SONOMA-MARIN AREA RAIL TRANSIT DISTRICT

VEHICLE TECHNOLOGY ASSESSMENT
FINAL DRAFT REPORT

Revised July 9, 2009

PREPARED BY

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Table of Contents

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

1.1 Purpose

The environmental assessment performed for the SMART rail corridor resulted in the authorization of DMU (Diesel Multiple Unit) technology for the intended service. There are two DMU technologies relevant to the SMART application; FRA (Federal Railroad Administration) compliant DMU technology and alternate-compliant DMU technology. The purpose of this study was to determine which of these two technologies would be best suited to the SMART application.

1.2 Approach

The approach used was to perform a series of studies designed to make evident the significant differences between the two DMU technologies, and, where possible, to identify the regulatory constraints specific to each. To the extent possible, the study team also attempted to determine the willingness of manufacturers to modify (or create) designs capable of meeting those regulations. In this regard, the following studies were undertaken:

- Implications of FRA Regulations for SMART Vehicle Technology Selection
- ADA: Level Boarding Implications for SMART
- Vehicle Characteristics Comparison

1.3 Summary of Findings

The *Vehicle Characteristics Comparison* report was the heart of the study and went deeper than the title of the report may suggest. For example, this report contains comparisons of the two candidate technologies from the following perspectives:

- Regulatory compliance
- Mechanical configuration
- Operational performance
- Energy and fuel consumption
- Exhaust emissions profile
- Proposer availability
- Capital cost

Details regarding the results of each of these comparisons can be found in Section 4 of this report; however, the key findings are summarized as follows:

- The FRA will be the regulator of the intended service. Vehicles must be either fully FRA-compliant (may run intermingled with freight) or meet an FRA-defined level of alternate-compliance (may only run under an agreed-upon temporal separation arrangement, and meet FRA mandated vehicle design requirements).

- Implementation of PTC (Positive Train Control) in the U.S. is not presently sufficient to allow the comingling of freight and alternate-compliant DMUs. It is noted that Caltrain is pursuing a ruling from the FRA that would permit co-mingling of compliant and alternate-compliant *passenger* vehicles, but freight would still remain temporally separated. A ruling to the effect that PTC *alone* would be sufficient to allowing co-mingling of freight and alternate-compliant vehicles, if granted by the FRA, would be many years in the offing, while SMART needs to firm up its technology decision by July of this year.

- Generally speaking, both vehicle types manifest a similar level of schedule performance (approximately 1.5 hours each way), but those vehicles in the alternate-compliant category achieve schedule performance with 41% less energy consumption and 37% less fuel consumption on a *per vehicle* basis; however, the proposed FRA-compliant vehicles will be larger than the proposed alternate-compliant vehicle. As such, an FRA-compliant DMU will provide about 50% greater passenger capacity, so the energy and fuel consumption *per seat* between the two te*chnologies i*s practically equivalent.

- The estimated per-unit cost of an FRA-compliant DMU for a small fleet would be about $8.5 million. The cost of an alternate-compliant DMU would be about $7 million.

- The time to deliver the first car for an FRA-compliant DMU would be about 32 months. The time to deliver the first alternate-compliant car would be about 26 months, although there is some possibility of delay beyond this 26 months if SMART's application for a Buy America waiver is not granted by the time Federal funding is required, and the FRA requires design modification to meet its definition of alternate-compliance, as was the case in Austin.

- Several manufacturers of potentially alternate-compliant, Tier 3 DMU designs were identified:

  — Alstom (2 applicable models)
  — Bombardier (3 applicable models)
  — Ansaldo Breda (1 applicable model)
  — Siemens (1 applicable model)
  — One alternate-compliant DMU manufacturer, Stadler, recently offered a Tier 4 compliant design[1]

- There are no FRA-compliant DMUs in production, although several manufacturers have produced conceptual designs for FRA-compliant DMUs. These manufacturers include:

  — Bombardier
  — CAF
  — Hyundai Rotem
  — Nippon Sharyo
  — Siemens
  — Brookville

[1] Earlier versions of this report indicated that no builder of alternate-compliant vehicles would offer SMART a vehicle meeting EPA Tier 4 emission requirements. Subsequent to the May 20 meeting of the SMART Board of Directors, staff re-surveyed the industry and asked manufacturers for Letters of Interest. At that time, Stadler responded that they will offer an alternate-compliant, Tier 4 vehicle in time to meet SMART's schedule. In further discussions with Stadler, they alleged that there had been miscommunication within the company regarding SMART's original inquiry. At that time, Stadler representatives had misunderstood SMART's timeline to be similar to that of the Denton County Transit Authority, for which Stadler is supplying DMUs by 2012. Because the company will not have Tier 4 vehicles available by that date for Denton, they responded to SMART's initial inquiry saying they could only provide Tier 3 vehicles to SMART. When the request for Letters of Interest went out in late May, Stadler realized its mistake and responded that it will be able to supply Tier 4 vehicles to meet SMART's startup schedule for 2014.

- EPA Tier 4 regulations go into effect on January 1, 2011. All engines manufactured after this date, with the exception of those which qualify under the *Transition Program for Equipment Manufacturers,* or TPEM (explained below), must be Tier 4 compliant. To date, we have only been able to identify one alternate-compliant carbuilder who will commit to proposing a Tier 4 compliant design; consequently, if SMART requires an alternate-compliant, Tier 4 design, there is a strong likelihood that there will only be one proposer, Stadler.

  There is an alternative approach to acquiring an alternate-compliant design (from an EPA-compliance perspective), but this approach is not without risk. As noted above, the EPA will allow diesel engine manufacturers to continue to manufacture Tier 3 engines until 2018 under the following conditions:

  — Tier 3 equipment users would have a number of reporting requirements to the EPA over the life of the engines

  — From 2011 until 2015, engine manufacturers may produce Tier 3 engines only as long as the quantity of Tier 3 engines produced is 50% or less of their total production run of engines in any given power range. Other uses in the DMU power range (300 kW) would be construction (cranes, bulldozers, dump trucks, etc.) and marine applications (ships, port facilities, etc.).

  — From 2015 until 2018, the production of *all* Tier 3 engines must be phased out. Given the lack of new Tier 3 engines available beyond 2018, SMART could employ a strategy wherein they purchased, say, two complete sets ("shelf life" would prohibit purchasing more than two sets) of Tier 3 engines for each car prior to the 2018 deadline, if the engines were available to purchase. Since the practical lifetime for these engines for the anticipated duty cycle would be no more than 5 years, a "spare engine strategy" could extend operations with Tier 3 equipment until (approximately) 2028, about the mid-point of the vehicle lifetime. At that point, SMART would have two choices:

    i. attempt to procure *rebuilt* Tier 3 engines in the requisite power range, should a market for same evolve, and should they be available; or,

    ii. commence a re-engineering and re-manufacturing program, using Tier 4 engines, and adding all the necessary ancillary components needed to meet the Tier 4 emissions requirements. This would include:

      – Increased cooling capacity
      – An SCR (catalytic) converter
      – Urea tank
      – Particulate filters
      – New, advanced controls

  Both approaches introduce a considerable amount of risk which cannot be mitigated at this time. A third possibility; i.e., that diesel engine technology in the mid-2020's will have advanced to the point wherein they will be Tier 4 compliant absent the need for selective catalyst reduction (SCR) and/or exhaust after treatments, also exists, but relying on this outcome introduces even more risk.

- The FTA's Buy America rules require that agencies using Federal funds for railcar purchases buy vehicles that have a minimum of 60% domestic content, and are assembled in the United States. Each of the potential FRA-compliant DMU manufacturers noted previously are presently meeting this requirement on other projects, and, if interested in the SMART vehicle procurement, could likely meet the requirement here as well. The potential alternate-compliant offerings, both Tier 3 and Tier 4, are all based on existing European designs, none of which are Buy America-compliant. To change an existing design to a Buy America-compliant design is a significant effort. No potential alternate-compliant DMU manufacturers willing to do this have been identified.

- Generally speaking, since FRA-compliant vehicles are designed to a higher longitudinal compression strength (800,000 lbs.) than typical alternate-compliant DMUs (300,000 to 400,000 lbs.), the compression load must be carried by linear structural members, known as center and side sills, through the length of the train. It would be difficult and costly to interrupt the linearity of these beams in a single-level DMU in order to provide a low (24") floor entry. Circumventing the FRA-mandated fuel tank design would also add complexity. As a consequence, FRA-compliant cars are designed to a high platform (51") floor height. This could require both architectural and right-of-way mitigation measures at some historic stations along the alignment.

- Interoperability with adjacent railways which are part of the "General Railway System of Transportation", such as Capitol Corridor and Napa County-based excursion trains, would be readily achievable with an FRA-compliant design, but not with an alternate-compliant design.

1.4 Conclusion

Generally speaking, an alternate-compliant car offers more operational efficiencies in comparison to an FRA-compliant design on a per vehicle basis. In order for SMART to be able to procure alternate-compliant rolling stock, however, the following must occur:

- SMART must come to an agreement with the present freight operator for temporal separation.

- The alternate-compliant DMU provider must be willing and able to meet FRA-defined conditions for alternate compliance. As we have found based on the experience in Austin, these requirements are still evolving and are, in part, project specific, resulting in change orders and delays.

- If Buy America provisions apply to this procurement, then SMART must petition the FTA for relief from this requirement. This could introduce program delay.

- SMART must be willing to construct and maintain its track to tighter tolerances than specified by the FRA class 4 track requirements. This would introduce additional cost.

- Interoperability would either be very difficult or impossible to attain.

On the other hand, if SMART were to solicit FRA-compliant rolling stock:

- No temporal separation agreement would be necessary, allowing SMART maximum operational flexibility as the service matures.
- The vehicle would be designed to be FRA-compliant, hence no waivers would be required.
- Acquiring a Buy America vehicle would not be an issue.
- Track Class 4 would be acceptable.

- Interoperability with other FRA-regulated services, such as Capitol Corridor, would not be an issue.

Although selecting FRA-compliant technology means sacrificing some efficiencies, it untangles many regulatory knots and would allow SMART to provide the voter-mandated commuter rail service on schedule, and unencumbered by the constraints of temporal separation allowing for uninterrupted service growth. All things considered, and based on the best information available to date, the recommended technology selection is for FRA-compliant DMUs.

2.0 FRA REGULATORY ISSUES

2.1 Background

The Federal Railroad Administration, or FRA, is a regulatory agency of the Federal Government, administratively part of the U.S. Department of Transportation. The FRA has some historical antecedents traceable to the early regulation of the railroad industry in the 19th Century, but the FRA in its present form was created with the establishment of the U.S. Department of Transportation in 1966. While it does have other functions, the primary purpose of the FRA (the one which makes it relevant to this study) is the development and enforcement of railroad safety regulations. Many of these regulations specify in some detail the physical design and method of operation of passenger equipment used on railroad lines.

The FRA issues regulations governing many aspects of railroad system design, construction and operation for all trains, freight and passenger, which are part of the “General Railroad System of Transportation”. Prominent among these are the regulations governing the safety of railroad passenger rolling stock, including DMUs. These regulations provide very rigid construction standards for passenger rolling stock. Rolling stock meeting these requirements is termed FRA-compliant. Application of these construction standards results in greater vehicle weight, surpassing that of alternate-compliant DMUs. Alternate-compliant DMUs use a different philosophical approach to achieving passenger safety. Though not as structurally “rigid” as FRA-compliant cars, alternate-compliant DMUs are typically designed to European crash-worthiness standards EN 12663 and EN 15227. Cars built to these standards are designed to absorb energy in an impact, rather than transmit impact energy through the structure. Also, typically, European DMUs are operated in an advanced-signal environment, the concept being more one of accident avoidance than accident survivability.

2.2 Scope of FRA Jurisdiction

A continuous topic of discussion is the nature of FRA jurisdiction relative to the jurisdiction of state agencies over rail transit safety. In very general terms, one can say that passenger services operated over “railroad” tracks, whether publicly or privately owned, fall under FRA jurisdiction. In contrast, safety regulations of “rail transit” systems, such as light rail or rapid transit (e.g. MUNI or BART) is left to the states. Specific oversight varies from state-to-state, but in California, the agency responsible for rail *transit* safety is the California Public Utilities Commission (CPUC).

This would seem relatively straightforward, but there are occasions upon which the distinction is blurred. In these cases, one key criterion is whether or not the tracks are part of the “General Railroad System of Transportation”. Absence of a track connection to the general railroad system does not in and of itself affirm that FRA lacks jurisdiction, but the presence of a connection, and the operation of the line as part of that system, as shown by the presence of through freight traffic, assures the validity of FRA jurisdiction.

These matters have become an issue in cases where there has been a desire to introduce alternate-compliant DMU vehicles onto tracks that are used at some point by freight trains. The FRA has made it clear that it retains jurisdiction in such cases, but that waivers from some requirements may be granted under proper conditions, of which the key provision is an absence of simultaneous, co-mingled operation of FRA-compliant “railroad” equipment and alternate-compliant “rail transit” equipment.

2.3 Temporal Separation

Trains operating in an FRA regulatory environment must comply with all FRA requirements. FRA regulations can be found in a larger body of Federal rules known as the “Code of Federal Regulations.” The Code of Federal Regulations, also known as “the Code” or “CFR”, is “…a codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the Federal Government. The Code is divided into 50 titles which represent broad areas subject to Federal regulation. Each title is divided into chapters which usually bear the name of the issuing agency. Each chapter is further subdivided into parts covering specific regulatory areas.” Title 49 of the Code of Federal Regulations addresses Transportation. Parts 200 through 299 of Title 49, published in a 900-page volume, contain the regulations of the Federal Railroad Administration. References in this study, formatted as “49CFR209” for example, refer to these regulations and their part and subparts specifically.

With regard to vehicles, the FRA requires that all rolling stock operating in an FRA-regulated environment must be designed and built to certain standards, as given in the 49CFR document.

That section of 49CFR which bears directly on the crux of the SMART DMU feasibility question is 49CFR238: “Passenger Equipment Safety Standards” or “Part 238” for short. Subpart C of this section, dealing with “Specific Requirements for Tier I Passenger Equipment”, comprising subsections 221 through 237, incorporates requirements for equipment, including DMUs operating at less than 125 mph (Tier 1) on segments of the “General Railroad System of Transportation”, which would include the entirety of the SMART alignment. Key provisions of this subsection, which, typically, are not met by alternate-compliant DMUs, include:

- Subsection 238.203, “Static End Strength,” which requires that vehicles “…resist a static end load of 800,000 pounds without permanent deformation…”

- Subsection 238.205, “Anti-Climbing Mechanism,” which requires anti-climbers at both ends “…capable of resisting an upward or downward vertical force of 100,000 pounds without failure.”

- Subsection 238.211, “Collision Posts,” which requires collision points at the one-third points of vehicle width, laterally, with an “…ultimate longitudinal shear strength of 300,000 pounds…”

- Subsection 238.213, “Corner Posts” which requires full-height corner posts “capable of resisting 150,000 pounds at the point of attachment to the underframe without failure.”

- Subsection 238.223, “Locomotive Fuel Tanks,” specifies fuel tank construction standards typical of mainline locomotives, but also applying to DMUs.

Under certain circumstances, however, the FRA will allow “alternate compliance”; that is, compliance to an alternate set of vehicle design standards. In order to be allowed alternate compliance, both the passenger operating agency and the freight railroad sharing the alignment must reach a temporal separation agreement, wherein the freight and passenger trains are each given a dedicated window in time in which they operate exclusively. These windows are separated by smaller, “buffer” windows, to insure that there will be no overlap in freight and passenger operations. The FRA must grant a waiver from full compliance in order for the passenger agency to operate under alternate compliance rules.

Since its initial application to electrified LRT systems using shared track, the FRA waiver process has been extended to projects planning to use the same tracks both for alternate-compliant DMU trains and "heavy" freight trains. The first of these projects, New Jersey Transit's 34-mile RiverLine linking Camden and Trenton, opened in 2004. Vehicles built to European railway structural requirements, enhanced by front-end designs applying crash energy management principles, initially had access to the shared portion of the route, about 32 miles, from 6:00 AM until 10:00 PM, when the shared section had to be vacated to allow for overnight freight operations (temporal separation). In the years since, with a process analogous to that in San Diego, which led to modifications of the rigid separation of the two services, NJT, Conrail (the freight operator) and FRA have agreed to a series of adjustments that have maintained the freight time window, while allowing a very limited expansion of the DMU passenger service. These adjustments are highlighted in Table 1 below, which also lists two additional DMU lines: the 22-mile *Sprinter* between Oceanside and Escondido in northern San Diego County (nearing its first anniversary) and Capital Metro's 32-mile *Metrorail* line, expected to begin serving Austin, TX sometime in mid-2009.

Year	Property	State	Transit	Dispatch Control	Synopsis of Waiver's Effect
2004	NJ Transit RiverLine	NJ	DMU	Transit	Day/evening DMU; late night freight (contract freight operator)
2004	NJ Transit RiverLine	NJ	DMU	Transit	Above modified to allow early AM DMU north of Florence, w/freight to south
2005	NJ Transit RiverLine	NJ	DMU	Transit	Add early AM service Cinnaminson-Camden
2006	NJ Transit RiverLine	NJ	DMU	Transit	Extend last northbound trip from 26th St to Pennsauken/Rte 73 Park-Ride
2006	NJ Transit RiverLine	NJ	DMU	Transit	Early AM & late PM service, Burlington to Camden & Trenton
2007	NJ Transit RiverLine	NJ	DMU	Transit	Modified track/signals to support expanded late evening DMUs north to Pennsauken/ Rte 73
2008	NCTD Sprinter	CA	DMU	Transit	Day/evening DMU; late night freight (contract freight operator)
2009	Capital Metro Rail	TX	DMU	Transit	Day/evening DMU; late night freight (contract freight operator)

Table 1: Synopsis of "Alternate-Compliant" DMU Shared Track Operation

2.4 The Caltrain Situation

Possible *simultaneous* use of tracks by FRA-compliant trains and those alternate-compliant DMUs under consideration in this study is an issue that arises repeatedly across the United States. Recent studies are now underway with the intent of examining the possibility of establishing alternative approaches to safety, while permitting more flexible employment of technologies new to this country. It will likely be some time (years) before we see any significant changes in the FRA's regulatory framework, however.

One property where the study of new technological approaches is under way is in the Bay Area at Caltrain. Caltrain is the marketing label applied to the regional rail service operated between San Francisco, San Jose and Gilroy by the Peninsula Corridor Joint Powers Board, an agency formed through a joint exercise of powers agreement of San Francisco, San Mateo and Santa Clara Counties. Under contract to the JPB, the San Mateo County Transit District provides administrative services and contract oversight. Formerly the Southern Pacific Peninsula Commuter Service, Caltrain has been significantly upgraded, and its popular "Baby Bullet" trains provide the Bay Area's fastest scheduled transit service.

The Caltrain Corridor has been selected as the route for High Speed Rail to enter San Francisco. For this reason, and to accommodate faster, more frequent service, Caltrain is investigating the possibility of a phased conversion into an electrified regional rail service, using

European-standard double-deck electric multiple unit (EMU) trains, consistent with California High Speed Rail equipment.

If ultimately permitted, this would allow Caltrain to use rail vehicles that would not be compliant with current FRA regulations, substituting international crashworthiness standards for same. Freight service, currently minimal on the Peninsula, would be restricted to early morning hours through temporal separation. This is essentially the present type and level of service. Some FRA-compliant passenger service might be retained in this concept, however, through the retention of diesel-powered Altamont Commuter Express (ACE) commuter trains and Amtrak service on the short shared segment between Santa Clara and San Jose; and, possibly, the reintroduction of passenger service between San Francisco, San Jose and Monterey Bay points (Monterey and Santa Cruz).

The potential co-mingling of FRA-compliant passenger trains and alternate-compliant passenger trains on the Caltrain alignment has led to a detailed technical study involving both Caltrain and the Federal Railroad Administration. The FRA presently approaches safety through requirements for conventional signals, and, based on the assumption that accidents will occur through some failure of (or failure to observe) the signal system, also requires a massive approach to construction for collision-survival. In the Caltrain concept, the proposed approach is somewhat different: Caltrain is proposing an advanced train movement system in concert with a Crash Energy Management (CEM) vehicle structure design that could provide passenger survivability equal to or better than that provided by current FRA construction requirements. Temporal separation would still apply to freight, but, as noted, the co-mingling of both FRA compliant and non-compliant passenger trains is also being considered.

A preliminary detailed CEM evaluation of a candidate Electric Multiple Unit (EMU) has demonstrated (via calculation) crashworthiness protection equivalent or better to that provided by conventional FRA construction regulations, although a final decision by the FRA to fully sanction this concept, implement new rulemaking through the comprehensive federal procedures, conduct a trial installation and test period, determine whether or not full grade-separation may be required and whether FRA-compliant passenger trains might be permitted is *far* from completion. If SMART intends to commence design of its selected-technology DMU by mid-summer of 2009, there is no chance that the Caltrain study will be completed in time to be used as a precedent to justify the introduction of alternate-compliant DMU equipment absent the need for temporal separation. Benefit may eventually be derived from the Caltrain work, but it appears that it will be useful only in the longer term.

3.0 ADA: LEVEL BOARDING IMPLICATIONS

3.1 ADA Level Boarding Requirements

Design and operating requirements for new and renovated facilities and public transportation vehicles are contained in several parts of the Code of Federal Regulations (CFR), including:

- 36 CFR Ch. XI, Part 1192 – ADA Accessibility Guidelines for Transportation Vehicles
- 49 CFR Subtitle A, Parts 37 – Transportation Services For Individuals With Disabilities (ADA) and 38 – ADA Accessibility Specifications for Transportation Vehicles

Section 37.1 sets the standard for newly constructed public transportation facilities, which must be "readily accessible to, and usable by, individuals with disabilities, including individuals who use wheelchairs." In regard to the correlation of railroad passenger car entries and station platforms, often referred to as the "car/platform gap," Section 38.113 of 49 CFR is specific in its requirements:

TITLE 49—TRANSPORTATION, Subtitle A--Office of the Secretary of Transportation, PART 38_AMERICANS WITH DISABILITIES ACT (ADA) ACCESSIBILITY SPECIFICATIONS FOR TRANSPORTATION VEHICLES, Subpart F_Intercity Rail Cars and Systems

Sec. 38.113 Doorways.

(d) Coordination with boarding platforms--(1) Requirements. Cars which provide level-boarding in stations with high platforms shall be coordinated with the boarding platform or mini-high platform design such that the horizontal gap between a car at rest and the platform shall be no greater than 3 inches and the height of the car floor shall be within plus or minus 5/8 inch of the platform height. Vertical alignment may be accomplished by car air suspension, platform lifts or other devices, or any combination.

(2) Exception. New cars operating in existing stations may have a floor height within plus or minus 1-1/2 (1.5) inches of the platform height.

(3) Exception. Where platform set-backs do not allow the horizontal gap or vertical alignment specified in paragraph (d) (1) or (2), platform or portable lifts complying with Sec. 38.125(b) of this part, or car or platform bridge plates, complying with Sec. 38.125(c) of this part, may be provided.

(4) Exception. Retrofitted vehicles shall be coordinated with the platform in existing stations such that the horizontal gap shall be no greater than 4 inches and the height of the vehicle floor, under 50% passenger load, shall be within plus or minus 2 inches of the platform height.

3.2 Level Boarding Alternatives

Similar requirements apply for FRA-compliant and alternate-compliant vehicles. In both cases, new FTA/FRA rules require that all doors be ADA accessible, ruling out mini-high platforms or wheelchair lifts. If FRA-compliant passenger cars are selected for the SMART application, entries will be 51" above the rail, and station platform edges can be no closer than 8 feet to the track centerline. If alternate-compliant cars are selected with entries approximately 24" above the rail, station platform edges can be no closer than 7' 6" to the track centerline. It is these dimensions that led to the installation of yellow movable platform bridgeplates at the *Sprinter* DMU stations in northern San Diego County. These devices rotate through 90 degrees from vertical to horizontal, and require trains to stop with sufficient precision that doors always align with the bridgeplates. Because temporal separation is used, freight trains run only at night when *Sprinter* is not operating, so the bridgeplates only need to be moved twice a day; that is, lowered at the end of the *Sprinter* service day, and raised after the freight train has cleared the line early the next morning.

Sprinter **Platform Bridgeplate –**
raised for nighttime freight operation

WES **Platform with Gauntlet Track**

A similar State of Oregon platform clearance requirement was met by using gauntlet tracks at stations on tracks shared by new *Westside Express (WES)* DMUs and freight trains. The gauntlet approach uses a set of controlled switch points at each end of the station area to divert stopping passenger trains to the high-level platform, while switching freight and non-stopping passenger trains to the main tracks, with safe side clearances provided as mandated by the applicable state laws. This solution adds track and signal (switch interlocking) costs to the project, but these are proven components of railroad hardware and electronics, so pose little technical risk and preclude the need for movable components as part of the station platforms. This is critical to *WES,* because the system is designed to allow intermingled passenger and freight train operations so that the freight operator can maintain competitive service to its customers. In this operating environment, multiple daily raisings and lowering of bridgeplates would have been a riskier and more cumbersome solution due to the following:

- Potential for failure of bridgeplates
- High maintenance due to frequent use
- Potential for a bridgeplate inadvertently left lowered to be struck by a freight train

It is safe to assume that SMART will need to be designed to accommodate “full level boarding” (all doors, all cars, ADA-compliant car/platform gap or bridgeplates), and that SMART’s station platforms will be higher than 8” above the rail. Thus, the system will fall under the requirements of CPUC G.O. 26-D, Sections 3.4 and 3.5 (even if the FRA is SMART’s regulator), and boarding platforms will have to be set back from the main track.

It should be further acknowledged that NCRA, and its designated freight train contractor, NWP Company, have asserted their preference for 24/7 freight train access to the SMART rail line. Even if temporal separation of SMART passenger and NWP freight trains is adopted as service begins, the eventuality of future mixed freight and passenger operation should be recognized, and facilities should be designed and built with this contingency in mind.

These factors, taken in concert, suggest the following design guidelines for SMART:

- Platform and car floor height should be the same height above rail, to enable ADA-compliant level boarding
- CPUC General Order 26-D platform clearance standards must be met
- Technical, maintenance and operating risks should be minimized

The following table summarizes the characteristics of the two car/platform gap approaches reviewed above (bridgeplates; gauntlet tracks) that permit level boarding while meeting G.O. 26-D clearances:

ACCESSIBILITY APPROACH	MOVABLE BRIDGEPLATES	GAUNTLET TRACKS
Existing Revenue Service	NCTD *Sprinter*	TriMet *WES*
Special or Standard Design	Specially designed for *Sprinter*	Standard hardware used by other rail applications worldwide
DMU/Freight Temporal Separation	Yes	No
Frequency of Use	Daily; lowered once and raised once	Used by every *WES* Train
Requires interlocked switch at each end of each equipped station	No	Yes
Track Edge of Platform Fenced	Yes; except at bridgeplates when lowered	No
Other Issues	Trash occasionally fouls operating mechanism	Interlockings part of signal system

Table 2: Summary of Characteristics: Movable Bridgeplates and Gauntlet Tracks

Based on the foregoing, it is concluded that the gauntlet track option better represents proven technology suitable for use on a rail line that, either initially or eventually, is likely to host simultaneous passenger and freight train operations. Pending further analysis as the vehicle identification and selection process proceeds, it is tentatively recommended that SMART design proceed on the basis that *gauntlet tracks* be installed at each station platform located on a track that will be shared by passenger and freight trains.

High Level Platform for Portland's WES DMU Service

Passengers Boarding a WES Train

3.3 Low Level Platforms

Low level, 8” high platforms cannot be used along the SMART alignment. No DMU is equipped to provide level boarding at this height. Also, none of the FRA-compliant or alternate-compliant vehicles are designed to accommodate wheelchair lifts; hence, this eliminates stairwells as a passenger boarding option.

4.0 VEHICLE TYPE COMPARISON

4.1 Introduction

As noted in the Executive Summary of this report, the purpose of this study is to make an assessment as to which technology, FRA-compliant or alternative-compliant, would best suit the SMART application from a variety of perspectives. In order to develop a genuinely meaningful basis for comparison, a number of parameters for each of the two candidate vehicle types were investigated. These parameters include the following:

- Regulatory Compliances
- Mechanical Parameters
- Operational Parameters
- Environmental Parameters
- Procurement Factors
- Diesel Fuel Consumption
- Emissions (Tier 3)
- Emissions (Tier 4)

Results from investigations in each of the above categories are summarized in the following tables: Table 3, **Vehicle Type Comparison,** and Table 4, **Operations Simulations**.

	ALTERNATE-COMPLIANT DMU	FRA-COMPLIANT DMU	SMART PREFERENCE
REGULATORY COMPLIANCES			
FRA	Requires "Alternate" FRA compliance with waivers	Fully FRA-compliant	To be decided
CPUC	GO 143B	No	To be decided
ADA	Comply	Comply	Comply
Crashworthiness	EN12663 & EN 15227	FRA	EN standards preferred, but not required
MECHANICAL PARAMETERS			
Standards	US and/or European	US	Depends on vehicle
Configuration (per unit)	Articulated	Married-pair	No preference
Seats	~100	150 → 170	To be decided
Required buff strength	340,000 lbs.	800,000 lbs.	Depends on vehicle
Weight (empty)	150,000 to 160,000 lbs	300,000 to 320,000 lbs.	Lower weight
Average axle load AW2	~40,000 lbs.	~ 50,000 lbs.	Lower axle load
Length	130 → 140 feet	150 → 170 feet	< 150 feet per unit (station length limits)
Width	9.7 feet	10 feet	To be decided
Floor height	~ 24"	51"	Low floor preferred
Carbody	Aluminum	Stainless Steel	No preference
Maximum speed	75 mph	79 mph	>= 75 mph
Track classification required	5 (maximum vertical deviations controlled to 6)	4	To be decided. Lower for cost; higher for ride quality
Powered axles	2 or 4 out of 6	4 out of 8	No preference
Propulsion	Diesel-electric or hydraulic	Diesel-electric or hydraulic	Diesel-electric preferred
Engines per unit	2	2 - 4	2
Typical total engine power	600 kW	1300 kW	Less required power preferred (assuming no impact to schedule)

	ALTERNATE-COMPLIANT DMU	FRA-COMPLIANT DMU	SMART PREFERENCE
OPERATIONAL PARAMETERS			
One way trip at AW2	1:28 hrs	1:30 hrs	N/A
Vehicles needed for service	13	11	As required
Level boarding platform height	24”	51”	Low platform preferred
Minimum platform gap	Bridge plates and gauntlet track, or movable platform edges	Bridge plates and gauntlet track, or movable platform edges	Gauntlet tracks
Deployment restrictions	Temporal separation, even with PTC	None	To be decided
ENVIRONMENTAL PARAMETERS			
Emission compliance	EPA Tier 4	EPA Tier 4	EPA Tier 4
Typical exterior moving noise emissions at 100 feet	Typical as measured: Less than 75 dBA	FRA regulation: Less than 90 dBA	Less than 75 dBA
PROCUREMENT FACTORS			
Service History	In service in Europe and US	Design studies	Service proven
Critical path	Adaptation of existing designs to EPA Tier 4 compliance and receipt of required waivers.	New vehicle design	N/A
Estimated delivery time NTP to delivery of 1st vehicle	26 months[1)]	32 months	26 months
Estimated costs per vehicle	$7M	$8.5M	Lower cost

[1)] Does not consider the time needed for a Buy America waiver

Table 3: Vehicle Type Comparison

	Stadler DMU CapMet, Austin	CRM DMU TriMet, Washington County	Estimated SMART FRA-Compliant DMU
DIESEL FUEL CONSUMPTION			
Vehicle configuration	6 axles articulated	4 axles single DMU	8 axle married-pair
AW2 passenger load	200	150	300
Estimated round trip time at vehicle weight AW2	3:00 hrs	2:56 hrs	3:04 hrs
Max. energy consumption	8.2 kW/h per mile	9.2 kW/h per mile	14 kW/h per mile
Total fuel consumption*	79.5 gallons	90.2 gallons	126 gallons
Gallons per mile	0.57	0.65	0.9
Miles per gallon	1.75 mpg	1.54 mpg	1.10 mpg
EMISSIONS			
CO	3,999 grams	4,887 grams	6,825 grams
PM2.5	11 grams	282 grams	20 grams
NOx+ NMHC	688 grams	5,638 grams	1,175 grams

Note: All values are applicable for one round trip between Larkspur and Cloverdale

Table 4: Operations Simulations

4.2 Regulatory Compliances

FRA-compliant cars will have no regulatory issues since they are, by definition, compliant with FRA regulations. The selection of an alternate-compliant design, however, could be problematic from a regulatory perspective in that, as we have found in Austin, Texas, there is no clear-cut FRA definition of “alternate compliance.” In Austin’s case, the definition of alternate compliance was a work in progress, necessitating a fairly continuous dialogue between Capital Metro (Austin's operator) and the FRA. .

4.3 Mechanical Parameters

Generally speaking, the investigation of the mechanical properties of the two different DMU technologies has produced results consistent with expectations; that is, the FRA-compliant design is heavier and structurally more rigid than the alternate-compliant design. This is a direct result of the two different regulatory environments the vehicles were designed to operate in. It should be noted that single-level FRA-compliant vehicles typically have a floor height of approximately 51". A 51" floor height is needed to accommodate the trucks, drawbar and coupler gear at the ends of the car. Alternate-compliant cars can drop the floor height to approximately 24" inside of the trucks, but it is difficult to do this with an FRA-compliant single-level vehicle design in that the load path from coupler-to-coupler is best kept linear (no turns or drops) to more easily develop the FRA requisite 800,000 lbs. buff strength, and to avoid intersection with the fuel tank designed and constructed to FRA standards, which consumes a significant amount of undercar space. It is for this reason, plus market considerations (level boarding is vastly preferred over stairwells), that carbuilders prefer not to provide stairwells and lifts, although some said they could be provided if required. Additionally, although low-floor (24") *double-deck*, FRA-compliant vehicles (non-powered coaches) have been designed, it is unlikely that any of those carbuilders proposing FRA-compliant DMUs would be interested in providing either a powered low floor double-deck or low-floor single-level design for a relatively small order. It must be realized that the carbuilders interested in proposing an FRA-compliant design to SMART will be leveraging this opportunity to develop a prototype for future (non-SMART) market sales. The market they are targeting is for single-level, high-platform DMUs, for applications throughout the U.S.

The fact that FRA-compliant DMUs are two times as heavy as alternate-compliant DMUs is evidenced by the fact that the Colorado Railcar DMU used in our computer simulation requires approximately 1300 kW of engine power, while the Stadler GTW alternate-compliant design requires only 600 kW.

Another difference between the two candidate designs is in the configuration and length of a standard operating unit. FRA-compliant vehicles are typically configured as "married-pairs"; that is, two cars, with two trucks each, semi-permanently coupled together. Most manufacturers have indicated that the cars of the married pair will be provided in a standard U.S. passenger rail car length of 85 feet (170 feet for the married pair). Manufacturers have also indicated that they can add a third car to the center of the married pair, making it into a "triplet". This center car could be configured without operator cabs. Passengers may pass through the couplings of the cars within the married pair or triplet. Cars in a married-pair configuration can also be operated independently, but they only have the operator's cab on one end. Although there are many advantages to this arrangement, one disadvantage is that the length of a married-pair could exceed 150 feet as noted above. A two-unit train ("consist") would then exceed 300 feet in length, longer than SMART's desired maximum platform length. Triplets, however, would only be 255 feet in length.

Alternate-compliant DMUs are typically configured as articulated units; that is, two passenger-carrying compartments with a center section acting as a "hinge" for the two passenger sections. Typically, one truck is located directly under the center articulation, with an additional truck located at each of the two non-articulated ends of each passenger section. Alternate-compliant DMU units are less than 150 feet in length, so that a two-unit consist would be less than 300 feet in length.

A final parameter of significance in this category for each of the two candidate technologies is "track classification". The classification of a track defines the amount of discreetly-sized deviations, both vertical and horizontal, permitted in a specified length of track. The lower the classification number, the more deviations are permitted. The higher the classification number, the more comfortable the ride and the greater the permissible speed.

Track classification numbers in Europe are typically higher than they are in the United States, in that the percent of *passenger* rail traffic as compared to all rail traffic is significantly higher than in the U.S. It should be noted that European freight trains are much lighter than in the United States. This is reflected in lower axle loads and shorter trains. This makes it easier to maintain to higher track classifications. Additionally, Europeans have invested in a rail network of "very high speed" ("Train à Grande Vitesse" or TGV) passenger trains. Such operations command a higher track classification, and the trucks for European alternate-compliant DMUs are designed to be consistent with these classifications. As an example, the Oceanside-Escondido rail line was built to a Class 5 and is only maintained to a Class 4. The trucks on the Siemens' Desiro had to be completely redesigned to accommodate this lower track classification. It is also noted that speed on the Sprinter Line is limited to 55 mph, for a vehicle operated at 75 mph in Europe. According to New Jersey Transit, they maintain their track on the River Line to Class 5, and operate at up to 65 mph.

In the United States freight traffic dominates our rail network. Since passenger comfort is of little concern in freight operations, track classifications are kept low to save money. Moreover, it is difficult to maintain high track classifications under U.S. freight traffic, due to the reduced emphasis on freight vehicle (wheel) maintenance, and the generally high weight of locomotives. It is for this reason that FRA-compliant rolling stock (including DMUs) is designed to accommodate lower track classifications, resulting in a softer, "springy" suspension.

4.4 Operational Parameters

In order to calculate certain operational parameters, such as run time and fleet size, it was necessary to construct an operational (computer) model of the system, using actual DMU performance characteristics (acceleration performance, braking rates, etc.) and the actual SMART alignment and service parameters (length, grade, curves, civil speed restrictions, station locations, headway, etc.). Two versions of Colorado Railcar DMU were used to simulate an FRA-compliant operation. The first simulation was done with a single DMU and the second one was done with a DMU and a coach to simulate a married-pair configuration, which will be the most likely FRA-compliant DMU arrangement proposed to SMART. For the alternate-compliant DMU simulation, the Capital Metro (Austin) DMU was modeled. All passenger loads were taken as an AW2 load, which is defined as all seats occupied and similar number of passengers standing. The results indicated that both the FRA-compliant and the alternate-compliant designs can travel the length of the alignment (one way) in about 1.5 hours. When the greater capacity of the married pairs is taken into account and the service plans are adjusted accordingly, this translates to a fleet of 13 alternate-compliant cars or 11 FRA married-pairs estimated to be required for SMART's system[2].

4.5 Energy and Fuel Consumption

In addition to the operations simulation described above, a second computer model of the system was constructed. This model was used in a different simulation program — one designed to produce more "technical" outputs, such as energy consumption and emissions generation. As in the operations study, real values for FRA-compliant (CRM) and alternate-

[2] A previous estimate, developed prior to more detailed modeling, indicated approximately 14 cars for each vehicle type.

compliant (Stadler GTW) DMUs were used, as well as actual SMART alignment parameters. Summary level results of this simulation were as follows:

- Energy consumption for an FRA-compliant married-pair DMU as proposed by carbuilders for SMART was 14 kWh per mile. For a single car FRA-compliant DMU (CRM), it was 9.2 kWh, while the energy expended by the alternate-compliant DMU was 8.2 kWh, about 32% lower than for a married-pair, FRA-compliant DMU.

- Total diesel fuel consumed for the FRA-compliant, married-pair SMART DMU was 126 gallons per round trip, whereas the alternate-compliant vehicle used 79.5 gallons over the same distance, about 37% less fuel. Factoring in the distance, this equates to 1.10 miles per gallon (mpg) for the FRA-compliant, married-pair SMART DMU, and 1.75 mpg for the alternate-compliant design.

4.6 Emissions

Emissions were calculated at both Tier 3 and Tier 4 levels for all candidate technologies by using the computer simulation program. Tier 3 results are not included now in this revised report since, carbuilders for both vehicle types now indicate that they will propose Tier 4 compliant engines. Although the computer model doesn't directly output engine-specific emissions levels, it assumes that the diesel engines are EPA compliant and calculates the worst case (maximum EPA allowable) emissions based on the fuel consumed and the relevant tier level. The maximum EPA-allowable emissions are used in that it is extremely difficult to obtain a precise emissions profile from the diesel engine manufacturers. Typically, the only information made available to the public is that the engines are “compliant”. It should also be noted that the emissions results given in this report are conservative, in that engine manufacturers will generally tailor exhaust output to minimize a specific pollutant, so long as the other emissions are contained within the appropriate tier limits. Consequently, the actual emissions levels should be no greater than the emission levels predicted in this report, and possibly less. The emissions considered in this report are as follows:

CO:	Carbon Monoxide
PM10:	Particulate Matter (coarse)
NOx + NMHC:	Nitrogen Oxide plus Non-Methane Hydrocarbons

In that the emissions produced are generally proportional to the fuel consumed, the ratio of pollutants emitted by the FRA-compliant DMU vs. the alternate-compliant DMU will be in the same rough proportion as the fuel consumed by each vehicle. For a typical round trip, the alternate-compliant DMU will have a carbon foot print (carbon dioxide) which is 66% of that for an FRA-compliant, married-pair DMU. Because of the higher capacity of the FRA-compliant married pair, however the carbon foot prints are virtually the same when calculated on a per seat basis.

The difference between the level of emissions between Tier 3 and Tier 4 is more dramatic. The NOx + NMHC emissions are reduced by 85% from Tier 3 to Tier 4, while the particulate matter (PM) emissions are reduced by 95%. Moreover, Tier 4 regulations require that all “coarse” (PM10) particulate matter emissions be filtered out, allowing only a very small amount of “fine” (PM2.5) particulate matter emissions in the exhaust.

4.7 Availability of Proposers

No FRA-compliant DMUs are currently in production. Since FRA compliance is strictly an American standard, there is no demand outside of the United States for cars of this design. Additionally, DMUs designed to FRA standards are not attractive transportation solutions in the world market. Typically, DMUs built to FRA requirements are heavier, and costlier, per vehicle, than alternate-compliant designs. Offshore properties prefer the lighter and less costly alternate-compliant DMUs found in Europe and elsewhere. Regardless, some DMU manufacturers see a niche FRA-compliant market emerging in the United States, and have expressed interest in SMART's comparably small order. Three carbuilders who have expressed a fairly strong interest in providing an FRA-compliant DMU are Siemens (USA), Nippon Sharyo (Japan), and Brookville (USA). CAF (Spain) has expressed moderate interest, and Hyundai Rotem (Korea) has expressed a mild interest, as has Bombardier (Canada), but it is not anticipated that either Hyundai Rotem or Bombardier would be willing to propose on a small 11 car fleet.

There are an abundance of alternate-compliant DMUs available in the marketplace, but there are engineering (alternate FRA compliance), environmental (Tier 4), and commercial (Buy America) constraints associated with this procurement which have *significantly* reduced (probably to one) the number of candidate alternate-compliant DMU suppliers who would be willing to propose to SMART. Although achieving a temporal separation agreement would most likely allow SMART to obtain a waiver from the most restrictive FRA vehicle design requirement; that is; the mandated 800,000 lb. compression end strength, there are a number of other FRA engineering design requirements which would force alternate-compliant suppliers to change or modify a portion of their designs. These would include:

- Requirements for corner posts (structural)
- Requirements for collision posts (structural)
- Requirements for anti-climbers (structural)
- Fuel tank requirements (structural)
- Window glazing requirements
- Flammability and toxicity (could necessitate major wiring and interior changes)

In addition unless SMART were willing to construct and maintain track to the levels required by alternate-compliant vehicles designs, the trucks would have to be re-designed and/or the maximum allowable line speed lowered.

Buy America requires 60% American components in the design, plus U.S. assembly of all but the pilot car in the fleet. Again, starting from a clean sheet of paper, it would be possible for the potential FRA-compliant DMU manufacturers to meet this requirement. Not so for the alternate-compliant manufacturers; to change their existing DMU platforms to incorporate 60% American components would necessitate accommodating new subsystem outputs, dimensions, weights, etc. To modify existing designs to such an extent for SMART's small order would not make good business sense. Based on conversations with the alternate-compliant carbuilding community, none are willing to provide a Buy-America compliant design.

4.8 Vehicle Cost

The cost of an FRA-compliant car, for an order size of 11 cars, is estimated to be $8.5 million. This estimate is based on the most recent cost of a Colorado Railcar DMU (no longer available), plus the one-time non-recurring costs (engineering, tooling, production set-up, administration) associated with a new product line.

The estimated cost for an alternate-compliant DMU is $7 million. This is based on recent bid prices plus escalation.

4.9 Delivery Time

Since no detailed design presently exists for an FRA-compliant DMU, it is anticipated that the time from NTP to delivery of the first car would be about 32 months. The candidate FRA-compliant manufacturers generally agree with this estimate, but there is always some risk associated with a new design; it could take longer.

Alternate-compliant designs are mature, and tooling already built (12 to 13 design-specific tools are typical for alternate-compliant vehicles). It is estimated that that the time from NTP to delivery of the first alternate-compliant car would take approximately 26 months, unless the process is delayed by SMART's petition for relief from Buy America, and the (likely) need to modify the design to achieve FRA District 9's definition of alternate-compliance.

5.0 CONCLUSIONS

Although alternate-compliance offers select technological advantages, such as reduced fuel consumption per vehicle, a smaller carbon footprint and a potentially smoother ride (but only at the expense of constructing and maintaining a higher track classification), the balance of the evaluation factors favor the selection of FRA-compliant technology for the SMART application. This conclusion is based, for the most part, on the following considerations:

5.1 FRA Vehicle Design Requirements

The FRA has a number of highly-specific, severe design requirements for vehicles operating within the General Railway System. FRA-compliant DMUs will meet all of these requirements, while most European DMUs meet none of them. An alternate set of design standards are allowed ("alternate-compliance") if temporal separation is implemented. While it is possible for some European DMU builders to meet these alternate requirements, it is no simple matter to do so. For example, the Austin car had undergone a number of design changes in order to meet FRA-mandated vehicle safety standards. After at least a year of testing and modification, the fleet finally is in simulated revenue service. SMART's car order is only for 11-13 cars. It will be difficult to interest the alternate-compliant carbuilders to bid on an order this size given the number of design modifications the FRA is likely to insist on, even if the operating environment includes both temporal separation and positive train control.

5.2 Buy America Compliance

Buy America regulations require that rail vehicles purchased by agencies using Federal funds have a minimum of 60% domestic content, and that all but the first car be assembled in the United States. As indicated previously, this will not be a problem for those carbuilders proposing to supply FRA-compliant cars, but it constitutes a major issue for carbuilders with existing alternate-compliant designs. To change a design from non-Buy America compliant to Buy America compliant would be too extensive an effort to consider for an 11-13 car order. If other decision factors point towards a recommendation for alternate-compliant technology, then SMART will have to pursue a waiver from the Buy America requirements. In all likelihood, SMART staff will have to wait until it is evident that all responders to the RFP have taken exception to the Buy America provisions before they can petition the FTA for relief. If the waiver process can be conducted in parallel with the design and construction of the first car, that is, if SMART can obtain a Letter of No Prejudice in this regard, then there would probably be no delay. This approach is not without risk, however; if the waiver is denied (unlikely, but possible), then SMART would have two choices:

(1) Forego federal funding; or,

(2) Terminate the vehicle contract, pay the appropriate penalties, and re-advertise for an FRA-compliant car. This will add cost and introduce delay to the program.

Alternatively, SMART can petition the FTA for relief from Buy America *before* executing a contact with the alternate-compliant carbuilder, but this will be cause for delay, and, possibly, increased costs if the delay becomes lengthy.

5.3 Track Classification

European alternate-compliant DMUs are designed to run on rail networks with a relatively high track classification. The primary reason for this is that European railways are, for the most part, fast (>79 mph) and passenger-intensive as opposed to freight-intensive. Additionally, there is a large high-speed rail network throughout Europe. Taken in combination, these factors lead to

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the need to construct and maintain the European rail infrastructure at a relatively high track classification which leads, in turn, to a high ride quality. In the United States, however, heavy freight dominates over rail passenger traffic. Since it is difficult (and expensive) to maintain track subject to heavy freight traffic to the higher track classifications, American railroads are typically operated at lower speeds and maintained to a Class 3, or, less likely, Class 4. FRA-compliant DMUs, which run exclusively on American railroads (the FRA only has jurisdiction in the United States), will be designed to accommodate the lower track classification. If SMART's policy is to maintain their trackage to Class 4, this will not be a problem for FRA-compliant DMUs. If, however, SMART selects alternate-compliant technology, they may have to construct and maintain their track to some deviations similar to Class 6 (vertical deviations, for example). This will introduce additional cost.

5.4 Temporal Separation

FRA-compliant vehicles are permitted to operate "co-mingled" with freight trains absent restriction. Alternate-compliant DMUs, however, are not permitted to co-mingle with freight trains. In order to operate on the SMART alignment, alternate-compliant DMUs must be separated in time ("temporal separation") from all other rail traffic. Negotiations in this regard are presently ongoing between SMART and the freight operator. Although there is speculation that the FRA may someday allow advanced train signaling in lieu of temporal separation, this is not a ruling change that can be relied on in the context of making a prudent technology decision.

5.5 Interoperability

SMART has expressed a desire to eventually run select trains on other alignments which are part of the "General Railroad System of Transportation." Practically speaking, interoperability on adjacent FRA-regulated alignment would not be achievable if alternate-compliant vehicles are the selected technology. If FRA-compliant DMUs are purchased, interoperability with other services within the "General Railroad System of Transportation" will be transparent. Examples of opportunities for interoperability that would exist if FRA-compliant DMUs were the selected technology include:

- Excursion trains to Willits where connections to the famous "Skunk Train" would be possible.

- Excursion trains to Napa, where connections to the Napa Valley Wine Train would be possible.

- Access to the Capitol Corridor alignment, where connections to BART service at Richmond, or Capitol Corridor trains to Sacramento would be possible.

5.6 Recommendation

SMART's planned rail service lies within a perfect storm of American rail service regulators; that is, the Federal Railroad Administration (FRA), the Environmental Protection Agency (EPA), and the Federal Transit Administration (FTA). These three agencies, taken in combination, have purview over the design, operation, environmental performance and funding of SMART's rail fleet. It is possible to specify a vehicle design and attendant commercial conditions which will satisfy *all* the requirements of these agencies. A solicitation of this nature will attract at least two proposers, either of which are capable of supplying a very high quality vehicle. This approach has the highest probability of a successful project implementation.

An alternate approach would be to specify a vehicle design which is more efficient than in the first approach, but which does not comply with FRA or FTA requirements; that is, a solicitation inconsistent with the known regulatory constraints. This approach could result in a more efficient operation, but carries the following risks:

- Risk of attracting only one proposer (likely).
- Risk of not achieving a temporal separation scheme adequate to sustain the intended service levels in the near-, mid- and long-terms.
- Risk of schedule delay as relief from the FTA's Buy America requirements are sought.
- Risk of schedule delay in obtaining waivers from select FRA-required vehicle design requirements.
- Risk of sacrificing interoperability with adjacent FRA-regulated rail services.

Given the above, our recommendation is to maximize the likelihood of project success by recognizing and accepting the regulatory environment in which SMART exists, and to develop a set of technical and commercial procurement documents for FRA-compliant DMUs consistent with this environment.

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