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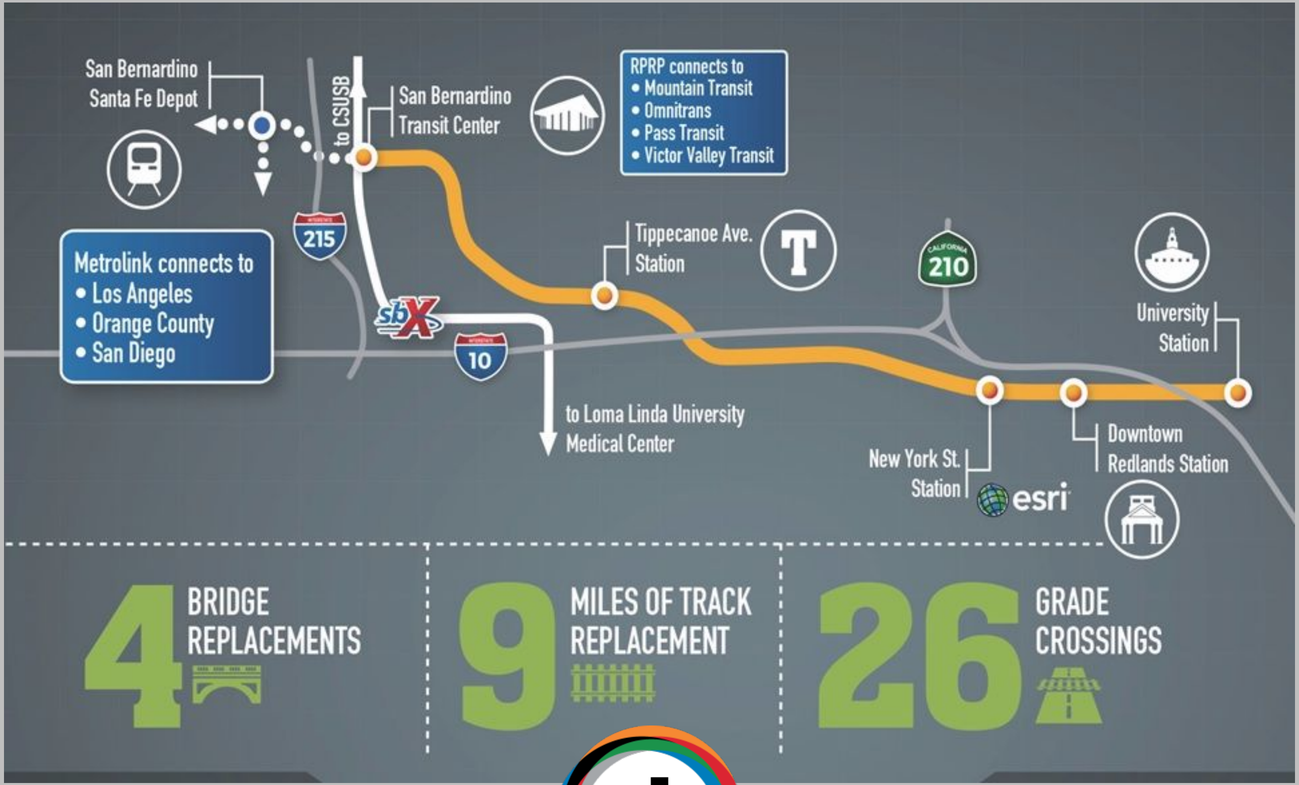
sbcta
San Bernardino County
Transportation Authority

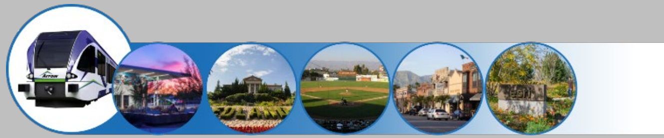
Carrie Schindler, PE
Director of Transit & Rail

Redlands Passenger Rail Project



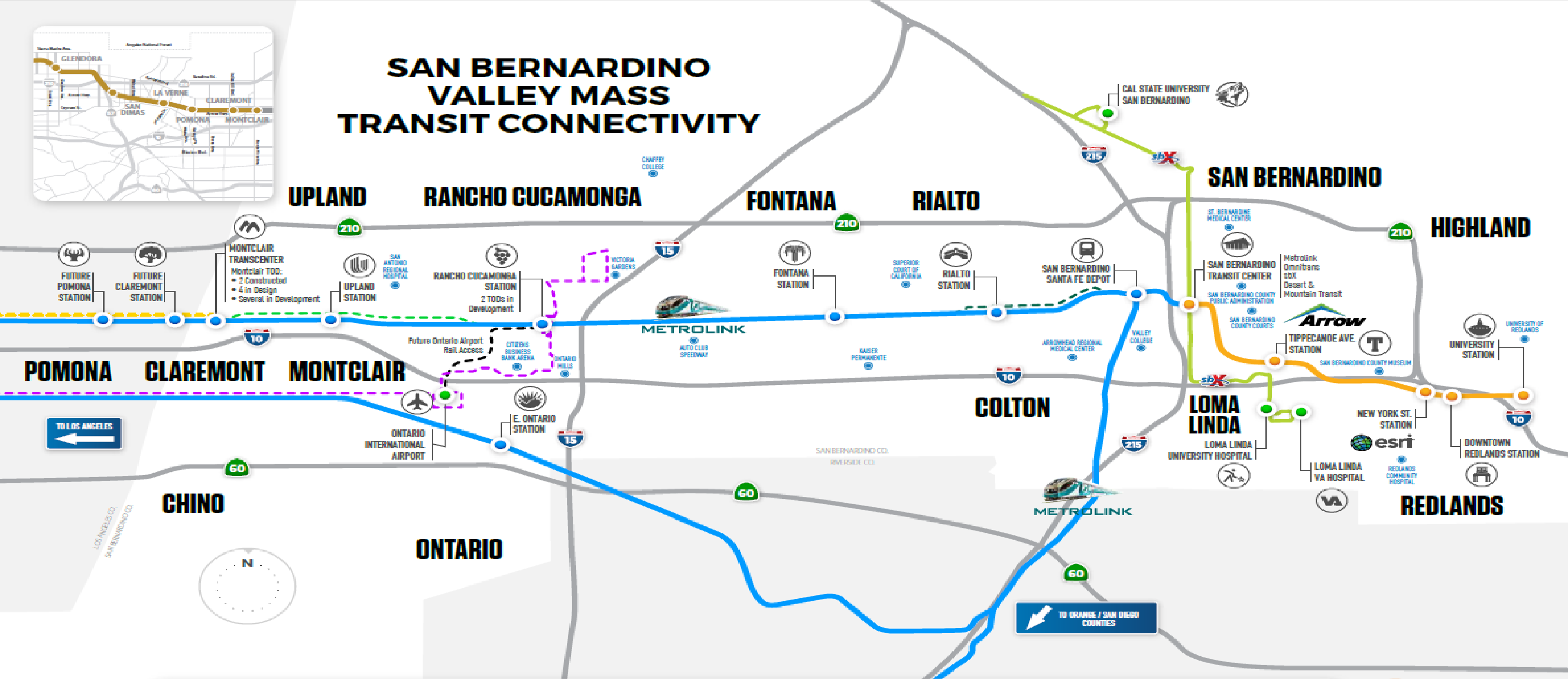
Background

Redlands Passenger Rail Project Schedule



2015	2016	2017	2018	2019	2021
ENVIRONMENTAL CLEARANCE	VEHICLE PROCUREMENT	START FINAL DESIGN	UTILITY RELOCATION	MAINLINE CONSTRUCTION	START OPERATIONS
March 2015	Oct 2016	January 2017	Early 2018	Early 2019	Mid 2021

SAN BERNARDINO VALLEY MASS TRANSIT CONNECTIVITY



LEGEND

- Redlands Passenger Rail (Future Arrow Service)
- Metrolink
- sbX Bus Rapid Transit
- **TOD** Transit Oriented Development
- Ontario Airport Rail Access (Future)
- Gold Line (Future)
- Omnitrans West Valley Connector – Phase I
- Central to Archibald Double Track (Future)
- Rancho to Lilac Double Track (Future)

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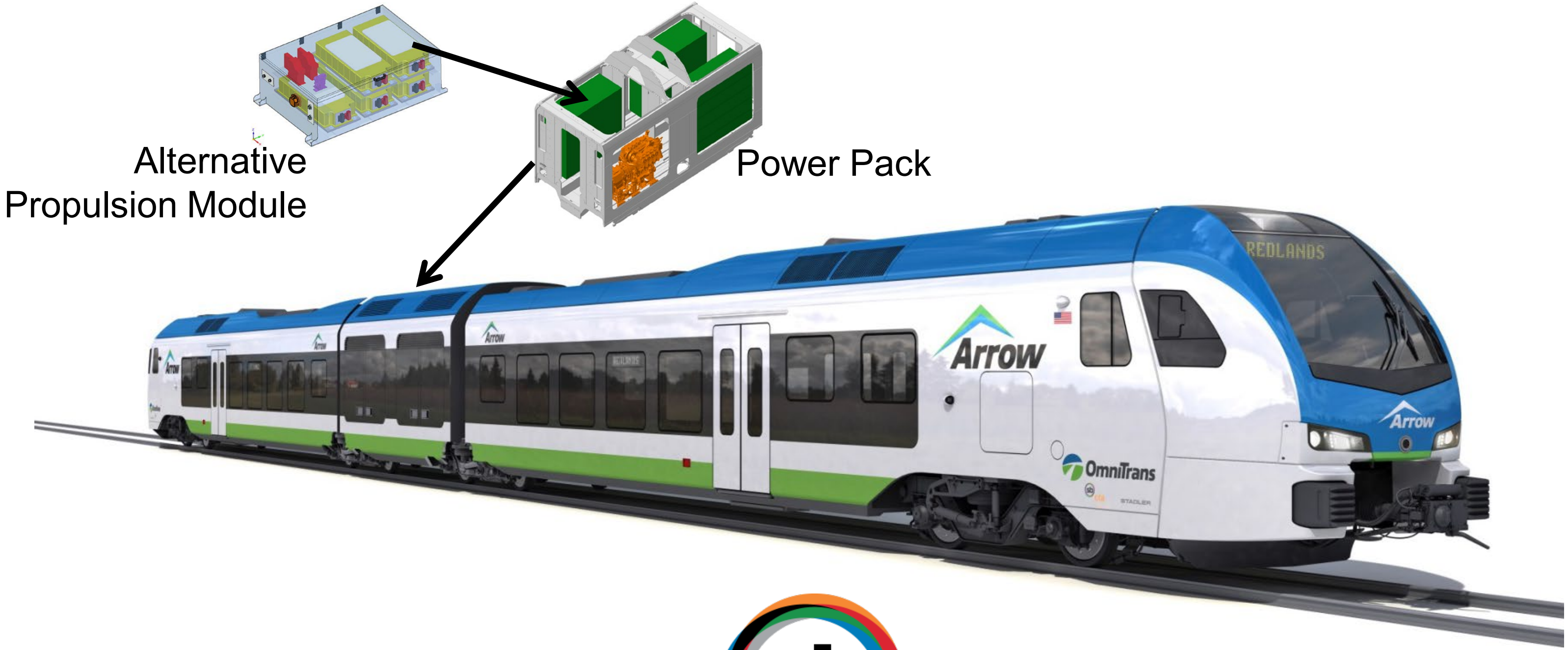
Potential Expansion

Diesel Multiple Unit Conversion



Power Pack

Diesel Multiple Unit Conversion

TIRCP Grant Award $30M

- SBCTA received funding from Transit and Intercity Rail Capital Program (TIRCP) to complete research and development on zero or low emissions rail vehicles (ZEMU)

Funding for:

- Research on the conversion of Diesel Multiple Unit to Zero Emission Multiple Unit
- Development of suitable technology and procurement of the zero emission unit and testing on the Arrow corridor

SBCTA ZEMU Program Approach

Phase 1 –
Planning

Phase 2 –
Design & Engineering

Phase 3 –
Project Implementation and Construction

Development Partner
U.S. Department of Energy

Regulatory Agency
Federal Railroad Administration

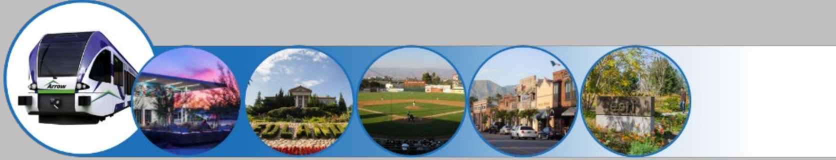
Funding Agency
California State Transportation Agency

Railroad of Record
Southern California Regional Rail Authority

Arrow Service Operator
Omnitrans

Key Project Stakeholders

Selection of Preferred Technology



Cost	Capital, Operations & Maintenance
Infrastructure	Right-of-Way, Charging & Fueling, Utilities
Environmental Considerations	Land use, GHGs, Aesthetics, Noise, Socio-Economic
Operations	Range, Scalability, Reliability, Operations, Life Span
Regulatory Compliance	FRA , NFPA, CPUC
Implementation Schedule	Timeline for Planning, Design, Construction phases
Risk Analysis	Identify and document risks for further analysis

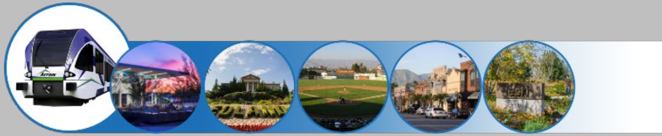
Evaluation Criteria

Key Tasks Underway

- Task 3 - ZEMU Project Definition and Constraints
- Task 4 - Assessment of OESS Rail Vehicle and Charging System Alternatives
- Task 5 - OESS and Charging Systems Feasibility Studies
- Task 6 - Options Evaluation and Report
- Task 7 – Contract Development for Supplier

Key Dates

- April 2018 – Grant Award
- October 2018 - Grant Allocation
- March 2019 – Complete Task 3 & 4
- April/May 2019 – Update to Transit Committee/Board & Complete Task 5
- June/July 2019 – Board direction on technology to carry forward (Task 6)
- July 2019 Vehicle RFP



Attendance at workshops, seminars, facility tours including:

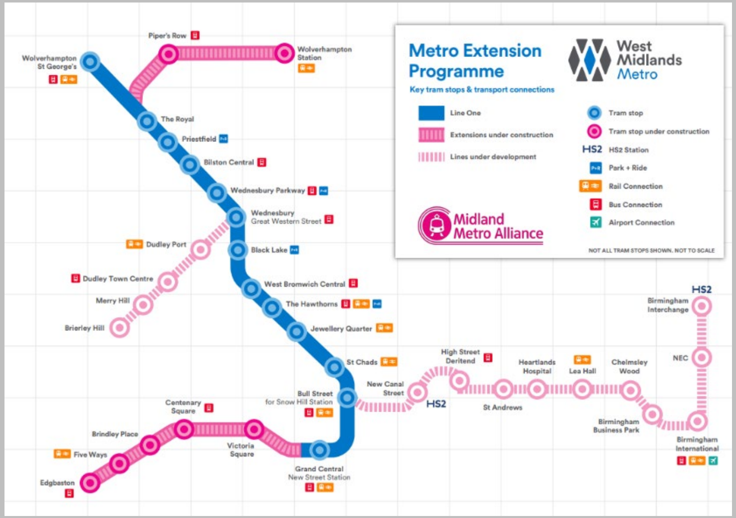
- Lessons learned from Midlands Metro Rail (Birmingham, England)
- SunLine Transit hydrogen facility tour
- Railway Motive Power and Alternative Propulsion Seminar

Supplier engagement

- Interviewed suppliers of battery, hydrogen fuel cell technologies and also rolling stock providers

Task 3 – Research Technologies

Midlands Metro Rail Lessons Learned Workshop



Task 3 – Research Technologies

SunLine Transit Hydrogen Facility Tour

Railway Motive Power and Alternative Propulsion Seminar – Port Tour

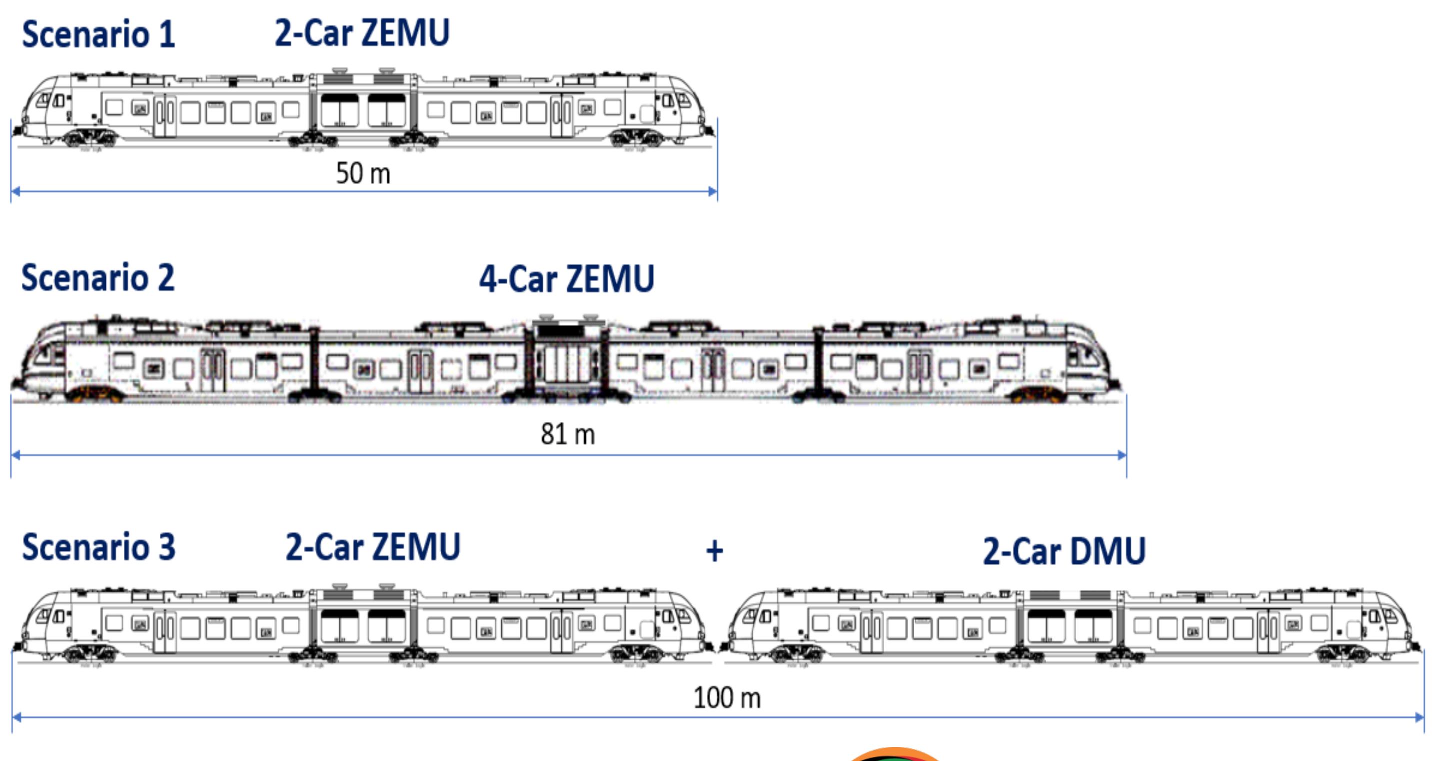
Railway Motive Power and Alternative Propulsion Seminar – Port Tour

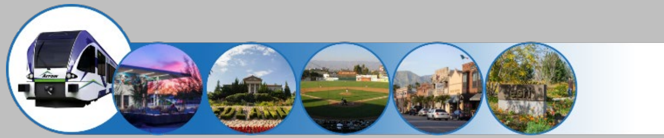
Engagement with Suppliers

High Level Pre-Screening

Category	Baseline – Arrow DMU	Wayside Power Supply		On-Board Energy Storage Systems (OESS)					Hybrid Systems			
Rail Technology	Diesel	Overhead Contact System (OCS)	Ground Level Power Supply – Third Rail	Battery	Supercapacitor	Hydrogen Fuel Cell	Biofuel	Natural Gas	Hydrogen Fuel Cell + Battery	Diesel + Battery	Biofuel + Battery	Natural Gas + Battery
Relative Capital Costs	**Good** Existing technology with known range of costs	**Poor** Design and installation of catenary systems and substations	**Poor** Design and installation of 3rd rail system and substations. Requires grade separations at many road crossings	**Moderate** Estimated to add 8-15% of the average selling price of a diesel vehicle. Design and installation of charging infrastructure, possibly at several locations along the route, likely requiring substation(s)	**Moderate** Estimated to add 8-15% of the average selling price of a diesel vehicle. Design and installation of charging infrastructure, possibly at several locations along the route, likely requiring substation(s)	**Moderate/Poor** Estimated to add 25-30% to selling price of comparable diesel vehicle. Single refueling station needed, with refueling on a daily basis or less often possible	**Good** The same equipment can be used for refueling up to high blends of biofuel substitution	**Good/Moderate** Combustion engine similar to diesel and natural gas/diesel blends possible. Additional cost for natural gas refueling infrastructure	**Moderate/Poor** Estimated to add 20-25% to selling price of comparable diesel vehicle. Single refueling station needed, with refueling on a daily basis or less possible	**Good** Only major cost would be the addition of batteries to vehicles	**Good/Moderate** The same equipment can be used for refueling up to high blends of biofuel substitution. Additional cost of batteries.	**Moderate** Combustion engine similar to diesel and natural gas/diesel blends possible. Additional cost for refueling infrastructure and batteries, and if diesel/natural gas capable additional on-board equipment.
Relative Life Cycle Cost	**Moderate/Poor** Existing technology with largely known costs, however operating costs influenced by relatively low energy efficiency, i.e. high fuel consumption, and diesel price volatility. Risk of not meeting future emission regulations.	**Good/Moderate** Limited maintenance cost over its useful life and low energy cost at current rates but high capital cost spread over relatively infrequent service	**Good/Moderate** Limited maintenance cost over its useful life and low energy cost at current rates but high capital cost spread over relatively infrequent service	**Moderate** Expected reduction in energy costs. High cost to replace batteries after reasonable life span.	**Good/Moderate** Expected reduction in energy costs. High cost to replace supercapacitors, but life span roughly 1.5 to 2 x battery life.	**Moderate** Limited maintenance cost over its useful life span, but fuel costs are high at low consumption rates. On-site production has potential for cost similar to diesel. High cost of refueling / production station.	**Moderate/Poor** Similar to conventional diesel.	**Good/Moderate** Will have further increased energy consumption than diesel but currently low energy cost for natural gas.	**Moderate** Similar life cycle costs as a hydrogen FCS but with battery replacement added. However, FCS and battery systems will be smaller than if either single technology were to be used.	**Moderate** Limited maintenance cost over its useful life but batteries will need to be replaced throughout vehicle life, but smaller capacity battery than a battery-only OESS	**Moderate** Similar to conventional diesel + battery.	**Moderate** Will have slightly increased energy consumption compared to diesel hybrid but currently low energy cost for natural gas. Plus battery replacement costs.
GHG Emissions	**Poor** While Tier 4 compliant, still results in diesel combustion emissions.	**Good** Zero local emissions	**Good** Zero local emissions	**Good** Zero local emissions	**Good** Zero local emissions	**Good** Zero local emissions	**Moderate/Poor** Combustion in engine results in emissions. Reduction of some local emission; overall GHG dependent on production method of biofuel	**Moderate** Combustion in engine results in emissions. Significant reduction in local emissions and GHG but not zero local emissions.	**Good** Zero local emissions	**Poor** Still results in typical diesel combustion emissions. Batteries provide some reduction of emissions.	**Moderate** Combustion in engine results in emissions. Reduction of local emission; overall GHG dependent on production method of biofuel. Batteries further reduce emissions.	**Good/Moderate** Combustion in engine results in emissions. Significant reduction in local emissions and GHG but not zero local emissions. Batteries further reduce emissions.
Aesthetics	**Good** No changes over existing corridor	**Poor** Visual impacts due to overhead wires along entire corridor	**Moderate** Likely requires grade separation but no overhead wires	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor	**Good** No changes over existing corridor
Range	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor	**Good** Full length of corridor	**Moderate** Longer range needs larger batteries and more charging points	**Poor** Require regular charging but can quick charge	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor, daily refueling or better	**Good** Full length of corridor, daily refueling or better
Scalability	**Good** Due to range and infrastructure can be easily expanded	**Poor** Unlikely to be able to operate in mixed corridors with freight	**Poor** Unable to operate in mixed corridors.	**Moderate** Will require new charging infrastructure along expanded route	**Moderate** Will require new charging infrastructure along expanded	**Good** Due to range and lack of new infrastructure can be easily expanded	**Good** Due to range and lack of new infrastructure can be easily expanded	**Good** Due to range and lack of new infrastructure can be easily expanded	**Good** Due to range and lack of new infrastructure can be easily expanded	**Good** Due to range and lack of new infrastructure can be easily expanded	**Good** Due to range and lack of new infrastructure can be easily expanded	**Good** Due to range and lack of new infrastructure can be easily expanded
Life Span	**Good** 30 year life of diesel engine, with engine overhaul typically 8-10 years	**Good** >30 years	**Good** >30 years	**Poor** Will have to replace batteries 8-10 years, similar time scale to diesel overhaul.	**Moderate** Will have to replace super capacitors after 10-15 years.	**Moderate** Requires midlife overhaul(s), similar time scale to diesel overhaul.	**Good** Similar to conventional diesel, 30 year engine life, overhaul typically 8-10 years	**Good** Similar to conventional diesel, 30 year engine life, overhaul typically 8-10 years	**Moderate** Requires midlife overhaul(s), similar time scale to diesel overhaul. Battery replacement 8-10 years.	**Moderate** 30 year life of diesel engine, battery replacement and, engine overhaul both typically 8-10 years	**Moderate** 30 year life of diesel engine, battery replacement and, engine overhaul both typically 8-10 years	**Moderate** 30 year life of diesel engine, battery replacement and, engine overhaul both typically 8-10 years.
Regulatory Compliance	**Good** FRA compliant vehicle	**Poor** Likely incompatible with freight railroads	**Poor** Likely incompatible with freight railroads or at grade crossings.	**Moderate** No current FRA specific standards	**Moderate** No current FRA specific standards	**Moderate** No current FRA specific standards	**Good** No major changes compared to diesel.	**Moderate** FRA specific standards exist for natural gas, which require co-ordination especially if vehicle operated over other railroads tracks.	**Moderate** No current FRA specific standards	**Moderate/Good** No current FRA specific standards for batteries but like existing rail freight hybrid vehicles	**Moderate/Good** No major changes compared to diesel but no FRA specific standards for battery.	**Moderate** FRA specific standards exist for natural gas, which require co-ordination especially if vehicle operated over other railroads tracks. No FRA standard for battery.
Result	Baseline	Incompatible	Incompatible	Compatible	Compatible	C[illegible]	[illegible]mpatible	Incompatible	Compatible	Incompatible	Incompatible	Incompatible

Energy Usage & Modeling Scenarios





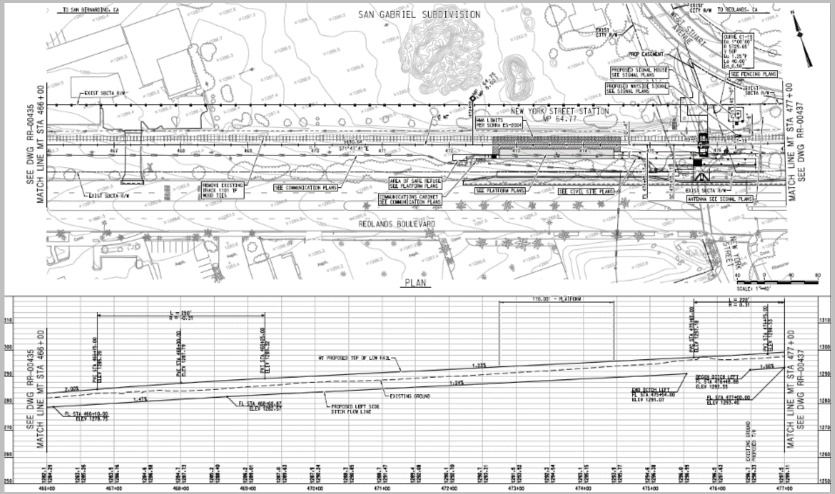
Journey		Section Length (Miles)	Energy Between Terminals					
			Scenario 1 2-Car ZEMU		Scenario 2 4-Car ZEMU		Scenario 3 2-Car + 2-Car	
			No Regen. Braking (kWh)	With Regen. Braking (kWh)	No Regen. Braking (kWh)	With Regen. Braking (kWh)	No Regen. Braking (kWh)	With Regen. Braking (kWh)
RPRP - West End	RPRP – East End	8.89	157.59	140.93	224.90	205.45	239.50	220.29
RPRP – East End	RPRP – West End	8.89	78.36	32.13	112.88	48.04	99.58	14.47
LA	RPRP – West End	57.63	811.77	672.23	1058.33	882.55	1163.83	959.13
RPRP – West End	LA	57.63	680.56	496.54	857.60	614.06	919.40	619.55

Power Demand Modeling

Performance and Energy Usage Modeling

Primary inputs

- Vehicle characteristics (mass, loading condition, tractive & braking curves, rotating inertia, electrical efficiencies and auxiliary loads)
- Track characteristics (distances, grades, curves, speed limits and restrictions)



Applications

- Quantify key requirements – power charge/discharge rates and energy storage capacity
- Support assessment of technology feasibility

FRA Engagement Process

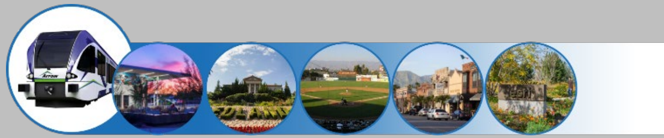
Research & Development → Supplier Contract Negotiation → Kick-off → Conceptual Design → Final Design → Qualification/ Acceptance Testing → Acceptance of Vehicle → Entry into Service

Initiate a regular communication plan with FRA

Technical discussions with FRA and Railway Safety Advisory Committee (RSAC)

Key FRA elements

- Crashworthiness
- Fire safety
- Inspection
- Vehicle Maintenance
- Record keeping



- Complete Feasibility Studies and Evaluation of OESS and Hydrogen Technologies
- Engagement with FRA – Develop plan for ongoing engagement
- SBCTA evaluation and selection of preferred technology alternative by SBCTA Board
- Engineering of ZEMU vehicle
- Determination of infrastructure needs and engineering design
- Project procurement and implementation
- FRA concurrence
- Operational testing
- Revenue service
- Statewide analysis for ZEMU service in California

Next Steps

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