A Global Leader of Train Control Solutions

Technical Response

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Concept Based on High Energy Ultra Capacitor & CBTC Light Solutions

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I. Introduction

CRSC (USA) Inc. is proud to present our technical response for City of San Jose Request for information soliciting ideas, concepts and solutions to reduce the construction and maintenance cost implementation of a mass transit infrastructure. Through this document, CRSC USA is providing details of our proposed concept that will support the savings on the construction and cost reductions on the maintenance and operation side. At the end of the document, a high-level budgetary cost was provided as a reference for the customer to support their process for the final determination of the best fitted solution and projected costs.

II. Company Profile & Background Summary

CRSC (USA) Inc. is the USA subsidiary of the China Railway Signal & Communication Corporation Limited (CRSC LTD) established in 1953. CRSC (USA) Inc. was incorporated in 2016 in Delaware with its office located in Jacksonville, FL. CRSC (USA) Inc. is also registered to perform business in California, Massachusetts, Florida, and New York. CRSC LTD is the pioneer of China's rail transportation control system industry and one of the largest rail transportation control system solution providers in the world and has been listed in the Hong Kong Stock Exchange since 2015.

CRSC (USA) Inc. understands the importance of US market rail signaling standards and has built a strong team of US-based Signal Engineers with an extensive knowledge in US railway signaling engineering standards, policies, procedures, and expectations in both freight and transit. Also, the CRSC (USA) Inc. team is knowledgeable of the best industry practices and applicable standards such as AREMA, IEEE, CENELEC, Federal Railroad Administration, and Federal Transit Administration regulations.

With a combined US railway industry experience of over 100 years, the CRSC (USA) Inc. team has an extensive experience in the US market with system integration/interoperability, equipment manufacturing, and project implementation services. This expertise has enabled CRSC (USA) Inc. to offer the capacity to provide, customize, and implement various train control and rolling stock solutions. CRSC (USA) Inc. has modified CRSC LTD products, which are proven technology in compliance with CENELEC Standards, to meet AREMA Environmental and Safety Standards

CRSC LTD is a global leader in train control and communications solutions providing turnkey design, system integration, and products for high speed rail, metro, light rail, streetcar, and freight rail for over more than 65 years. CRSC LTD has 19 first-level subsidiaries, with a total number of 19,000 employees. Globally, the company completes numerous projects per year including large design build projects by providing field surveys, gap analyses, estimates, aspect charts, design, system implementation, and As-built plans all communications, wayside and onboard signals systems. As the main research institute of China railway and urban transit control systems, CRSC LTD owns a whole series of train control technology and standards. CRSC LTD is the developer and design authority who independently developed ATG-2000 (Advanced Train Guidance – ETCS2) for high-speed train control technology in accordance of ETCS level 2 of the European Standards (CENELEC). CRSC LTD also developed the CBTC (Communication Based Train Control) passenger rail transit control technology that complies with international standards including European Standards with best practice and implementation for the Global markets. CRSC LTD owns many factories that manufactures signal equipment like switch machines, track circuits, axle counters, computer-based interlocking, relays, transponders (balises) and etc. CRSC LTD has two factories, one in China and the other in Prague, that manufactures Light Rail

Vehicles, Streetcars and Monorail. CRSC USA will bring the rolling stock and train control manufacturing capacities to USA soil.

The following bullets are some of CRSC Global accomplishment;

- Designed, deployed, and/or upgraded signaling systems for over 65 passenger transit lines, both wireless CBTC (Communication Based Train Control) moving block systems and fixed-block systems;
- Designed and deployed train control systems for over 12,500 miles high-speed rails;
- Upgraded 15,500 miles conventional railway to allow speed increase from 50mph to 125mph;
- Designed and upgraded/retrofitted signaling systems for over 100 railway hubs with mixed passenger, freight traffic, and complex junctions;
- Deployed computer based interlocking systems at over 1,700 interlocking stations;
- Designed, manufactured and deployed over 1000 fleet of Monorails Vehicles, LRV Vehicles and Streetcars
- Carried over 2 million passengers daily, safely, and reliably with our train control systems.

Further details of our CRSC USA company are found within our web site http://crsc-us.com or http://crsc-us.net/

III. Qualifications and Project References

While CRSC LTD has a vast global expertise with over 65 years in communications, signals and train control, CRSC USA has incorporated a local team with more than 20 years (Combined is more than 100 years) of signal and communications design and implementation expertise within the U.S. Market both Freight and Transit. This expertise enables our team to apply our products and interface with others to meet our customer's needs and US Market requirements. Final product selections will be made during the design process, based upon meeting technical requirements with the lowest life cycle costs. Due to the rapidly advancing technology, it is very likely key components and communications products will be selected based on the latest model to avoid obsolescence's or support issues. All our manufactured products will be supported within the 30 years' time frame required by US Market.

Additionally, CRSC USA provides services, from project inception to completion, such as project management, construction management, engineering management, systems integration, installation support and commissioning execution. CRSC's engineering services conform to all federal and state regulations as well as the end user's operating rules, train control standards and safety programs.

CRSC USA services conform to all applicable statutory requirements, standards and codes. All services performed under this proposal will conform to our Corporate Quality System, assuring that your expectations are met or exceeded. CRSC USA will provide all required documentation, programs, plans, quality assurance and necessary certifications to comply with the project contract requirements including FTA and FRA requirements. CRSC USA will manufacture and perform final assembly of our products to ensure compliance with Buy America Act.

The key benefit with CRSC USA is the comprehensive solution of train control systems integration responsibility, with reduced risks. There is a substantial systems integration effort to design all the major sub-systems to work with each other. Purchase of separate signaling, ATC, CBTC, dispatching, on-board, and communications sub-systems from different suppliers would leave a large and complex task to clearly define interfaces and responsibilities between sub-system

suppliers. The total system requirements are more than the “sum of the parts”, based upon needing to provide a totally integrated train control and communications system solution.

The following table depicts some of the global projects where we have deployed our products.

#	CONTRACT NAME	RAILWAY TYPE	SCOPE OF WORK	PROJECT VALUE (USD)	COMPLETION DATE	KM	STA #
1	Mombasa-Nairobi Standard Gauge Railway Project of the Republic of Kenya	Passenger & Freight railway	Design, Supply, of Communication, Information, Signaling and Electrical Power System.	$43,141,880.26	2018	472	33
2	Addis baba/ Sebeta-Djibouti Freight line Information system integration, Ethiopia	Freight railway	Design, CTC	$ 4,533,499.65	2016	430	20
3	Pakistan Railway control system upgrading project	Passenger & Freight railway	Design, Track circuit, Signal	$ 8,453,250.00	2016	886	54
4	Mughalsarai-New Bhaupur Section of Eastern Dedicated Freight Corridor in India	Freight railway	Design, Supply, of Communication, Information, Signaling and Electrical Power System.	$68,059,500.00	Under Construction	388	12
5	Supply of ATP/ATO for Line 13 of Sao Paulo Metro in Brazil	Metro	Supplier of onboard ATO/ATP	$ 3,973,750.00	Under Construction	N/A	N/A
6	Resignaling project for Mitre&Sarmiento line, Buenos Aires, Argentina	Suburb Passenger Railway	Design, On-board equipment, LEU, Balise	$27,310,500.00	2017	105	54

The following table depicts some of CBTC projects.

#	Project Name	RAILWAY TYPE	SCOPE OF WORK	SIGNALLING SYSTEM PROVIDER	PROJECT COMPLETION DATE	KM	STATIONS
1	Signaling System of Beijing Metro Line 8 Phase 1 & Phase 2 Project	Metro	Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM	CRSCD	2013.12	28.00	19
2	Signaling System Of Beijing Metro Line 8 Phase 3 Project	Metro	Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM	CRSCD	2016.12	17.30	14
3	Signaling System of Chongqing Rail Transit Line 5 Phase 1 Project	Metro	Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM	CRSCD	2017.12	39.70	25
4	Signaling System Of Beijing Maglev Line S1	Maglev Light Rail	Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM	CRSCD	2017.12	10.00	8

5	**Signaling System of Changchun Rapid Rail Transit Beihu Line Phase I Project**	**Metro**	**Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM**	**CRSCD**	**2018.10**	**13.30**	**12**
6	**Signaling System of Xi'an North to Airport Intercity Rail Transit Project**	**Intercity Railway**	**Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM**	**CRSCD**	**2018.12**	**29.30**	**10**
7	**Signaling System of Changsha Rail Transit Line 5 Project**	**Metro**	**Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM**	**CRSCD**	**2020.12 Under Construction**	**23.00**	**18**
8	**Signaling System of Heifei Metro Line 3 Project**	**Metro**	**Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM**	**CRSCD**	**2019.12 Under Construction**	**37.00**	**33**
9	**Signaling System of Hangzhou to Haining intercity railway Project**	**Intercity Railway**	**Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM**	**CRSCD**	**2020.12 Under Construction**	**46.00**	**12**
10	**Signaling System Of Beijing Metro Line 12 Project**	**Metro**	**Design, Supply, Testing and Commissioning of FZL300 CBTC SYSTEM**	**CRSCD**	**2021.12 Under Construction**	**29.30**	**21**

IV. Manufacturing Capabilities, Quality and Buy America Requirements

CRSC USA will extend the manufacturing capacity to United States for all rolling stock and train control products by using local subcontractors properly certified having facilities in compliance with our Quality standards. CRSC USA will provide a Quality Assurance Program to our subcontractors ensuring adherence and compliance by effectively monitoring and controlling the manufacturing and assembly of CRSC products; thus, meeting and exceeding customer requirements. CRSC (USA) Inc. has a comprehensive knowledge of Buy America Requirements and has partnered with local US Manufacturing companies to meet the Buy America Requirement for all their marketed products.

The manufacturing of the major system components and the final assembly will be performed in the United States in compliance with Buy America requirements. At least more than 70% of all sub-components such as capacitors, FPGA, and other electronic components used within our products will be purchased from local providers. All steel and iron needed for products and Rolling stock will be purchased from a certified USA BAA provider. The associated ancillary products will be locally purchased or manufactured by subcontractors in the United States. Installation will be mainly carried out by local contractors with direct supervision from CRSC USA engineering personnel. Testing and Commissioning will be performed by competent experts hired within the USA. The Executive and Application software for all applicable products will be fully tested and approved before release. CRSC USA is committed to ensure the proper utilization of US products and US local labor to meet the 70% requirement by the Buy America Clause.

All products and final assembly are stringently tested by competent CRSC USA engineers for quality and integration purposes. CRSC USA will perform all field tests including post installation to final integration

test. The proper testing ensure that the design and quality of the system has been completed satisfactory based on the design expectations; minimizing the possibility of field recall due to design and manufacturing defects. All hardware, including all type of components and subsystems, utilized for the composition of the system will be based on proven technology. With CRSC integration expertise and vast experience in manufacturing in conjunction with the aforementioned process, the risk of having design and manufacturing defects are mitigated and reduced to a minimum.

All Product Designs are compliant with:

- AREMA (Under Development)
- IEEE
- CENELEC standards EN50128 & EN50129
- ISO9001;2008 quality management systems
- ISO14001:2004 environmental management systems
- CMMI Accreditation
- IRIS Certification

All main control systems have been safety assessed and certified by third-party assessors and are SIL4 certified, the highest safety integrity level. By implementing systems using strictly proven technology products, introducing world-class technology, understanding implications of executing properly the system integration, performing testing, commissioning and successfully completing the systems demonstration, and establishing a complete quality and safety system, the CRSC (USA) Inc. ensures the ability to provide a safe and reliable system.

All our products are manufactured using the highest quality US electronics components and are certified by independent third parties such as TUV/RSC and Lloyd Register, in compliance with the industry standards. Furthermore, CRSC USA has partnered with local US Cybersecurity companies to verify and to identify any possible vulnerabilities within the products and systems, designed to provide a more robust system and to remove any possible cybersecurity threats.

V. Customer High-level Questions

5.1 Are there new technologies, project delivery, or operating models that can provide grade-separated high capacity, high-speed transit?

There are new technologies such as High-Speed Rail, Maglev, and Monorail that can provide grade-separated high capacity, high speed transit. CRSC USA in junction with other partners has implemented numerous high-speed rail projects worldwide. Due to the distances of the routes, CRSC USA recommends evaluating the utilization of light rail systems instead. High-Speed Rail Systems are utilized for longer distance especially intercity and those requires soil acquisition for ensuring the grade separation. Building High-Speed Rail would be an enormous capital cost.

5.2 Do these systems have lower construction, operations, and/ or maintenance costs than traditional Systems?

High-Speed Rail has the highest cost in overall in comparison with other solutions. Commuter Rails based on a hybrid solution can offer some savings in overall implementation and maintenance. Due to the distances of the routes, CRSC USA recommends evaluating the utilization of light rail systems based on Ultra-Capacitor and CBTC light version solution instead.

5.3 Can these systems be deployed faster than traditional projects?

If the customer considered an at grade light rail system using on Ultra-Capacitor and CBTC light version solution, then it will allow a faster deployment due to the elimination of the catenary and traction system but also the reduction of secondary train detection.

5.4 Do these systems have viable financial outlooks?

Building High Speed Rail requires an enormous investment due to higher cost and viable financial outlooks will depend on the connectivity achieve by the new systems increasing the ridership. In the case of the Light Rail using the suggested solutions will observe prompt recovery on investment since it requires lower initial investment due to reduction on construction and reduction on the cost for maintenance.

5.5 How will these systems be constructed and deliver service on the specified corridors?

Further analysis of the areas including traffic studies is needed to properly response to this question. It is suggested to implement the system at grade.

VI. System Solutions & Products

7.1 Light Rail System Based on Ultra Capacitor Solution and CBTC light solution

7.1.1 Overall Description

Due to the distance of the current routes, CRSC USA is recommending designing the new mass transit system based on at grade light rail instead of high-speed rail. With this approach, the customer can use a CBTC light version for the train separation, where the amount of secondary train detection can be limited to the critical areas such as interlockings and crossings. Reducing the amount of secondary train detection, it will make reductions on the construction and maintenance costs.

Furthermore, it can be combined with the utilization of High Energy Ultra capacitors in combination with Lithium titanate battery to reduce the dependence of catenary or third rail systems. By increasing the Energy storage capacity by the means of using high performance batteries and high energy super capacitors, Streetcars & Light Rail vehicle can run or operate a maximum run distance of more than 10 km (6.21 miles) without charging. This means that the needs of a catenary or third rail systems can be limited to the charging stations lowering the cost of traction power maintenance and reducing the energy consumption up to 40%. High Energy Super Ultra-capacitors are equipped with prominent advantages such as large power density, rapid charging, long cycle life, high energy density, wide using-temperature scope, long storage life, high reliability and is environmentally friendly. It is especially suitable for high power output and quick charging. Super capacitor absorption of regenerative braking energy reduces overall energy consumption and therefore provides energy cost savings for the operator. Its properly solves the contradiction between the specific power and specific energy output of the energy storage device.

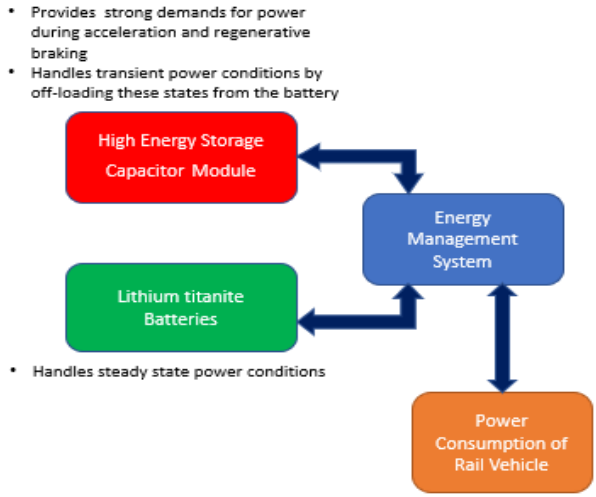
Our Partial Off Wired Technology solution is as follows:

a. Requires at least 30s in the station with charging capacity to reach full charge. Charging locations should be strategically designed to ensure terminal station and mid points are provided to guarantee the energy demand of the vehicle. Depending on the operating maximum speed, the charging stations can be installed every 5 miles;

b. It can run 10km (6.21 miles) after full recharge at 35 mph;
c. Super capacitors are replaced every 10 years;
d. lithium-titanate batteries unit can provide 150kWh electric power for traction and assistance of running stability
e. Charging Points at Station Interval average energy consumption is 2kWh.
f. I-type super capacitor is installed on each roof of MC carriages.
g. Using lithium-titanate batteries unit, the whole accumulator is composed of 2 boxes. Amount of energy storage system：4 boxes / vehicle
h. High Capacitors are UCK42V28000 monomer. The effective voltage range of the monomer is 2.85-3.8v under the condition of the guaranteed life of 1 million times.
i. Parameters of UCK42V28000 unit performance：

Product type		UCK42V28000				
Working voltage		2.85-3.8V				
Capacity		28000F				
Inner resistance		0.358mΩ				
Available energy storage		≥22Wh				
Standard charging current		150A				
Maximum charging current		280A				
Cycle life		1 million				
Working temperature range		-25~55℃ (QC/T741 test)				
		-15~55 (140A test)				
Storage temperature		-30~60℃				
Dimension	Parameters	L1	L2	D	d	h
	Figure	145	137.5	60.5	14	3

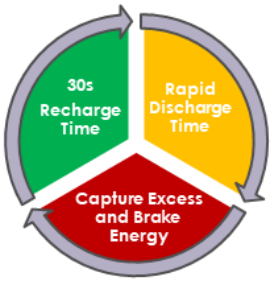
j. Ultracapacitor / Lithium Battery Concept

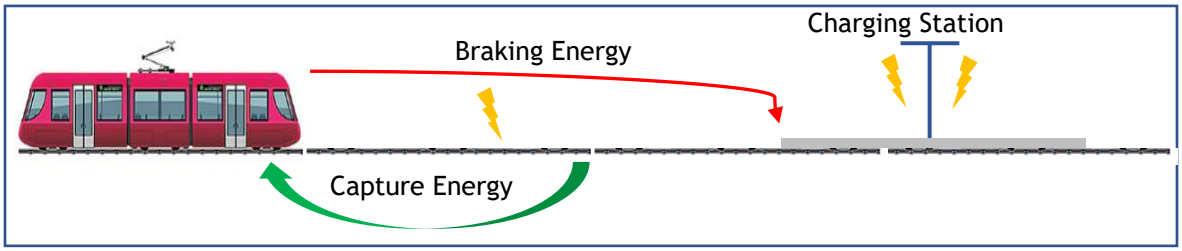


7.1.2 Key Benefits of Ultracapacitor Solution

The following tables shows the capacity for each tram or streetcar and combine configuration;

- Reduces the Infrastructure Cost (Both OCS and Traction Power)
- Reduces Construction and Maintenance Cost
- Reduces Power Substation Load since it only requires 2kWh per 30s to charge
- Reduces Energy Consumption generating more than 38% of Energy savings
- Reduces peak-load demand during rush hours
- Efficiently Optimizes the Energy Management and Energy Transmission by reducing losses in the systems
- Increases the availability
- Reduces Safety Risks associated with the OCS
- High Current Capability, High power output, rapid discharging and quick charging
- Instantaneously Captures and Stores the regenerative braking energy reducing Electromagnetic Interference (EMI) effects
- High Power with 1Million cycles with life expectancy of minimum of 10 years due to absence of chemical bonds causing accelerated deterioration
- Limits depth of discharge to battery, extending battery life
- Recycles energy and reduces heat and noise





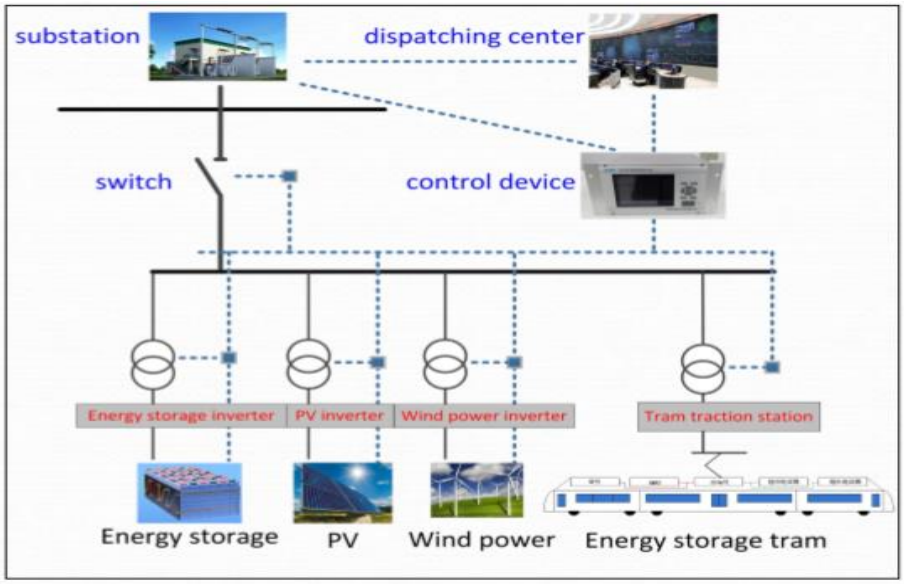
7.1.3 Description of System Wide Implementation and Characteristics

For the Ultra-capacitor solution, the catenary or third rail system is eliminated and the traction power substations are replaced by charging stations that are strategically located to warrant the charging support and operations of the vehicles. The way the system will work is the supercapacitor will capture the regenerative braking energy and will provide the necessary power for vehicle propulsion system. Consequently, the batteries would store the remaining unused energy waiting to be discharge as required by the propulsion system and operation needs. In this operation, the batteries would be protected against peaks causing less discharge cycles, therefore significantly increasing the lifespan and performance of the batteries. Also, by eliminating the amount of energy and current loss throughout the negative return, the system reduces the amount of EMI effects created between the Overhead Catenary Systems and the negative return to the traction power substations.

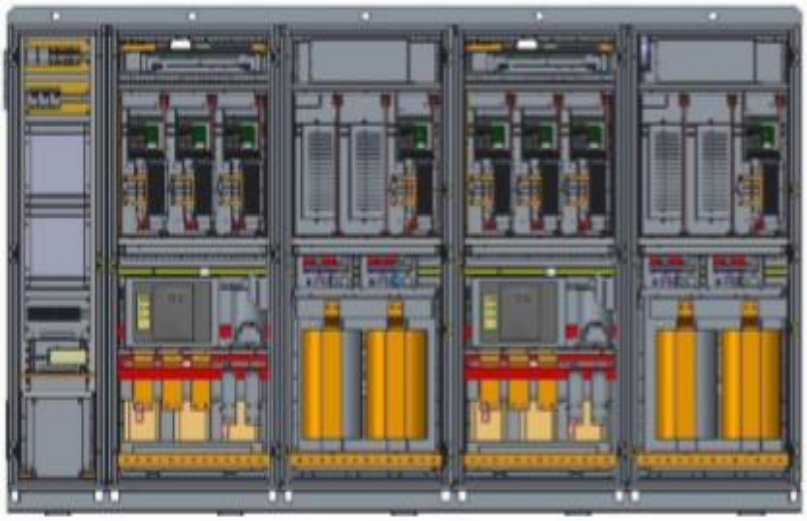
- Reduce dependencies on typical power systems
- Provides fast charging and discharging to boost energy to support the propulsion system. Charging Stations should be strategically designed to guarantee the energy demand of the vehicle depending on the desired headway and civil speeds.
- Supports distance capability to run 10 Km (6.21 miles) after full recharge at an average speed of 35 mph
- lithium-titanite batteries unit can provide 150kWh electric power for traction and running stability

- Consumes an average of 2kWh of energy at charging points stations
- I-type supercapacitors are part of the roof-mounted accumulator/storage system, which is composed of 3 boxes per vehicle
- The charging stations are designed to lower the EMI and harmonics effects below the required standards
- Ultracapacitors have a 1M Life Cycle requiring replacement every 10 years

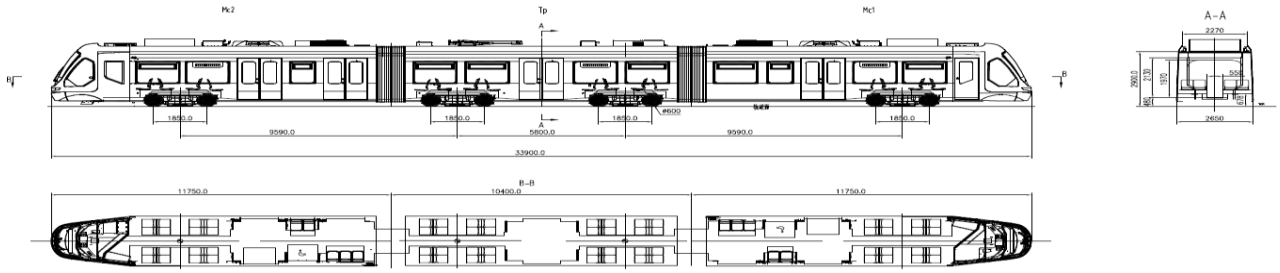
Systems Interface



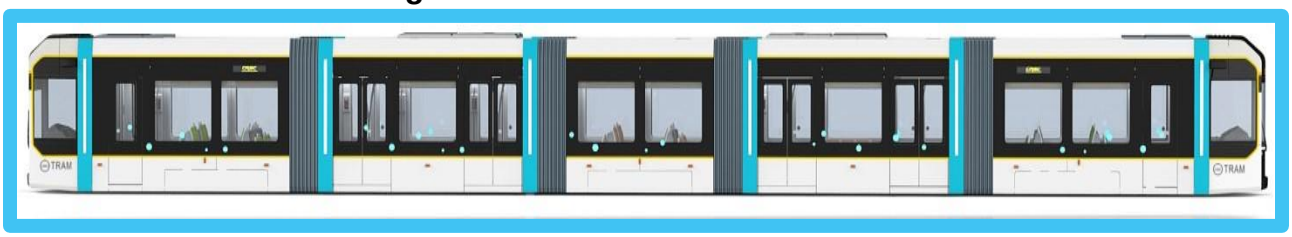
Charging Station

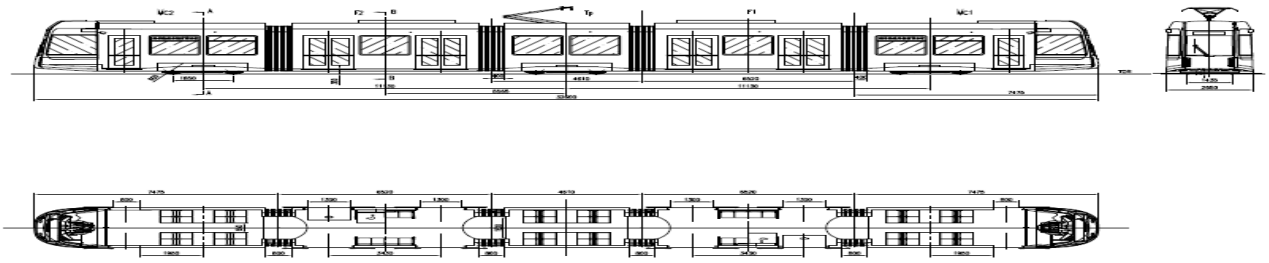


7.1.4 Pictures and Drawings for 3 Section Car Model



7.1.5 Pictures and Drawing for 5 Section Car Model





7.1.6 Vehicle Dimension

Vehicle Dimensions		
	3 – Module Tram	**5 – Module Tram**
Length	33900mm 112 ft	32600mm 107 ft
Width	2650mm 8 ft 9 in	2650mm 8 ft 9 in
Height	3600mm 11 ft 10 in	3600mm 11 ft 10 in
vehicle weight (energy storage devices included)	52t+/-3% 119,050 lbs +/-3%	49t+/-3% 108,027 lbs +/-3%
minimum curve radius	25M 82 ft	25M 82 ft
bogie wheelbase	1850mm 6 ft	1850mm 6 ft
wheel diameter	600/520mm 24in/21in	600/520mm 24in/21in

7.1.7 Performance and Capacity

Performance and Capacity		
	3 Rail Cars	**5 Rail Cars**
Formation	-Mc+Tp+Mc-	-Mc+F+Tp+F+Mc-
Motor power rating	8x75 kW	4x120 kW
Passenger Capacity	74 seats per car	58seats per car
	Total capacity 276(6 persons/m^2)	Total capacity 292 (6 persons/m^2)
	Total capacity 343 (8 persons/m^2)	Total capacity 370 (8 persons/m^2)
Supply voltage (Catenary, third rail collector, or high storage capacitor)	750Vdc +/- 33%	
Maximum Operational Speed	45 MPH with OCS / Third Rail, 45 MPH using Ultracapacitor	
Service acceleration and deceleration	Acceleration: 1.0 m/s^2	
	Deceleration: 1.2 m/s^2	
Emergency Braking rate	2.25m/s^2	
Gradeability	60 %	

[redacted]

[redacted]