacity - Design capacity shall be calculated by assuming all seat positions are occupied by passengers, no wheelchair passengers, and one standing passenger for each 2.7 ft^2 of standee floor area.

Normal Capacity - Normal capacity shall be calculated by assuming all seat positions are occupied with passengers, no wheelchair passengers, and one standing passenger for each 6 ft^2 of standee floor area.

In calculating design and normal capacities, the number of standing passengers shall be rounded downward to the nearest integer.

9.6.3 Ride Comfort

Vehicle ride characteristics for maximum sustained acceleration and deceleration, maximum rate of change of acceleration, and ride quality shall be in accordance with ASCE 21.2-08, Section 7.7.3, Ride Quality, except that (1) vertical acceleration shall be limited to plus or minus 0.05 g with respect to 1.0 g datum, and (2) the normal longitudinal acceleration, excluding grade effects, shall be limited to plus or

minus 0.1 g. Furthermore, ride quality testing shall be required. Additional definitions and exceptions to the ASCE requirements for ride quality are as follows:

A. The limit on emergency deceleration may be exceeded under conditions of brake equipment failure. However, the Contractor shall carry out an analysis to determine and propose an upper limit on deceleration under such failure conditions that shall be subject to review and acceptance by the Owner.

B. Sustained refers to the nominal values used for design of curves, crests, sags, and speed profiles and excluding random vibration effects. Sustained shall include durations equal to or greater than 1.0 seconds.

C. Longitudinal is fore and aft motion, the x direction in ISO 2631; vertical is up and down motion, the z direction in ISO 2631; and lateral is side to side motion, the y direction in ISO 2631.

D. Lateral and vertical acceleration and deceleration include grade effects and are the values obtained with a standard piezoelectric accelerometer with a frequency range of at least 0.1 - 80 Hz.

E. Longitudinal acceleration and deceleration ignoring grade are the rates of change of train speed as determined from the maximum slope of tachometer generated data. Longitudinal acceleration and deceleration including grade are the values obtained with a standard piezoelectric accelerometer with a frequency range of at least 0.1 - 80 Hz, noting that this device reads acceleration along the longitudinal (fore/aft) axis of the vehicle.

F. “Jerk” is the rate of change of sustained acceleration/deceleration with lateral and vertical acceleration/deceleration and with longitudinal acceleration/deceleration ignoring the effect of grade. Jerk limiting is required for normal longitudinal acceleration and braking. Longitudinal jerk during removal of emergency brakes need not be controlled.

These ride quality criteria and measurements are with respect to the vehicle while it is operating anywhere on the APM System guideway. The Contractor shall coordinate the vehicle ride quality responses and the guideway tolerances of TP 13.1.1 to achieve these requirements.

Ride quality shall be verified by human response testing in accordance with the requirements of Section 7.7.3.2 of ASCE 21.2-08.

9.7 PROPULSION AND BRAKING SYSTEMS

The propulsion and braking systems (PBS) shall be rated to provide traction and all train movement along the guideway, under the specified loads and environmental conditions specified by the Owner and to ensure motion control up to the maximum specified speed, so that the acceleration, deceleration and jerk rates are within acceptable passenger comfort limits per TP 9.6.3.

All vehicles, and all trains up to and including the maximum length train, shall be capable of continuous operation at a sustained cruise speed as required for this application and for the maximum speeds proposed for the APM Operating System for vehicles loaded at AW1 and operating on level, tangent APM System guideway.

All vehicle and train configurations at loading of AW1 shall be able to:

A. Cruise at least at maximum normal cruise speed under all conditions along the guideway where grade, geometry, and station constraints permit.

B. Maintain normal cruise speeds on the steepest grade in the APM System guideway.

C. When stopped on the steepest uphill grade, start and accelerate to 25 mph within 750 feet without violating the ride quality requirements of TP 9.6.3.

The smallest sized self-propelled train shall be propelled by more than one electric motor, such that the train, when operated with one motor inoperative, shall have its power reduced by not more than 50 percent and the train can be operated in service indefinitely at a level of service not less than 75 percent of normal service.

All vehicles and trains shall be capable of bi-direction operation, and shall be operable throughout the APM System with either end of the vehicle in the forward orientation.

9.7.2 Duty Cycle

The PBS shall be thermally rated at AW2 load for the highest Owner approved temperature, without degradation to equipment. The APM Operating System shall also be rated for the intermittent operating conditions including pushing or pulling another train as specified below, motor failures and other specified conditions. Limits of stopping distance per TP 9.7.4 and 9.7.5 shall be met.

Multiple brakes or combinations of dynamic/regenerative braking with mechanical friction braking when used simultaneously, shall be applied in such a fashion as to not exceed the limits for deceleration and jerk specified in TP 9.6.3.

Overheating of the PBS elements shall be addressed in the Owner approved hazard resolution process.

The thermal capacity of the propulsion and brake systems shall be based on the greater of the following two requirements:

A. Continuous operation of a maximum length train over the APM System guideway. Dwell time as established in TP 5.1.3. Headways shall be set for the maximum line capacity required in TP 5.1.5. All vehicles in the train shall be loaded to AW2. The maximum Owner approved ambient temperature shall be assumed and does not include local temperature changes due to vehicle or wayside equipment. Air conditioning and other accessories shall be operating.

B. One maximum length AW1-loaded train shall be able to push or pull another maximum length AW1-loaded inoperative train into the most convenient station, regardless of where it is located, and then push or pull the same train with both trains empty (AW0) to the M&SF. The environmental and operating conditions of Paragraph A above shall apply except that degradation in speed, acceleration, and deceleration will be permitted. Assuming only one train is operable; the service brakes on one train shall be able to stop both trains. Emergency braking shall be available from both trains; that is, an emergency brake condition shall cause emergency brake application on both trains, except under special conditions when the emergency brakes of the failed train must be disabled for it to be moved.

Where traction is required for either propulsion or braking, measures shall be taken to provide proper guideway running surface traction.

9.7.4 Emergency Brakes

Emergency braking shall be provided in accordance with Section 8.3.2, Emergency Braking, ASCE 21.2-08, and this TP 9.7.4. Where applicable, the Owner approved Hazard Identification, Analysis, and Resolution Process shall be used instead of the process identified in the ASCE reference.

The emergency brakes shall stop the train whenever a potentially dangerous condition occurs. Such conditions include failure to maintain proper safe speed, failure of the normal braking system, or other ATP conditions as required in TP 11.1. Emergency braking rates shall meet the requirements of TP 9.6.3.

The emergency brakes shall be irrevocable, that is, once the command is issued for them to be applied, they shall remain applied continuously until the train comes to a complete stop, even if the initiating command is removed. After the train has stopped, the emergency brakes shall be reset for normal operation by a manual reset on the train by authorized personnel; additionally, the emergency brakes shall be reset by a control signal to that train from the CCO, unless otherwise prohibited for specific situations by these Technical Performance Provisions. If conditions are not safe for the train to move, the emergency brakes shall remain applied regardless of any reset signals or actions. If, when safe conditions exist and the train is allowed to move, a subsequent malfunction occurs, the emergency brake shall be applied as before.

The emergency brake controls shall be interlocked with the propulsion controls and designed in accordance with the safety principles and ATC system fail-safe design requirements of TP 7.1.1, to include removal of propulsion power during emergency braking such that braking commands dominate and shall have priority over any other method of braking.

The emergency brake may use components of the service braking system, but must operate properly without any guideway or propulsion system power and in accordance with the requirements for design stopping conditions as specified in TP 9.7.5.

If the emergency braking system has any elements in common with the service braking system, then the emergency braking system shall comply with the above stopping requirements after meeting all requirements for the service brake duty cycle in TP 9.7.2. In addition, the emergency brake shall incorporate sufficient redundancy and capacity such that the safe train separation assurance requirements of TP 11.1.2 can be met under design stopping conditions as specified in TP 9.7.5.

The energy source for emergency brakes using electrical, hydraulic or pneumatic power for actuation shall be redundant; and the failure of any one active source shall be detected in accordance with the safety principles and ATC system fail-safe design requirements of TP 7.1.1. Failure of any one active energy source shall not result in a braking capability less than as from a single, worst case failure of the braking system; and in the event that a failure has been detected, the emergency brakes shall be applied and the train shall not be permitted to be operated under automatic control until all braking power sources have been restored.

For self-propelled vehicles that depend upon traction between wheels and running surfaces for emergency braking, the devices that provide braking effort shall be located on either the axles or wheels, and shall not be located on the motor shaft or other drive links separated from the drive axle by gears and/or other forms of drive coupling devices except where the coupling device can be shown to meet Frequency “D-Remote” of Table 3-1, ASCE 21-05.

9.7.4.1 Heat Fade

The emergency braking system shall function without degradation for a minimum of three successive applications from the maximum speed with an AW2 load and without overheating at the maximum ambient temperature defined by the Owner or, alternatively the ATP system shall prohibit more than one remote reset of the emergency brake from the CCC within a cooling period of not less than five minutes. If the emergency braking system has any components in common with the service braking system, then the emergency braking system shall function without degradation after meeting all requirements for the service brake duty cycle as specified in TP 9.7.2.

9.7.4.2 Wet Fade

Wet conditions, as defined by thorough spraying of all mechanical portions of the braking system with water for ten minutes or the immersion technique of Paragraph 5.19 of Society of Automotive Engineers (SAE) J843d, shall not cause any departure of the braking capability from the deceleration and stopping distance requirements necessary for the safe train separation assurance requirements of TP 11.1.2 and the overspeed protection requirements of TP 11.1.4.

9.7.4.3 Contaminants

Contamination of the emergency braking system by any fluids or foreign substances in proximity to braking components that might reasonably enter through a leak or other system malfunction shall not adversely affect the deceleration levels required for the safe train separation assurance requirements of TP 11.1.2 and the overspeed protection requirements of TP 11.1.4.

9.7.5 Design Stopping Conditions

Design stopping distances for the APM Operating System shall be developed analytically and the results provided to the Owner for review and acceptance. Such computations shall include all worst-case time delays, train and motor overspeeds, and acceleration conditions. The effects of any grade shall be properly accounted for. The maximum length, AW2 loaded train shall be used. Guideway, tire, and other relevant conditions shall be the cumulative worst-case conditions as specified in TP 9.7.4, 9.7.5.1, 9.7.5.2, 9.7.5.3 and 9.7.5.4 and temperature conditions specified by the Owner. The deceleration rate shall be appropriately reduced to reflect the emergency brake performance and holding capability resulting from a single worst-case element failure or loss within the brake system. This consideration is to be applied irrespective of emergency brake fail-safe design criteria.

The design stopping distances, as computed above, shall be greater than the actual worst-case stopping distance exhibited by the completed APM Operating System. When tested under the conditions specified in this section, the worst-case stopping distance shall be determined as the sum of the three-sigma upper limit from statistically significant samples that include all vehicles tested on several different days and a distance analytically calculated that accounts for worst-case conditions not present in the tests. Both manual on-train and Central Control remote reset of emergency brakes shall be provided. The Contractor shall conduct these stopping distance tests off-site as the qualification test required as part of the initial verification of design. Subsequently, stopping distance tests shall also be included over the APM System guideway in the APM Operating System acceptance tests.

9.7.5.1 Guideway Conditions

Design stopping distances shall be calculated assuming a wet guideway. For rubber-tired technologies that depend upon traction for braking, a wet guideway is defined as one that is watered at a rate sufficient to produce a 0.02-inch film depth. For steel wheel/steel rail technologies, rails are to be assumed to be wetted with condensation or rain that will produce the least adhesion.

9.7.5.2 Tire Conditions

For rubber-tired technologies that depend upon traction for braking, the design stopping distance shall be calculated assuming the standard vehicle tires are operated at maximum specified pressure. Tread shall be assumed worn to the depth at which tires of the APM Operating System would normally be replaced. These requirements are intended to assure that assumed traction is the minimum anticipated in service.

For vehicles on which emergency braking is accomplished through other than rubber tires, this requirement shall be interpreted appropriately to assure that the minimum traction condition is assumed for such vehicles.

9.7.5.3 Out-of-Tolerance Conditions

The effect of out-of-tolerance conditions caused by brake lining wear, low air pressure, etc., shall be investigated by means appropriate for the particular brake subsystem to assure that proper parameters are used in the stopping analysis. Tolerances to be investigated shall include at least: (1) variations in brake lining coefficients as manufactured and after operation; (2) effects of wear on mechanical tolerances, clearances, and seals; and (3) other characteristics that, while not representing a brake subsystem failure, could reasonably be expected to cause degraded APM Operating System performance. Stopping distances shall be calculated for the worst-case of all plausible combinations of out-of-tolerance conditions that are individually inadequate to constitute APM Operating System failure.

9.7.5.4 Wind Loads

Design stopping distance calculations shall include the effects of tail-wind loading that occurs at the maximum allowable operating wind specified by the Owner.

9.8.3 Power Collection

Vehicle power shall be obtained from power collectors as specified in Section 7.12.4, Power Collectors, ASCE 21.2-08, with the following exceptions and/or additional requirements:

A. Pantographs and trolley poles shall not be used.

B. The power collector shall function under all permissible vehicle dynamic operating conditions as specified in TP 9.1 and the vehicle environmental operating conditions specified by the Owner.

C. The brushes used in the power collectors shall have a service life of at least 10,000 vehicle-miles, except that no more than three percent of all brushes may have a service life of less than that amount.

D. The connector(s) of the power collectors and the vehicle electrical subsystem shall ensure that power to the collectors is disconnected whenever maintenance shop power is provided to the vehicle. This connector and the location(s) for application of shop power shall be protected from the environment. They shall include a locking device to ensure that connections are not broken while the vehicle is in service. They shall not expose maintenance personnel to hazardous conditions.

9.9 SUSPENSION AND GUIDANCE SUBSYSTEMS

The vehicle suspension and guidance subsystems shall provide positive mechanical methods for retaining the vehicle in the lateral direction. The vehicle shall be stable against tipping for all operating and environment conditions.

9.10 DOORS

Automatic, power-operated, bi-parting, horizontally sliding doors shall be provided on both sides of the vehicle for passenger entrance and exit. The number and width of doors shall meet the requirements of TP 9.10.1 given the vehicle capacity calculated as per TP 9.3.

If doorways connecting adjoining cars in a multi-car train are provided, then such doorways shall have 30-inch minimum clear opening widths.

9.10.1 Features and Dimensions

It shall be possible to completely unload a vehicle filled to the normal capacity, as defined in TP 9.3, in 25 seconds or less through the doors on one side only, under the assumption that one passenger per 2.2 seconds can be unloaded through each 30-inch unit of clear width at each doorway. For this calculation, the clear width of each doorway shall take into account any reduction in width due to stopping misalignment within the tolerances specified in TP 11.2.1 for a normal programmed station stop. Doorway exit width shall be measured on a doorway basis; combining "extra" width from different doorways is not permitted. In calculating loading and unloading times, the effective clear width, in inches, of each doorway shall be divided by 30 inches and rounded downward to the nearest 0.1 units.

The minimum doorway height shall be 76 inches. The doorway width shall provide a minimum clear opening per TP 11.2.1.

9.10.2 Door Operation

Automatic operation of the vehicle doors, and station platform doors where provided, shall occur only if the conditions specified in TP 11.1.8, are satisfied. Automatic operation of the vehicle doors, and station platform doors where provided, shall be controlled by the ATO subsystem, subject to the ATP subsystem safety checks.

Door closing shall be annunciated by audio and visual warning signals, as specified in TP 9.13.9.

9.10.3 Door Safety

Door or door control subsystem failures shall not result in a vehicle door unlocking or opening when not commanded to do so and shall meet all requirements of TP 11.1.7.

It shall not be possible to entrap fingers, hands or clothing between door panels and adjacent fixed sections while doors are opening or closing. Door panels, operating mechanisms, and linkages that could pinch or injure passengers shall not be accessible.

All vehicle door panels shall have sensitive edges and a door reopening feature that, when activated by the leading sensitive edge of a door panel contacting an obstruction of one-inch or greater diameter located at any point along the closing edge and at any point of door travel, shall cause both panels to recycle: that is, stop, reverse direction, return to the fully opened position, and then begin the closing cycle again. Any object of one inch or greater diameter detected between the closing door panels shall cause them to recycle. Any proposed alternative to the use of sensitive edges shall provide equivalent safety and be subject to acceptance by the Owner. The door open period in this cycle shall be adjustable from one to five seconds and in not greater than one-second increments. Door panels at unaffected doorways on the train shall not be recycled. Activation of the door reopening feature causing the doors to recycle three times, or causing the doors to be held open for more than ten seconds, shall result in an alarm at Central Control. Door interlock requirements are discussed in TP 11.1.8 and 11.1.9.

Doors shall be mechanically locked. With vehicle power applied to the door operating mechanism, the door panels shall automatically unlock and open or close and lock, as appropriate. The doors shall not be locked until the space between door edges is 0.25 inch or less. In the event of loss of power to any vehicle door mechanism or failure of either the door controls or devices that power the lock, it shall be possible to open the failed door manually, with a force not exceeding 35 pounds, after manual unlocking. All vehicle doors shall have a mechanism on the exterior of the vehicle to unlock and open the door panels manually without the aid of vehicle power and without the use of a key or similar device.

No door panel shall exert a closing force in excess of 30 pounds for the full range of door motion, even when the reopening feature has been deactivated or has failed. The kinetic energy of each vehicle door panel, including all parts rigidly connected to the door and computed for the average closing speed, shall not exceed 7 foot-pounds. The average door closing speed shall be calculated by measuring the time required for the leading edge of the door to travel from a point 1 inch away from the open jamb to a point 1 inch away from the point of closure of the doors. Demonstration of compliance by test in lieu of calculation may be provided. When the door-reopening feature is no longer active, just before door closure, the kinetic energy, as computed above, shall not exceed 2.5 foot-pounds.

When the doors are fully closed and locked there shall be no air gap and the total opening shall not be greater than two inches when an attempt is made to push the doors open. The door panels shall not separate due to forces from acceleration or deceleration in combination with guideway grades.

Each door panel shall be of sufficient strength to meet the requirements of Section 7.4.4.1.2, Worst-Case Loads, ASCE 21.2-08. Door performance shall not be adversely affected after such loads are removed.

Station platform doors shall operate the same as the vehicle doors and shall meet all of these vehicle door safety requirements. Corresponding train and station platform doors shall be operated as a set for all normal and recycling operations.

9.10.4 Door Alignment

Allowable vertical and horizontal gaps between the vehicle door threshold and the station platform shall be as specified in Section 7.3, Clearance in Stations, of ASCE 21.2-08.

To prevent entrapment of persons between the vehicle and stations doors, the requirements of Section 10.2.1, Intrusion Prevention System, Item (6), of ASCE 21.3-08, shall be satisfied.

9.10.5 Emergency Exits

Each car or passenger compartment shall be equipped with two or more emergency exit(s). At least one of these shall be a door that leads directly to a safe emergency egress route at any point in the APM System, regardless of train length. The second may be a door that leads indirectly through other vehicles to a safe emergency egress route or a window that leads directly to such a route. If emergency exits separate from the regular passenger doors are required to meet evacuation requirements, they shall meet the retention and release requirements of Federal Motor Vehicle Safety Standard 217. Emergency doors shall not impede passenger exiting. There shall always be at least one unblocked emergency exit from each passenger compartment at all locations along the guideway.

A safe emergency egress route is either onto the emergency walkway or onto the station platform.

Opening of any emergency door and/or any regular passenger door used as an emergency door shall be possible from inside and outside the vehicle by means of a mechanical latch that operates independently of any on board power and with a force not exceeding 35 pounds. The emergency door-operating mechanisms on the inside of the vehicle shall be conspicuously marked, including simple operating instructions that discourage unintentional operation. Actuation of the emergency door operating mechanism while a train/vehicle is in motion shall cause the train to stop and remain stopped in accordance with TP 11.1.7. Only after the vehicle reaches a zero speed in accordance with TP 11.1.13 shall the door be able to be opened for passenger egress. For conditions where operation of an emergency exit could present a hazard, such hazard shall be resolved in accordance with Owner approved Hazards Resolution Identification Process.

These mechanisms and instructions shall be clearly visible under normal and emergency lighting conditions. The emergency door and any such operable passenger door shall open onto the safe emergency egress route. Except for failures that are determined to be “Improbable” in accordance with the criteria of Table 3-1, Risk Assessment of ASCE 21-05, the emergency door unsafe side door blocking mechanism shall fail in a manner that permits the emergency doors to open when operated. Such failure shall result in an alarm message to Central Control. Opening any emergency exit shall meet the requirements of TP 11.1.7.

9.13.9 Passenger Information

9.13.9.1 Audio Announcements

All passenger compartments for all vehicles shall have automatic on board announcements, synchronized with the location of the train on its route that accomplish the following:

A. Announce the imminent departure of a train from a station.

B. Announce the imminent arrival and impending stop of a train at a station, together with the identity of that station.

C. Announce the imminent commencement of door closing with audio and visual signals.

9.13.9.2 Graphics

Dynamic graphic devices shall be provided in each passenger compartment to provide operational and emergency information to passengers. These devices shall conform to the following requirements:

A. through G. – Reserved.

H. Automatically display emergency or informational messages as may be selected by the Central Control Operator; these messages shall be synchronized with, and substantially the same as the audio messages described in TP 9.13.9.1 and any station dynamic graphics messages.

I. Reserved.

J. The vehicle Dynamic graphics shall be Liquid-Crystal (LCD) type (or equal, per Owner’s approval). They shall have adequate bandwidth for data transfer for future use of these displays for other non-APM type information by the Owner. The exact nature shall be coordinated during preliminary Vehicle Design Review.

All interior graphics shall be subject to the review and acceptance of the Owner as part of the Graphics Plan.

9.16 VEHICLE COUPLING

Coupling shall be designed in accordance with Sections 7.5, ASCE 21.2-08, and this TP 9.16.

The following coupling requirements shall apply regardless of the type of coupling provided:

A. Vehicle to vehicle connections that are used to form multiple vehicle trains shall meet the requirements of this section for mechanical, electrical, and pneumatic coupling.

B. Any non-automatic coupling and uncoupling operations shall require local manual supervision. The coupling/uncoupling process shall not endanger personnel safety and in no case shall the coupling process require placement of an individual between vehicles while either vehicle is in motion.

C. All mechanical coupling shall be slack-free and shall have bearing and/or wear surfaces that have a means to compensate for wear. The mechanical parts of couplings shall not be used as an electrical ground nor shall they conduct current between vehicles.

D. Failure of the critical mechanical, electrical, or pneumatic connections in any coupler in a train or vehicle shall result in the application of vehicle brakes in accordance with TP 11.1.5. Reset of this brake application shall be accomplished only on each vehicle and only by authorized personnel.

E. It shall be possible to couple vehicles and trains easily anywhere on the guideway, except in crossovers, to push or pull a failed train with an active train, or with the maintenance and recovery vehicle (MRV), if provided. This shall be accomplished by using mechanical couplers as specified in TP 9.16.1.

9.16.1 Mechanical Couplers

All vehicles provided for the APM Operating System shall be equipped to be coupled into trains for operation by use of mechanical latching type couplers as specified herein. Drawbars may, at the Contractor's option, be used only between individual cars of a vehicle. Where mechanical couplers are provided between individual cars of a vehicle, the requirements of this TP 9.16.1 shall apply. Where drawbars are provided, the requirements of TP 9.16.2 shall apply.

Mechanical couplers shall be provided at each end of all vehicles and shall allow coupling and uncoupling of any two vehicle ends anywhere on the APM System guideway, including within the maintenance and storage areas, without the need for manual alignment of the couplers or special tools. The following requirements shall apply:

A. A positive lock shall assure that the coupler, once engaged, cannot release without prior, on board release of this lock.

B. All required electrical and pneumatic coupling connections (train lines) shall be accomplished automatically during a mechanical coupling and shall be disconnected automatically during a mechanical uncoupling. Upon uncoupling, all required electrical and pneumatic coupling connections shall be protected by automatically deployed weather- and moisture-resistant covers. (See TP 9.16.3 for requirements for trainline connections incorporated into mechanical couplers).

C. Mechanical coupling and uncoupling shall normally be accomplished only by moving vehicles or trains under on board manual control. Under such conditions, the coupling or uncoupling operations shall require local manual supervision and shall not require special tools. There shall be means to couple and/or uncouple from both inside and outside the vehicles. A person shall not be required to stand between vehicles during the coupling or uncoupling process. No more than one person in each vehicle shall be required to perform coupling or uncoupling, including operation of the vehicles.

D. Mechanical coupling and uncoupling may also be accomplished by moving vehicles or trains together to form a single train, or separating them to form two trains, under automatic control. When such automated mechanical coupling or uncoupling is employed, it shall be initiated and directed by the Central Control Operator as appropriate and meet all applicable requirements of TP 7.1.1 and TP 11.1.

9.16.2 Drawbars

Drawbars (including tow bars) shall provide a slack-free connection between the cars. All drawbar and tow bar components that must be removed to uncouple cars shall be positively retained. No part of the drawbar or tow bar, or its components, shall be able to come in contact with power rails.

9.16.3 Trainlines

The requirements of this TP 9.16.3 shall apply to all trainlines, regardless of whether they are (1) incorporated into mechanical couplers, or (2) independent hose/wire connectors.

Trainlines shall be used to provide pneumatic and/or electrical connection between vehicles. There shall be no hydraulic trainlines. It shall not be possible to move a mechanically coupled train automatically unless all trainlines necessary for safe operation are complete.

All required electrical and/or pneumatic coupling connections shall be made automatically during a mechanical coupling event. Similarly, all required electrical and/or pneumatic coupling connections shall be disconnected automatically during a mechanical uncoupling event. Use of manual quick-connect/disconnect electrical and pneumatic connections shall not be permitted.

Electrical trainlines connections shall prevent incorrect alignment of trainline connections and shall have positively-retained, weather- and moisture-resistant covers to protect contacts when not in use. High voltage circuits shall not be trainlined between vehicles, but may be trainlined between cars in a vehicle if that connection cannot separate or permit shorting during normal operations. Electrical connections between coupled vehicles shall include circuit and shield grounds as appropriate. To prevent ground loop currents, electrical grounds shall not be connected between vehicles and shielded cables shall have shields grounded only at one end.

Pneumatic trainlines between vehicles shall have automatic sealing valves for mechanical couplers to shut off the lines when not coupled to another vehicle. If more than one pneumatic trainline is required, they shall be configured so that misconnection is not possible.

Trainlines shall prevent damage to vehicle-borne equipment and connectors if vehicles, which have trainlines connected but are mechanically uncoupled, are moved apart. The weak link shall be the connector so that damage does not occur to vehicle wiring or piping.

10 APM OPERATING SYSTEM POWER DISTRIBUTION SYSTEM AND BACKUP POWER SUPPLIES

The Contractor shall provide all power conditioning equipment, circuit protection equipment, and switchgear required to supply electric power to all APM Operating System equipment as specified herein and in accordance with Chapter 9, Electrical Equipment, ASCE 21.3-08. The Contractor shall provide and install all necessary power panels, wiring, conduit, and other electrical equipment to power Contractor-provided equipment. Where a conflict exists between the requirements of the referenced ASCE Standards and the specific requirements of this TP 10, the more stringent requirement shall govern. Power substation facilities shall be provided by the Contractor in accordance with the Contractor's requirements at the locations shown on the Preliminary APM Project Layout Plan. These power substations shall be the source of all power for propulsion and other APM Operating System equipment. The Contractor shall provide and install all facilities required for the power distribution system (PDS) and equipment grounding that are not specifically identified on the Preliminary APM Project Layout Plan or in these Technical Performance Provisions to be supplied by the Owner.

The propulsion and auxiliary power systems shall be networked throughout the APM Operating System so that the loss of any one Los Angeles Department of Water and Power (LADWP) primary feeder does not affect overall APM Operating System performance. All APM Operating System operations specified in these Technical Performance Provisions shall be possible with one LADWP primary feeder at any and all substations out of service or with one APM Operating System substation completely out of service as defined in TP 10.1.

The PDS shall be sized to withstand peak loads encountered during the normal start-up and operation of trains based on the following criteria:

A. Trains of the maximum length required to meet the specified requirements.

B. Trains loaded at the AW1 weight.

C. Trains operating at the non-interference headway specified in TP 5.1.2.

D. All on board electrical equipment that could be operated simultaneously, operating and without any restrictions.

E. All guideway and other ancillary power equipment on, including power required for normal maintenance.

The PDS shall have a level of voltage regulation as specified in Section 9.1.7, Voltage Regulation, ASCE 21-3-08.

All primary power equipment, voltages, ratings, capacities, and feeder locations shall be as determined by the Owner, LADWP, and the Contractor and meet the provisions of IEEE 519.

The Contractor shall provide a Power Distribution Loads Analysis showing the real power requirements and reactive (VAR) requirements; the harmonics and their magnitudes; any voltage flickers and dynamic over voltages in case of ac/dc conversion failures for all APM Operating System equipment and operations, and estimated power demands and maximum power surges at each substation.

Ratings for all proposed transformers, rectifiers, and switchgear shall be included, as shall short circuit, circuit protection coordination, grounding, and cathodic protection analyses. All of these analyses and information shall be for the Ultimate System. These analyses shall be submitted for review and acceptance to the Owner as part of the Power Distribution System Design Review.

The PDS as initially installed shall be capable of satisfying the Ultimate System Operational requirements.

10.1 APM OPERATING SYSTEM POWER DISTRIBUTION SYSTEM

Vehicle propulsion power and auxiliary power shall be supplied through power substations. Possible substation locations for the APM System are (1) just east of the East CTA Station, (2) between the West ITF Station and M&SF, and (3) near the east end of the East ITF Station, as shown on the Preliminary APM Project Layout Plan. The precise locations shall be selected by the Contractor based on the requirements of its technology and APM System design, the specific site conditions, and subject to coordination with and acceptance by the Owner. Substation facilities and equipment shall not be located in any public roadway and shall not be installed under the level of the water table, except as accepted by the Owner.

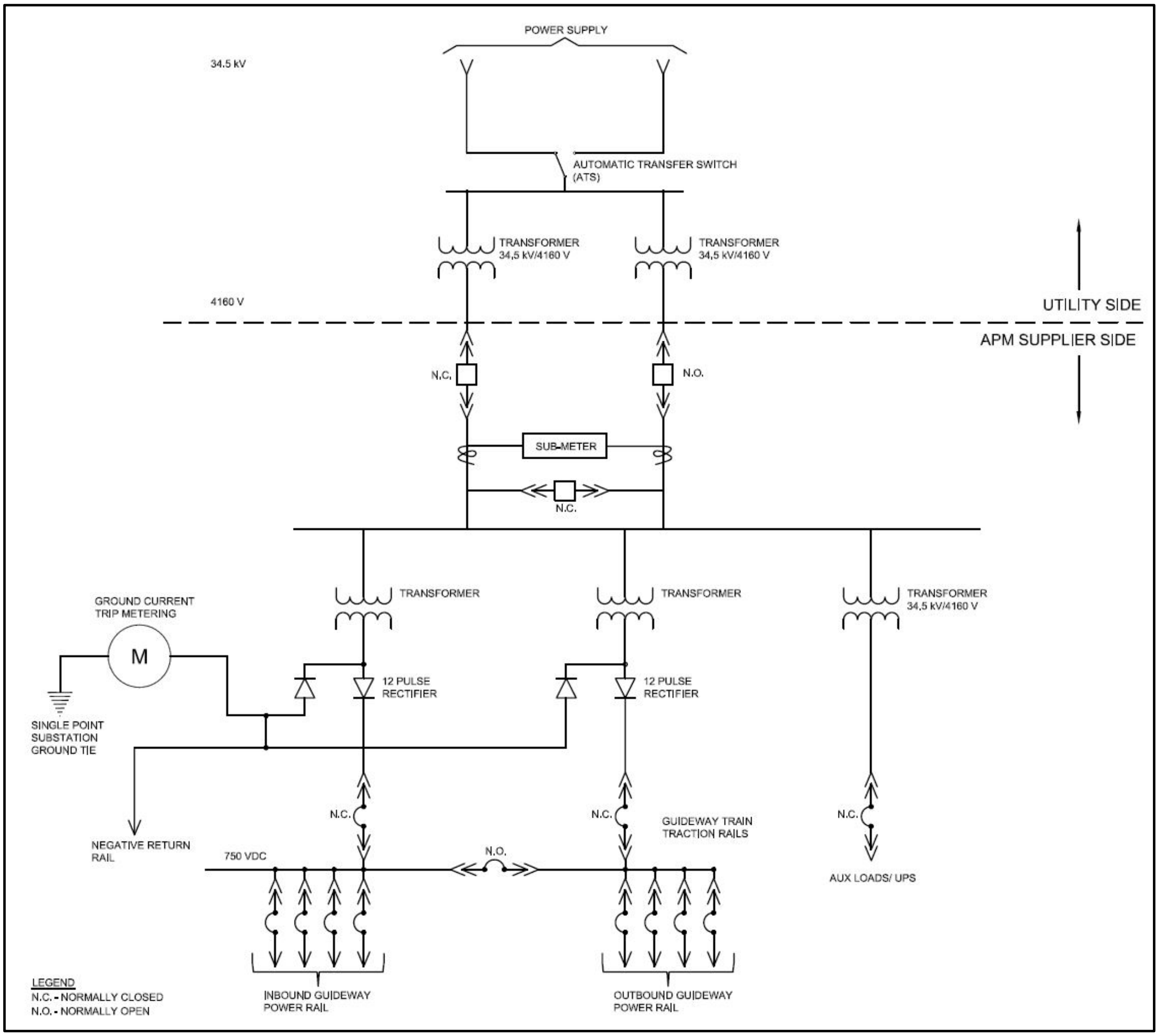
Each substation shall include all power conditioning equipment, circuit protection equipment, and switchgear required to provide vehicle propulsion, other guideway equipment operation, and auxiliary power to all guideway lanes. The power substations shall be self-sufficient in terms of auxiliary and control power requirements and shall include grounding of all equipment therein.

Each substation shall be configured so that under normal conditions, all power upon which operation of the APM Operating System is dependent (i.e., for propulsion, station equipment, ATC, communications and auxiliaries) is supplied by two independent LADWP, 3 phase, 4160V, 60 Hz primary sources. This shall be accomplished by connecting each substation primary to LADWP-supplied feeders. The Contractor is responsible for defining the requirements for all ductbanks, conduit, cables and connections in accordance with local and national electrical codes and LADWP requirements from the APM System substation primary switchgear to the nearest useable LADWP manhole or vault location to be established as part of the Contractor's coordination with LADWP through the Owner. Location of the nearest useable LADWP manhole or vault shall be coordinated with the Owner and LADWP. All ductbanks/conduits to route primary power to/from the LADWP vaults to the substations will be provided as part of the project. Ductbanks/conduits to route traction and auxiliary power feeders to/from the substations to the nearest feasible location of the guideway will be provided as part of the project based on Contractor's requirements. The Contractor shall provide the cable/wire to/from the LADWP metering interface cabinets and the APM substation. Contractor to coordinate primary power feeder connections with LADWP. The Contractor is responsible for providing and installing the cable/wire to/from the APM substation and the guideway for power feeders.

In addition, all power required for the operation of the APM Operating System shall normally be monitored and controllable from the CCC, and shall not be controllable by non-APM Operating System entities.

A typical single line APM Operating System substation conceptual diagram is provided below:

Figure 10.1-1 – Typical Single Line APM Operating System Substation



The Contractor is responsible for connecting the primary feeders to the Contractor-supplied and installed primary switchgear in close coordination with LADWP. The Contractor shall provide, install, and connect all equipment within each substation, including, at a minimum, transformers, primary and secondary switchgear, cabling, wiring, wireways, conduits, rectifiers, and any other equipment required for APM Operating System performance as specified herein.

During a primary preferred source outage, switchover to the alternate primary source shall be accomplished automatically and interlocked so that paralleling of independent primary sources by Contractor equipment does not occur under any circumstances. Switch back to the preferred primary source when its voltage is restored shall be selectively controlled from the CCC. The loss of any single primary source, or primary feeder, or any single failure within a PDS substation, shall not cause the loss of propulsion power to any guideway section except that a momentary disruption in service shall be allowed. Breaker controls shall energize the substation sequentially; using the LADWP preferred primary source, then the LADWP alternate primary source. This primary feeder switchover equipment design and control shall be closely coordinated with LADWP and meet all of the LADWP requirements for such function, control and interlocking.

In addition, the CCO shall be able to remotely accomplish this switchover of primary sources, provided also that the switchover is interlocked so that paralleling of independent primary sources by Contractor equipment does not occur under any circumstances. When switching of primary sources is accomplished remotely by the CCO, switch back to the preferred primary source when voltage is restored shall be selectively controlled from the CCC.

There shall be sufficient redundancy in the design of the substations and switchgear that no single-point failure (such as a loss of a single primary feeder) can result in more than a transitory disruption in service nor cause any degradation in APM Operating System and train performance or impose any restriction on trains or auxiliary equipment. Where such redundancy is provided within the design of each substation and the APM Operating System has more than one substation, the loss of a complete substation (e.g., both transformers or transformer/rectifiers) shall not impose any restrictions on trains or vehicle auxiliary equipment due to voltage regulation or substation capacity, except that train performance over the affected portion of the APM Operating System may be degraded to twice the non-interference headway (see TP 5.1.2).

If power to any guideway lane or segment is interrupted for any reason, except for the loss of a primary feeder or momentary arcing faults power shall not be restored without action either by the CCO at the CCC or by maintenance personnel at the appropriate substation(s). Restoration of power shall be done in accordance with operational procedures.

The PDS shall impose no restriction on train operations or on vehicle auxiliary equipment required to meet the Ultimate System requirements. The PDS design shall facilitate APM Operating System and PDS maintenance as well as all of the operating modes of TP 5.2 and Owner approved failure management procedures.

Redundant secondary feeders are not specifically required. To meet the single-point failure requirement, power to an affected power rail segment may be restored by closing the appropriate tie breakers to connect two segments temporarily until the problem is resolved. See the segmentation requirements of TP 10.1.4.

The PDS shall protect passengers and O&M personnel from contact with lethal currents as well as isolate faults to minimize damage and interruptions to service.

Power regeneration, if provided, shall be in accordance with the requirements of Section 9.2.5, Power Regeneration Equipment, ASCE 21.3-08. Under no circumstances shall regenerative power be permitted back to the LADWP primary source. In addition, the hazard of regenerating power into a de-energized power rail shall be analyzed in accordance with the Owner approved Hazard Identification, Analysis and Resolution Process.

All PDS components, devices, wires, cables and assemblies shall be UL labeled or based on other demonstrated measures of quality accepted by the Owner and meet all requirements of these "Select Draft Project Technical Performance Provisions". The feeder, interconnecting, and branch cables shall be single, copper, thermosetting insulated conductors rated at the appropriate voltage and 90°C, with an allowable capacity as given in the appropriate tables of the NEC. The Contractor shall verify that the PDS as designed and installed complies with all applicable local codes, national codes, and industry standards and IEEE 519. If the Contractor identifies any conflicts between the TP specifications and applicable local codes, national codes, and industry standards and IEEE 519, the more stringent requirements shall be used.

10.1.4 Power Rails

10.1.4.1 General

Power distributed to the vehicles shall be by rigid power rails mounted on the guideway. An overhead or catenary distribution system shall not be used.

The requirements of Section 9.3, Wayside Power-Collection Equipment, ASCE 21.3-08, and of TP 10.1.4.2 and 10.1.4.3 shall apply in the design of the power rail system.

The power rail system shall be sized for its current/voltage drop requirements. The rails and mountings shall be of sufficient size to withstand vehicle dynamic loads, wear, and electromagnetic and thermal loads due to short circuits. The power rails shall be solidly supported to prevent lateral or vertical motion, while allowing longitudinal movement as necessary for thermal expansion. Expansion joints shall minimize collector wear, acoustic noise, and arcing.

Power rails shall be either conventional third rails as used on conventional steel wheel/steel rail systems or of stainless-steel-clad aluminum as used on automated guideway transit systems.

Alternate materials will be considered by the Owner if that alternate is normally used by the Contractor and is demonstrated by the Contractor to provide equivalent performance. Power rails shall withstand arcing caused by normal operations and corrosion due to all environmental conditions as specified by the Owner.

All rails shall be suitably insulated from each other and from adjacent structures, as determined by the operating voltage, to prevent electrical interaction and the possibility of a short circuit by the vehicle power collector. Coverboards protecting the rails and other insulators shall prevent accidental contact by personnel on the guideway and prevent short circuits caused by wind-blown conductive debris or deposits. Such shielding and insulating material shall be rated either self-extinguishing or non-burning per ASTM D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position and shall meet the wind load requirements of the California Building Code and requirements of the Contract.

The power rail subsystem shall be segmented to allow isolation of guideway sections for fault isolation, maintenance, and other purposes. Each segment/section of guideway, such as those for the guideways between stations, each station lane, any storage lanes, and the test track in the M&SF, shall be individually powered so that power may be removed from any one or a combination of sections without affecting power to any other section. Segmentation shall be such that de-energized sections correspond efficiently with guideway access locations and in full consideration of the proposed failure modes of operation. Two adjacent segments may be temporarily tied by switchgear as a means to continue power to a segment that has lost power due to a failure in the secondary distribution system. This feature shall not defeat the deactivation of a power rail segment by manual lockouts or a blue light station. Segmentation shall prevent bridging by a vehicle or a train from the adjacent powered sections when a segment is deactivated. This feature shall be activated by the use of interlocked gap sections of greater length than the electrical length of the maximum length train, as determined in TP 5.1.6.4. The use of permanently unpowered "dead rail" sections shall not be permitted. Power zone boundaries and sections/segmentation shall be defined by the Contractor and submitted to the Owner for review and acceptance as part of the APM Operating System Power Distribution System Design Review.

Near stations and emergency egress points, power rails shall be located and protected to preclude accidental contact by passengers.

10.1.4.2 Power Rails Design Data

The Contractor shall provide an APM Operating System that has been demonstrated in similar applications to be reliable, easy to maintain and have a long life. In this regard, for a conductor rail system, the Contractor shall provide the following technical data, at a minimum, in support of its system:

A. Conductor rail current rating for 40^{o}C ambient and 60^{o}C conductor temperature.

B. DC resistance in ohms/1,000 ft. at 60^{o}C.

C. Contact surface material and life (number of vehicle passes).

D. Ability to withstand forces due to short circuit currents versus maximum available short circuit currents.

E. Minimum arcing distances (conductor rail to conductor rail, conductor rail to ground, between current collector shoes, current collector shoe to conductor rail, and current collector shoe to ground).

F. Rail expansions characteristics (coefficient of expansion, interval of expansion joints, and details of expansion joints and anchor strain insulators).

G. Power taps (current ratings and design details).

H. Splice joint resistance (percent efficiency relative to same length conductor rail).

I. Isolating gap (if applicable) design details.

10.1.4.3 Power Rail Connections

All wire and cable connections to the power rails shall be bolted; exothermic weld (i.e. CADWELD) connections shall not be used. Connections other than to power or ground rails may be exothermic welds.

10.1.5.2 Grounding

General requirements for grounding shall be in accordance with Section 9.1.4, Grounding, ASCE 21.3-08, and as specified by the Owner. The following exceptions and additional requirements shall apply.

The enclosures of all PDS equipment shall be connected to the grounding subsystem using conductors having a minimum cross section equal to or larger than the sizes shown in Table 250.122 of the NEC. The worst-case fault current shall not permit a voltage of greater than 50 volts to appear on any enclosure when measured between the enclosure and its connection to the grounding electrodes in the substation.

Cars within a vehicle shall be connected to achieve grounding requirements throughout the vehicle. Vehicles shall be grounded to ensure that under conditions of the worst-case operating current and/or vehicle fault current a voltage (touch potential) greater than 50 volts shall not appear anywhere on the vehicle when measured between the vehicle and earth ground and any adjacent station platforms, metallic enclosures, or metallic guideway structure. The metal structural elements of the passenger station and guideway, and the exposed metal at the passenger/vehicle interface shall be connected to the ground rail at intervals not greater than 100 feet, with connections having a minimum cross section equal to or larger than the minimum sizes shown in Table 250.122 of the NEC. In no case shall a conductor smaller than a cross section electrically equivalent to 4/0 copper be used.

For dc power distribution systems, the current-carrying return rails for each substation shall be electrically isolated from and not be connected to the APM Operating System ground. For dc systems deletion of the non-current carrying ground rail may be considered as described by Section 9.1.4.1, Traction Power Grounding, ASCE 21.3-13. However, in addition to to the ASCE 21-13 requirement, the contractor shall provide a design and analysis that sufficiently mitigates potential hazards including step and touch potential along the entire guideway and at stations and station platform doors.

The grounding and cathodic protection designs of any direct current power distribution system shall specifically be subject to the acceptance of the Owner as part of the APM Operating System Power Distribution System Design Review.

11 AUTOMATIC TRAIN CONTROL (ATC)

The Contractor shall design, provide, install and test an ATC system with all hardware and software necessary to comply with the requirements of this section. The ATC system shall provide performance that is compatible with the requirements of the Ultimate System guideway and train length configurations and shall be expandable to service the Ultimate System in accordance with the requirements of TP 3.5.5.

The ATC system shall include automatic train protection (ATP), automatic train operation (ATO) and automatic train supervision (ATS) subsystems and their means of communication. The ATC system shall automatically regulate the movement of all trains, except those temporarily under onboard manual control.

The ATP subsystem shall provide protection against collisions between trains and with end of track buffers, unsafe switch operations, overspeeds, unsafe door operations, and other potential hazards of operations in automatic mode.

The ATO subsystem shall provide the automatic control of vehicle/train motion, including speed, acceleration, deceleration, and jerk control; station stops; and door operations.

The ATS subsystem shall provide the interface between the Central Control Operator (CCO) and the APM Operating System, giving all pertinent information about the APM Operating System and means for the CCO to control various APM Operating System functions. The ATS subsystem shall also provide APM Operating System supervision, including automatic routing, schedule keeping, and maintenance management information system (MMIS) data acquisition and reporting.

11.1 AUTOMATIC TRAIN PROTECTION (ATP)

The ATP subsystem shall perform the following operating functions, the requirements for which are given in subsequent subsections:

A. Presence detection.

B. Safe train separation assurance.

C. Unauthorized motion prevention.

D. Overspeed protection.

E. Parted train protection.

F. Lost signal detection.

G. Unscheduled door opening protection.

H. Vehicle/station alignment and door interlocks.

I. Departure interlocks.

J. Direction reversal interlocks.

K. Obstructed motion detection.

L. Switch interlocking protection.

M. Zero speed detection.

All ATP functions shall be performed in accordance with the safety principles of TP Section 7.1.1 and they shall be verified and validated in accordance with the Owner approved verification and validation process.

The safety provided by the ATP subsystem shall exist under all circumstances of guideway power, vehicle power, automatic operations, and with malfunctions in the ATP subsystem itself. Should a failure occur, or should the ATP subsystem become inoperable, no unsafe condition shall result. The ATP subsystem shall react appropriately, in a safe manner, whether or not an indication is provided to the CCF, and it shall react to an indication regardless of whether a failure has actually occurred or not.

11.1.1 Presence Detection

The ATP subsystem shall continuously detect, throughout the entire APM Operating System, the presence of all vehicles; including passenger vehicles/trains, and any maintenance vehicles that are designed for use during passenger service operations, including the MRV, whether moving or stationary, or under automatic or manual control. No undetectable vehicles, trailers or carts shall be used over the passenger-carrying guideway once passenger service operations have begun.

The ATP subsystem shall systematically track the presence and progress of each vehicle, train, or other on-guideway vehicle throughout the APM Operating System. Additionally, the ATP subsystem shall detect the loss of presence detection if ever the presence of a previously detected vehicle of any kind becomes undetected. If there is a loss of presence detection, the APM Operating System shall assume a safe state such that the undetected vehicle, if being operated under automatic control, shall stop (preferably at the next station) and any following vehicles operating under automatic control shall stop clear of the point at which detection was lost, in accordance with the safe train separation assurance requirements of TP 11.1.2. There shall be no reset action(s) that permits the ATP subsystem to detect or indicate an unoccupied (no presence detected) status for any guideway section that is actually occupied.

The presence detection function shall be self-initializing in the event of any interruption to power, ATC computers or ATC communications. After any such interruption occurs, when the interruption is cleared, the location of all vehicles in the APM Operating System shall automatically become known to the ATP subsystem, within five seconds, to the degree of resolution normally known to the APM Operating System. Presence detection shall not depend on input of vehicle location by the CCO. Manual vehicle operations for the purpose of providing the ATP subsystem with knowledge of the location of a vehicle are permitted only (1) when a vehicle is first brought into the APM Operating System (for example, from a maintenance facility) and (2) in those rare cases where failure has resulted in loss of both the primary and standby equipment required for redundancy.

Non-vital train location information may be provided to ATO/ATS, if required, for the automatic control of train operations and for the display of train locations on the system schematic display.

11.1.2 Safe Train Separation Assurance

The ATP subsystem shall maintain safe separation between trains traveling in the same or opposing travel directions, between trains and switch conflicts, and between trains and end-of-track buffers. This protection shall accommodate the allowed maximum speed limit (see TP 11.1.4) and be based upon the assumption that any detected entity may instantly stop ("brick wall stop").

Train speed commands shall be dynamically controlled on the basis of detected train presence (TP 11.1.1) and detected switch position/status (TP 11.1.12). ATO train movement control (TP 11.2.3) shall affect normal service braking of trains so that they stop at a point that is short of the safe separation distance. In the event that ATO control fails or otherwise allows encroachment on the safe separation distance, the ATP subsystem shall enforce safe train separation assurance by the application of emergency brakes and the removal of train propulsion power. Both remote (from Central Control) and local onboard manual brake reset shall be possible.

The worst-case performance of emergency brakes must be capable of stopping trains to prevent collision and shall be a fundamental consideration in the implementation of safe train separation assurance design. The ATP subsystem design shall account for stopping distances and worst-case performance conditions determined in accordance with TP 9.7.4 and 9.7.5 plus appropriate margins.

11.1.3 Unauthorized Motion Prevention

The ATP subsystem shall ensure that irrevocable emergency brakes are applied if there is train movement when the train is supposed to be stopped (zero-speed condition as defined in TP 11.1.13) or when the train moves more than 20 inches (or to safe limits as justified by Owner approved hazards analysis) in a direction other than the commanded direction of travel (rollback). Reset and restart shall be possible both remotely from Central Control and manually on board the train.

11.1.4 Overspeed Protection

The ATP subsystem shall provide an overspeed protection function to preclude a train’s speed from exceeding the safe speed limit at any point on the guideway. The safe speed limit shall be determined by ATP based on guideway alignment, civil constraints and guideway/train traffic conditions. To accomplish this, the overspeed protection subsystem shall include fail-safe or checked redundant speed measuring subsystems that furnish signals that are a measure of the actual speed of the train. If the actual speed of the train is below the safe speed limit, the emergency brakes shall be held off. If the actual speed of the train unsafely encroaches upon or exceeds the safe speed limit, the overspeed protection subsystem shall cease holding off the emergency brakes so that they are applied to bring the train to a full stop. Reset of emergency brakes shall be possible both remotely from Central Control and manually on board the train.

Certain sections of guideway may have civil speed restrictions requiring trains to reduce speed when traversing them. If a train is traveling within such a restricted zone, all portions of the train must maintain a speed not greater than the zone speed limit. If two or more speed restricting conditions exist, the train shall be governed by the lowest of these.

At the guideway ends, the overspeed protection function shall ensure that under the worst-case conditions the train shall not overshoot the stopping point and strike the buffer at a speed greater than the crashworthy design speed (see TP 9.4.5).

11.1.5 Parted Train Protection

The ATP subsystem shall ensure that if a train is parted, each of the separated units shall immediately and irrevocably brake to a full stop. Only local (onboard the train) manual brake reset shall be possible. ATP presence detection (TP 11.1.1) shall detect the individual presence and location of each of the separated units and ATP safe train separation assurance (TP 11.1.2) shall protect the separated units from other trains operating in automatic mode on the APM Operating System.

11.1.6 Lost Signal Detection

All signals that are critical to the ATP subsystem shall be continuous or of such a repetitive nature that interruption of any such signal shall initiate braking. The maximum allowable time to initiate such braking shall be determined by the Owner approved hazards analysis, such that none of the safe braking requirements of TP 11.1 and its subsections are violated. Reset of brakes shall be possible both remotely from Central Control and manually on board the train.

11.1.7 Unscheduled Door Opening Protection

The ATP subsystem shall ensure that no automatic mode failure shall result in the unlocking or opening of any train door. The ATP subsystem shall also prevent the unsafe opening of train emergency exit doors in accordance with the requirements of TP 9.10.5.

Except where train doors are being operated in stations as part of passenger operations, if any train door or emergency exit unlocks for any reason while a train is in motion or is stopped anywhere in the APM Operating System, the train shall irrevocably apply service brakes. Actuation of the emergency release on any regular train door or the unlocking of any train emergency exit at any time shall also cause irrevocable application of service braking.

If any automatic station platform door, maintenance or emergency walkway access door or station emergency egress door or gate is unlocked for any reason, trains shall be prohibited from entering or leaving that area. If any station emergency door or gate is unlocked for any reason, after a train has entered the ATC-defined door protection area, but before the train has stopped in the area, then that train shall emergency brake to a stop.

For all instances in this section, only local manual reset of brakes shall be permitted. Remote reset by the CCO shall not be permitted. Restart shall not be permitted until all doors (train and/or station) are properly closed and locked and a local check by APM Operating System staff ascertains that no person is on the guideway.

For any unscheduled unlocking or opening of a train door or automatic platform door, maintenance or emergency walkway access door, station emergency egress door or gate, regardless of the cause, an alarm shall be sent to Central Control. Opening any facility door that leads onto the guideway shall result in the sounding of a local alarm in addition to the alarm that is sent to Central Control.

11.1.8 Vehicle/Station Alignment and Door Interlocks

The ATP subsystem shall ensure that automatic opening of train doors and matching station platform doors shall occur only after all of the conditions listed below have been satisfied. Automatic door opening under any other conditions shall not be possible.

A. The train speed is zero as defined in TP 11.1.13.

B. The train is properly aligned with the station platform.

C. The brakes have been properly applied and power has been removed from the propulsion motor(s).

Train-station misalignment or failure of doors to open shall initiate the actions required in TP 11.2.1.

11.1.9 Departure Interlocks

The ATP subsystem shall ensure that a train stopped in a station shall not be allowed to move unless all train doors and any platform doors are properly closed and locked and the train brakes have been released. Once these conditions are satisfied, if the train does not then move within ten seconds of being commanded to do so, brakes shall be applied and a “train failed to depart” alarm shall be sent to Central Control. Reset of the service brakes shall be possible both remotely from Central Control and manually on board the train.

11.1.10 Direction Reversal Interlocks

Reversing train direction shall be possible at all locations where automatic train operation is possible. Except for reversing at stations and/or other Contractor-designated automatic reversing zones, as part of normal or ATC-governed failure management operations, the train reversing command shall originate with the CCO. Reversal shall occur only after zero speed has been detected in accordance with TP 11.1.13. Once commanded, the train shall proceed automatically. ATP interlocks shall ensure that an automatically controlled reversing train does not violate the safe train separation assurance requirements of TP 11.1.2.

Interlocks on each train shall prohibit manual operation in the reverse direction from the forward end of that train.

11.1.11 Obstructed Motion Detection

The ATP subsystem shall monitor the response of the train to ATC commands for propulsion. If train movement is not detected after being commanded within a predetermined time, as determined by the Owner approved hazards analysis, the train shall be safely stopped and the condition shall be annunciated at Central Control. Reset and restart shall be possible both by remote command from Central Control and by manual reset on board the train.

11.1.12 Switch Interlocking Protection

Switching shall be implemented in accordance with the requirements of TP 13.7.

The ATP subsystem shall provide switch interlocking protection in accordance with 5.1.14, Guideway Switch Interlocks, ASCE 21-05. Hazards analyses, if required as stipulated in the ASCE reference, shall be conducted in accordance with the Owner approved Hazard Identification, Analysis and Resolution Process.

Both power-actuated and manually-actuated switches shall be interlocked with the ATP subsystem to assure safe operation of trains through the switches.

The ATP subsystem shall prevent a train from entering a switch that is unsafe and shall prevent a switch from becoming unsafe once a train is committed to traverse it.

11.1.13 Zero Speed Detection

Zero speed shall not be registered until a speed of one foot per second or less is attained and braking is commanded. The ATP subsystem shall ascertain when a train reaches zero speed in accordance with TP 7.1.1.

11.2 AUTOMATIC TRAIN OPERATION (ATO)

The ATO subsystem shall include the equipment necessary to automatically perform the following functions within the constraints of the ATP subsystem:

A. Programmed station stop.

B. Door operation and station dwell time control.

C. Train movement control.

D. Operating mode control.

E. Train location determination.

11.2.1 Programmed Station Stop

A programmed station stop is the control of train speed and final application of brakes, under jerk and acceleration limits, to make a precise station stop. Programmed station stops shall be made so that the centerlines of the train doors and the corresponding station platform doors, or designated passenger boarding/discharging zones, are aligned to within 6 inches of each other. Trains shall be properly aligned for not less than 99 percent of all station stops. Brakes shall apply when zero speed (TP 11.1.13) is detected and remain applied until the vehicle is ready to depart the station.

If, during a programmed station stop the train brakes to a stop for other reasons and the conditions that caused the stop are subsequently removed and the brakes are properly reset, the train shall reacquire the programmed speed-distance profile under jerk and acceleration limits and proceed to complete the programmed station stop as though the premature stop had not occurred.

The stopping positions at each station platform shall be designed for the maximum length trains as shown in the Preliminary APM Project Layout Plan. However, all trains regardless of their length arriving at the CTA West Station shall stop such that the mid-point of the train aligns with the mid-point of the maximum length train berthing position. Similarly, all trains regardless of their length arriving at the

ConRAC Station shall stop such that the front of the arriving train is nearest to the ConRAC customer service lobby at the east end of the station.

Whenever the train doors and station stopping points are not properly aligned as required above, but portions of the vehicle doorways are within the station platform doorway openings and at least a 32.5 inch wide clear opening is provided and where the opening is only onto the platform, then the doors shall be allowed to open automatically but an alarm shall be sent to Central Control. This alarm shall indicate the misalignment and identify the train and station involved. At the conclusion of the specified station dwell time, the train doors shall close and the train shall automatically depart the station.

For all other misalignments, the train shall remain at the station with all doors remaining closed until a decision is made by the CCO regarding the disposition of the train. During this time, it shall not be possible to open the doors remotely by CCO command. Automatic announcements shall be made on the train and in the station involved. At the option of the CCO, maintenance personnel may be summoned to manually open the train doors and assist passengers in exiting the train. In any case, when the train is dispatched by the CCO, it shall automatically depart the station.

Any train jog movements implemented in the Contractor's design to allow recovery from an initially misaligned station stop shall comply with the requirements of TP 11.1.10. Such maneuvers shall be invoked only upon command from the CCO and the moves accumulated by one or more successive jog commands shall not collectively exceed 4 feet of reverse direction distance. Jog maneuvers shall not be considered to satisfy the 99 percent station stop alignment requirement specified above.

11.2.2 Door Operation and Station Dwell Time Control

The ATO subsystem shall automatically control train and station platform doors during station stops so that they open and close together.

As defined in TP 5.1.3, station dwell time is the amount of time during which the train is stopped in the station, measured from when the train doors are commanded to open until the train doors are closed and locked. The ATO subsystem shall control station dwell time and the ATS subsystem shall manage it for headway regulation purposes. ATO shall have default station dwell times defined for each individual station platform that shall be used in the absence of dwell time management/override commands from ATS. The CCO shall have the capability to adjust dwell times on an individual station platform basis for all modes of operation.

Train and station platform doors shall operate in accordance with the following requirements:

A. An ATP function shall be implemented as described in TP 11.1.8 such that it shall not be possible for the ATO to automatically open any train door anywhere in the APM Operating System except when the train is properly stopped and aligned at a station platform. Further, it shall not be possible to automatically open any train door unless the door is properly aligned adjacent to a station platform door.

B. Train doors and corresponding platform doors shall be controlled as a set. Each such door set shall open and close as a coordinated movement when signaled to do so by the ATO subsystem. It shall not be possible to automatically open any train door unless there is a corresponding platform door to comprise a complete and functioning door set. Furthermore, if any door of a door set is cutout or otherwise rendered inoperable by maintenance, then ATO shall not signal that door set (platform and vehicle) to open.

C. Automatic platform doors shall be powered independently of train doors. Train and platform doors shall not share any mechanical linkages, operating mechanisms or physical components. Secured access panels, associated with the automatic platform door operating mechanisms, shall be accessible from the station side of the automatic platform doors to provide access for maintenance.

D. The train doors and corresponding automatic platform doors shall be commanded to open automatically only after the successful completion of a programmed station stop in accordance with TP 11.2.1.

E. After the predetermined time for which the doors are to remain open, or upon removal of any door hold command that has been placed on the station, all train and corresponding automatic platform doors shall be commanded to close.

F. If, during the closing cycle, an obstruction is detected on any train door or any corresponding automatic platform door, all door panels of that door set shall be recycled in accordance with TP 9.10.3. The unobstructed door sets shall not be recycled.

G. If, for any reason, any train or platform door fails to open or close as commanded, an alarm shall be sent to the CCC. The CCO shall be able to attempt to open or close the door(s) remotely (conditioned on the requirements of TP 11.1.8). If the CCO is successful in remotely operating the doors, the train shall depart the station at the end of its normal station dwell time. If the CCO is not successful in remotely operating the doors, the train shall remain at the station until it is remotely dispatched by the CCO.

H. The ATO subsystem shall generate an individual control signal for each train/platform door set. The door sets to be opened and closed at each station platform shall be determined automatically by the ATO based on the route identity of the train at the station.

11.2.3 Train Movement Control

Train starting, stopping and speed regulation shall be controlled by ATO so that acceleration, deceleration and jerk are within the ride comfort limits of TP 9.6.3 and speed is maintained within the speed limits imposed by the ATP subsystem.

Upon loss of propulsion power, train(s) shall coast under ATO control and under the protection of the ATP subsystem. Should the train(s) reach zero speed, then brakes shall be irrevocably applied. Normal train operation shall automatically resume upon restoration of propulsion power as permitted by the ATP and ATO subsystems. If zero speed occurs and parking brakes are set, or if the train brakes to a stop, restart shall be possible by remote CCO command or by manual reset on board the train, subject to ATO and ATP restrictions. Train propulsion power loss shall be automatically alarmed at the CCC. The train number, location, and fault condition shall be identified.

The ATC system (including the ATP, ATO and ATS subsystems) shall incorporate all design features and equipment to assure the bi-directional operation of vehicles and trains.

11.2.4 Operating Mode Control

When the operating mode is selected by the CCO, the operation of the APM Operating System in that mode shall be accomplished automatically through the ATO subsystem. Operating mode commands shall be initiated from the CCC and assigned to vehicles anywhere in the APM Operating System subject to the safety constraints of TP 11.3.1. Routes and station stops for all of the modes of TP 5.2 shall be predetermined and included in the ATO subsystem for CCO/ATS selection. Station dwell times shall be controlled by the ATO subsystem and supervised by ATS. The dwell time at each station shall be individually adjustable by the CCO.

11.3 AUTOMATIC TRAIN SUPERVISION (ATS)

In the following sections, the ATS portion of Central Control is generally described as if it is fully integrated with the power distribution system (PDS) and other similar systems (e.g., access control and intrusion detection) that could alternatively be handled by commercially available systems such as a supervisory control and data acquisition (SCADA) system. Separation of functions (and separation of workstations and monitors) to take advantage of such commercially available systems may be permitted if they: (1) are fully disclosed in the Contractor’s Proposal, (2) provide for efficient and logical APM Operating System operation by the CCO, (3) provide all of the required CCO interfaces, (4) comply with the Owner’s redundancy requirements and (5) are fully described as part of the CCC Design Review.

The ATS subsystem shall monitor and manage the overall operation of the APM Operating System. The ATS subsystem shall not be essential to continuing automatic APM Operating System operations by the ATO and ATP subsystems once such operations have been started. The ATS subsystem shall provide the interface between the APM Operating System and the CCO. Through audio and visual displays, information shall be presented to the CCO describing the status of the APM Operating System on a real-time basis. This information shall allow the CCO to assess conditions throughout the APM Operating System and to take appropriate actions. The CCO shall be able to issue commands to initiate and terminate APM Operating System operations; override any normal and failure management operating modes; and perform other System management functions subject to the safety constraints of TP 11.3.1.

The ATS subsystem shall provide the following functions, the requirements for which are given in subsequent subsections:

A. Performance monitoring.

B. Performance control and override adjustments.

C. Alarms and malfunction reporting.

D. CCO communications subsystem interfaces.

E. Data recording and reporting.

F. Weather Station and seismic monitoring.

Unless specifically stated otherwise, the functions and capabilities of the ATS subsystem described in this section shall be incorporated into the CCF. The Contractor shall furnish all equipment, computer hardware and software, and associated efforts necessary to provide the functions and capabilities described in this section and its subsections. The ATS subsystem shall be designed with fully automatic modes of APM Operating System operation as the normal condition.

11.3.1 Safety Constraints on ATS

The ATS subsystem shall be such that no action or lack of action by the CCO, either purposeful or inadvertent, or any malfunction of the ATS equipment can subvert or compromise the ATP subsystem functions and thereby cause an unsafe condition. Thus, both the ATP and ATO subsystems shall take precedence over the ATS subsystem. Should the ATS subsystem become completely inoperative for any reason, the APM Operating System shall be capable of continuing to operate in the automatic mode under the ATO subsystem and remain fully protected by the ATP subsystem.

Regardless of this capability, the APM Operating System should not be operated for extended periods of time when critical ATS-related functions, including the audible and visual annunciation of all Priority I and Priority II alarms, are inoperative. Such a failure of the ATS subsystem shall not be permitted as exclusion for the service mode availability calculations. The Contractor’s provisions and procedures to continue APM Operating System operations during a failure of any critical ATS-related function shall be incorporated in the APM Operating System Operations Plan.

Emergency controls on the CCC shall provide at least two independent APM Operating System emergency shutdown functions: (1) stop all trains, and (2) remove all propulsion power. Stop all trains shall be an ATP-related function that is independent of the ATS. The emergency power shut off shall be a PDS-related function that is independent of the ATC system. See TP 11.3.3.2.W.

11.3.3.2 CCO Control Functions

The capabilities and functions described in this section shall be provided on the Central Control Console (CCC). All equipment, computer hardware and software, peripheral equipment, data storage equipment, other devices and associated efforts necessary to provide the functions and capabilities described in this section shall be furnished by the Contractor.

Generally, the CCC controls and displays shall be separated into two major functional groups: (1) APM Operating System operations, consisting of the ATC, PDS and alarms; and (2) audio and video communications. Common CCO interface equipment, safety devices and switches, and voice communication capabilities shall be located at, or accessible to, each CCC position.

The CCC positions, the system schematic display (SSD), the power schematic display (PSD), and the other displays shall together constitute an ergonomically designed, well-coordinated, efficient, and easily operable system.

The CCO control functions described below shall be incorporated into the CCC in a manner that allows maximum flexibility of operation. Except for single event commands, once a command is imposed by the CCO and accepted by ATS, these actions shall remain operative until subsequently removed by the CCO.

Vehicle/train identification numbers shown at the CCC, used by the CCO for input to the ATS subsystem, and used for the alarm event logs shall be the same as the numbers/markings on the vehicles/trains themselves. Similarly, the identifiers shown at the CCC for all other APM Operating System equipment including, at a minimum, PDS circuit breakers, guideway switches, blue light stations etc. shall be the same as the markings on the equipment that they represent.

The Contractor's design of the CCO control functions shall be submitted in accordance with the CDRL for review and acceptance by the Owner as part of the CCC Design Review.

Subject to the safety constraints on ATS required by TP 11.3.1, the CCC shall have at least the ATC, power distribution, and communications control functions described below:

A. through V. – **Reserved**.

W. **Emergency Controls** - (See also TP 11.3.1)

1. Stop All Trains. The CCO shall be able to irrevocably service brake all trains on the guideway by activation of a single-action button or switch. One button shall be located at each of the CCO work positions at the CCC. A deliberate and positive action shall be required to release the button to eliminate the imposed condition.

2. Remove All Propulsion Power. The CCO shall be able to irrevocably remove all propulsion power from the APM Operating System by activation of a single-action button or switch. One button shall be located at each of the CCO work positions at the CCC. A deliberate and positive action shall be required to release the button to eliminate the imposed condition.

13.1 RUNNING AND GUIDANCE SURFACES (TRACKWORK)

The Contractor shall provide all aspects of the track, including final vehicle running and guidance surfaces and appurtenances (including all necessary guidance equipment, such as running rails (tracks), lateral guidance rails or beam(s) and/or other devices and equipment required to guide the vehicles while in motion), either as an attachment to the guideway structure or as a separate structure, depending on the Contractor's basic APM Operating System design. The Contractor shall establish alignment, design, and construction criteria, including construction tolerances, for the track and its installation in accordance with the minimum requirements specified in this section and the design criteria for the guideway structure. However, if additional and more restrictive trackwork installation and construction tolerances are required by the proposed technology, the Contractor shall establish these installation and construction tolerances and include these requirements in its trackwork design criteria.

The Contractor shall verify the accuracy of the as-constructed trackwork and other guideway equipment by field survey, to assure that the ride quality, noise, vibration, alignment and other requirements of these Technical Performance Provisions are met.

If the running and guidance surfaces and appurtenances are painted or otherwise coated, the coating shall ensure that adequate traction is provided for safe stopping distances and normal acceleration/deceleration. The coating shall match any other paint or coating on the guideway in color, and shall be installed to provide complete coverage. The running surface coating and application shall ensure that it and its tractive ingredients do not spall or otherwise separate from the guideway for at least five years. This coating shall be identified, and data describing its tractive ingredients, color, application process, manufacturing sources, locations where currently in use, maintenance requirements, and other pertinent information shall be submitted, with a sample, to the Owner for review and acceptance as part of the Guideway Equipment Design Review.

13.1.1 Construction Tolerances

The Contractor shall construct the running and guidance surfaces to at least the following minimum construction tolerances, regardless of the degree of contact experienced during vehicle guidance:

A. The variation in gauge of running surfaces and lateral control surfaces or structures shall not exceed ±0.125 inches.

B. The deviation in cross level of designed super elevation shall not exceed ±0.125 degrees.

C. The total horizontal or vertical deviation from the designed position shall not exceed ±0.25 inches.

D. The total horizontal deviation in passenger stations shall not exceed 0.0 inches toward the platform edge and 0.125 inches away from the platform edge.

E. The local roughness of running and guidance surfaces shall not deviate more than 0.125 inches from a 10 foot straightedge.

13.1.2 Running and Guidance Surface Durability

Running and guidance surfaces shall be constructed to avoid surface deterioration. The Contractor shall take all reasonable actions to prevent surface cracks from developing in concrete running surfaces, and shall submit these proposed actions to the Owner for review and acceptance as part of the Guideway Equipment Design Review. All maintenance procedures required to maintain the minimum running and guidance surface conditions consistent with the structural design, ride comfort criteria, operational and safety requirements shall be identified by the Contractor and included in the Maintenance Manuals for the APM Operating System.

13.1.4 Superelevation

The Contractor shall construct the guideway structures with minimal cross slope as required to provide for guideway drainage as shown on the Preliminary APM Project Layout Plan. The Contractor shall design and construct trackwork to provide super elevation through horizontal curves.

Superelevation values and curve radii shall be determined by the Contractor for each horizontal curve such that the lateral acceleration limits (parallel to the vehicle floor) specified in TP 9.6.3 are satisfied at any speed from zero up to the maximum speed for the curve, including the effects of vehicle roll about its longitudinal axis. Actual super elevation in curves shall not exceed 6 percent. Lower super elevation limits may be imposed on certain curves within the alignment due to transition length restrictions imposed by technology and site constraints. Super elevation transition (run-out) shall occur uniformly, only in the length of spiral transitions.

13.1.5 Guideway Camber

The Contractor shall provide guideway superstructures as shown on the Preliminary APM Project Layout Plan. As a result, camber of varying amounts will exist in guideway spans when they are turned over to the Contractor. Guideway construction documents will include estimated camber values and values for dead and live load deflections. These values are approximate and actual values will vary from estimated values. The Contractor's APM Operating System design and construction shall account for and accommodate variations in actual camber and deflections from estimated values.

13.5 WAYSIDE EQUIPMENT

The Contractor shall provide any required cable trays, wireways, conduit, and equipment enclosures to be mounted along the guideway for power distribution, ATC, communications, or other subsystems. Such equipment shall consider potential future expansion and such future expansion, if any, shall be accomplished with only minor adjustments. Conduit shall conform to NFPA 70 for specific types of locations.

The Contractor shall submit the locations, installation and aesthetic treatment of this wayside equipment to the Owner for review and acceptance as part of the Guideway Equipment Design Review.

The Contractor shall define its requirements for propulsion feeder wire/conduit installation, including that between the power distribution system substations and the power rails, and the location and aesthetic treatment of this wayside equipment, in the APM Operating System Power Distribution System Design Review.

13.7 SWITCHING

Guideway switches shall be provided and installed by the Contractor to enable the APM Operating System to operate as specified in TP 3 and 5. Switches also are required in conjunction with the M&SF, departure test track, and storage areas. Provisional switch locations are shown in the Preliminary APM Project Layout Plan. The Contractor shall submit switch information including proposed final switch locations, switch operations, reliability, and design information to the Owner for review and acceptance as part of the Guideway Equipment Design Review.

Switches shall comply with the construction tolerances and adjustment ranges specified in this TP 13.1.

13.7.1 General Requirements

Switching may be performed by onboard equipment, in-guideway equipment, or a combination. It shall be possible to operate trains through all switches in either travel direction.

Spiral transitions are not required for switches, provided the ride comfort requirements of TP 9.6.3 are met. Speed reduction is permissible while traversing switches, provided travel time requirements of TP 5.1.4 are satisfied.

An indication of the switch aligned and locked status shall be provided at all entrances to each switch either on the wayside or the vehicle manual control panel. A status indication of onboard switching equipment shall be provided on the vehicle manual control panel. Switch status indications shall also be provided at Central Control.

Switch operation, including speed of movement and reliability, shall meet the APM Operating System operational requirements of TP 5 and service availability requirements. The Contractor shall provide switches that permit full APM Operating System operation in all the Owner specified environmental conditions.

Switches used for normal passenger service operations shall be proven by duty cycle tests of one million cycles, or by prior installation and operation for a comparable time at a similar system, before their installation in the APM Operating System. For the purpose of this test, a cycle shall be defined as: unlock, move, lock (in opposite position), unlock, move (return to the initial position) and lock again.

13.7.2 Basic Principles for Switching

All switching systems shall comply with the following principles:

A. Any switching mechanism(s) with powered actuation, either on the vehicle or in the guideway, must comply with the following: (1) the switch must be set in a position corresponding to the commanded position; (2) the power must be removed from the mechanism; (3) a mechanical lock must be in position; and (4) all of these conditions must be verified through continuous locking detection and point detection before the approaching train reaches a position less than a safe separation assurance distance (TP 11.1.2) from the diverging or converging switch point. Loss of electrical power to the switch shall not cause any change of switch status and the mechanical lock shall remain in position. As long as the switch verification, including locking detection and point detection, is continuously received, the train may proceed normally through the switch.

"Continuous" shall include monitoring of a repetitive nature that accomplishes the same function. If a repetitive signal is used, the time between repetitions must be considered in block length or safe stopping distance calculations. If switch verification as defined above is not received, the ATP subsystem shall ensure that approaching trains stop before reaching the switch. If switch verification is lost while a train is in the switch zone, the ATP subsystem shall emergency brake that train immediately. Brake reset shall be by remote command from Central Control or locally onboard the vehicle. Switch verification and its use, and all other actions of the ATC system relating to the safe operation of switches, shall satisfy the interlocking requirements of TP 13.7.3 and 13.7.5.

B. Non-powered, onboard guidance mechanism(s) shall satisfy at least one of the following conditions:

1. They must be set and locked in the commanded position and must meet all of the conditions specified in TP 13.7.2.A.

2. They and the guideway must be so designed that the onboard mechanism(s) is positively entrapped by the guideway mechanism throughout the length of the switch in a safe and reliable manner so that the train must follow the intended route.

C. All elements of the switch control system shall be in accordance with the safety principles and ATC system fail-safe design requirements of TP 7.1.1.

13.7.3 Mechanisms

All switching mechanisms shall provide continuous, positive guidance to trains as they are traversed, with minor exception for proven special trackwork components where loss of positive guidance may be momentary. Loss of positive guidance by entering, from any direction, a switch aligned to either guideway route shall not be possible. All switching equipment, whether part of the vehicle or the guideway, shall meet the relevant design loads criteria of Section 7.4.4.1, Design Loads, ASCE 21.2-08.

Switches that operate during any of the APM Operating System operating modes or during a transition between operating modes shall be fully automatic. Power-actuated switch mechanisms shall be operated by electric, hydraulic, or pneumatic actuators. To minimize noise, hydraulic equipment shall be insulated or encapsulated and any pneumatic exhausts shall be muffled.

All switches shall meet the following interlocking requirements:

A. **Alignment Detection** - A means shall be provided to detect that the main element(s) of the movable portion of the switch is at either end of the physical displacement it undergoes during actuation. For purposes of this section, these positions shall subsequently be called the tangent and turnout positions.

B. **Actuating Power Removal** - A means shall be provided for removing power from the switch actuator.

C. **Mechanical Locking** - A means shall be provided to mechanically lock the position of those switching elements that directly interact with the train and guideway to cause the switching of the train, and that move to change the state of the switch from tangent to turnout. This means of locking shall keep the switch safely locked under the full force of a moving train in the switch and the full force, in either direction, of the actuator. A means shall also be provided to remove power from the mechanical lock after its actuation is completed.

D. **Locking Detection** - A means shall be provided to detect that the switch mechanical lock is in the locked position. The position of the lock shall be sensed directly from the lock itself. Detection of the lock in the locked position shall ensure the switch is locked.

E. **Point Detection** - A means shall be provided to detect that each switch point on any switch whose accurate positioning is essential to safe initiation of the switching interaction between train and guideway and that moves to change the state of the switch, is positioned with sufficient accuracy to ensure safe travel through the switch.

13.7.4 Manual Operation

All switches shall allow for local manual operation without normal switch activation power. Switches shall be manually operable by one person. Manual activation equipment shall be secured and locked to prevent unauthorized use.

A power disconnect device shall be provided to enable maintenance personnel to disconnect and lock-out power to the switch and prevent switch actuation.

13.7.5 Switching Safety

Switch interlocking protection shall be provided in accordance with the requirements of TP 11.1.12.