A) Applicant Information

1. **Name of Applicant:** Michael J. Cook
2. **Contact Phone Number:** (617) 990-6181
3. **Contact Email Address:** cook.mike@crrcma.com
4. **Application Title:** Rapid Delivery of High Quality and Technology Advanced Cars
5. **Application ID #:** 170811-000050
6. **Application Type:** On behalf of a Company: CRRC MA Corporation

B) Executive Summary

The current design philosophy for passenger rail vehicles is to design the structural components of the vehicle to withstand 40 years of revenue service. This philosophy dates to the era prior to micro-electronics when manual calculations were the norm for structural and mechanical design, and when system controls were based on relay logic and electro-mechanical relays. Slow technological change during this period resulted in the continued use of mechanical and electrical systems over the vehicle life-span with a mid-life systems' overhaul.

This design philosophy in today's market technology leads to rapid obsolescence of electronic and microprocessor-based equipment. A shift in the passenger vehicle design philosophy from a 40-year vehicle structural design life to a 20-year vehicle design life will provide transit authorities with the lighter vehicles that are of more current technology. This shift allows car builders to provide vehicles based on new structural materials and with the latest electronic technology. This will result in increased vehicle availability and reliability, decreased operational cost due energy saving from decreased vehicle weight and reduced scheduled heavy maintenance.

C) Technical Overview

Please explain your proposed solution in detail and include the following information

1. Please explain your solution's technical components and specifications

Current mass transit vehicles are designed for a 40-year structural life and are designed for a scheduled systems mid-life overhaul after 15 to 20 years of revenue service. This design standard was established more than 40 year ago and continues to be perpetuated in rail vehicle technical specification. Given the rate of technological change today, CRRC proposes to define a procurement methodology based on a 20-year vehicle design life. This design life will enable NYCT to procure vehicles in a shorter time and allow them to maintain a fleet of cars with high reliability, the latest technology, maximum availability and minimum overhaul cost.

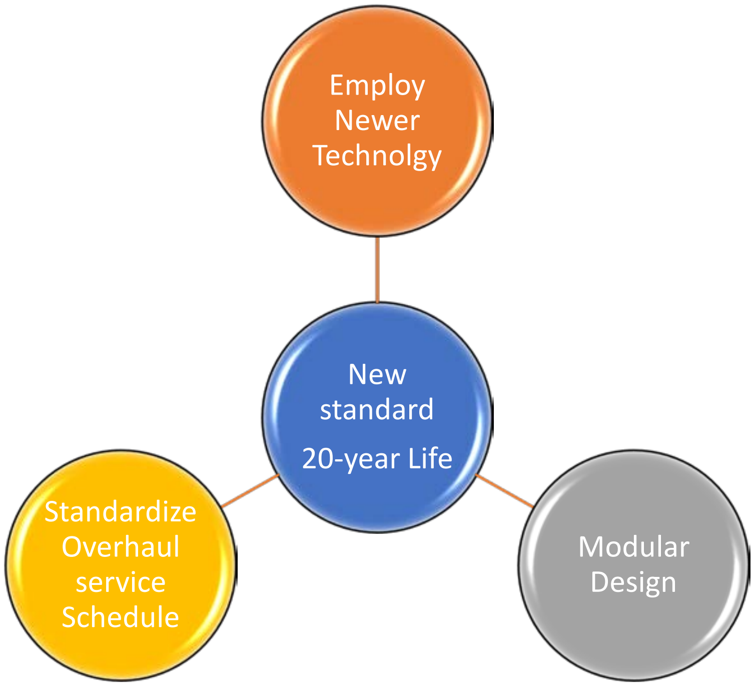
Such a design-life philosophy aims to capitalize on reduced overhaul costs and increased revenue (from improved reliability and energy savings) for accelerating procurement in pace with technological change.

The current standard of a 40-year structural life with a 20-year system overhaul imposes the follow constraints on the vehicles:

1. Complete Vehicle Technology Updates
    a. Complete vehicle technology updates are constrained by spatial considerations.
    b. Newer and more advanced Technology due to legacy equipment (such as door, HVAC and propulsion systems)
2. Material and Systems Rated for a 40-year Life
    a. Higher Material Cost to meet fatigue requirements
    b. Increased vehicle weight to meet fatigue requirements
    c. Performance Degradation over the vehicle life
3. Different system overhaul service schedule
    a. Reduces Vehicle Revenue Service Availability
    b. Reduced Vehicle reliability due to multiple removal and replacement of equipment

CRRC proposes to create a new standard based on a 20-year vehicle life. This will lead to multiple advantages in vehicle quality, availability and reduced cost.

20-year life car + standardized maintenance schedule		**40-year life car + non-standardized maintenance schedule**


Employ Newer Technolgy
New standard
20-year Life
Standardize Overhaul service Schedule
Modular Design

Standardization of Service and Overhaul Service Schedule

Various systems on the vehicle require periodic maintenance and overhaul based on each system manufacturer's requirements. During the design vehicle phase the authority, contractor and system manufacturer's work together to attain maintenance intervals that conform to an authority's needs. This is the design goal that often cannot be completely attained. Heavy maintenance of the vehicle systems involves non-concurrent schedules due to mechanical, electrical or electronic differences. Multiple dedicated maintenance schedules adversely impact the vehicle availability, the overhaul labor cost, and the risk of defects due to frequent removal and replacement of equipment adjacent to the system undergoing heavy maintenance.

The CRRC proposal intends to standardize the heavy maintenance service schedule of systems into one period at 10 years. The standardization would be applicable to all systems such that:

Systems with less than a 10-year overhaul service schedule will be upgraded to a 10 years interval.
System with greater than a 10-year overhaul service schedule to be reduced to a 10 years interval.

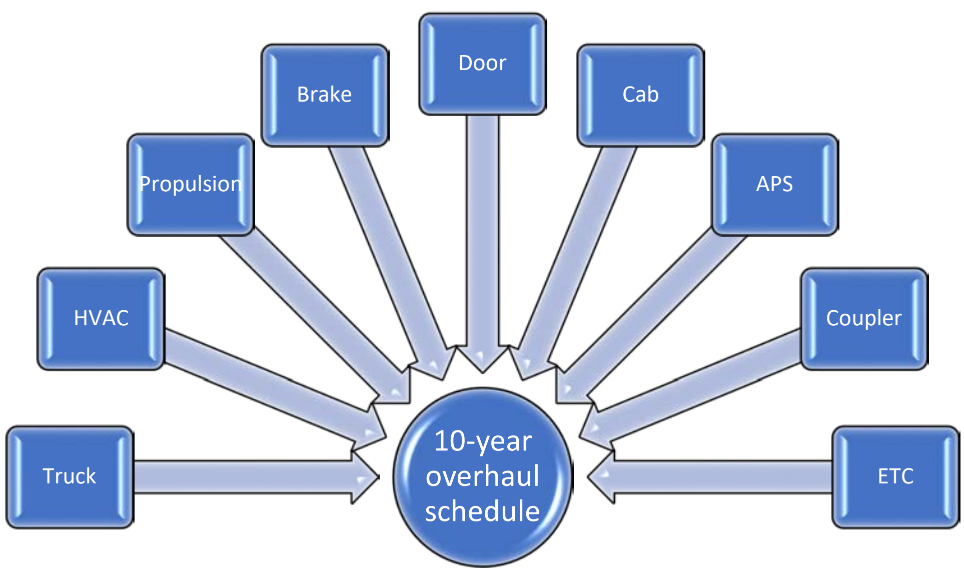


Figure 1: Standardized Maintenance

<u>Employment of New Technology</u>

The pace of technology evolution is faster today than in the past decades and continues to increase exponentially. Figures 2 and 3 show estimated rates of technology advancement for the next 20 and 40 years[1].

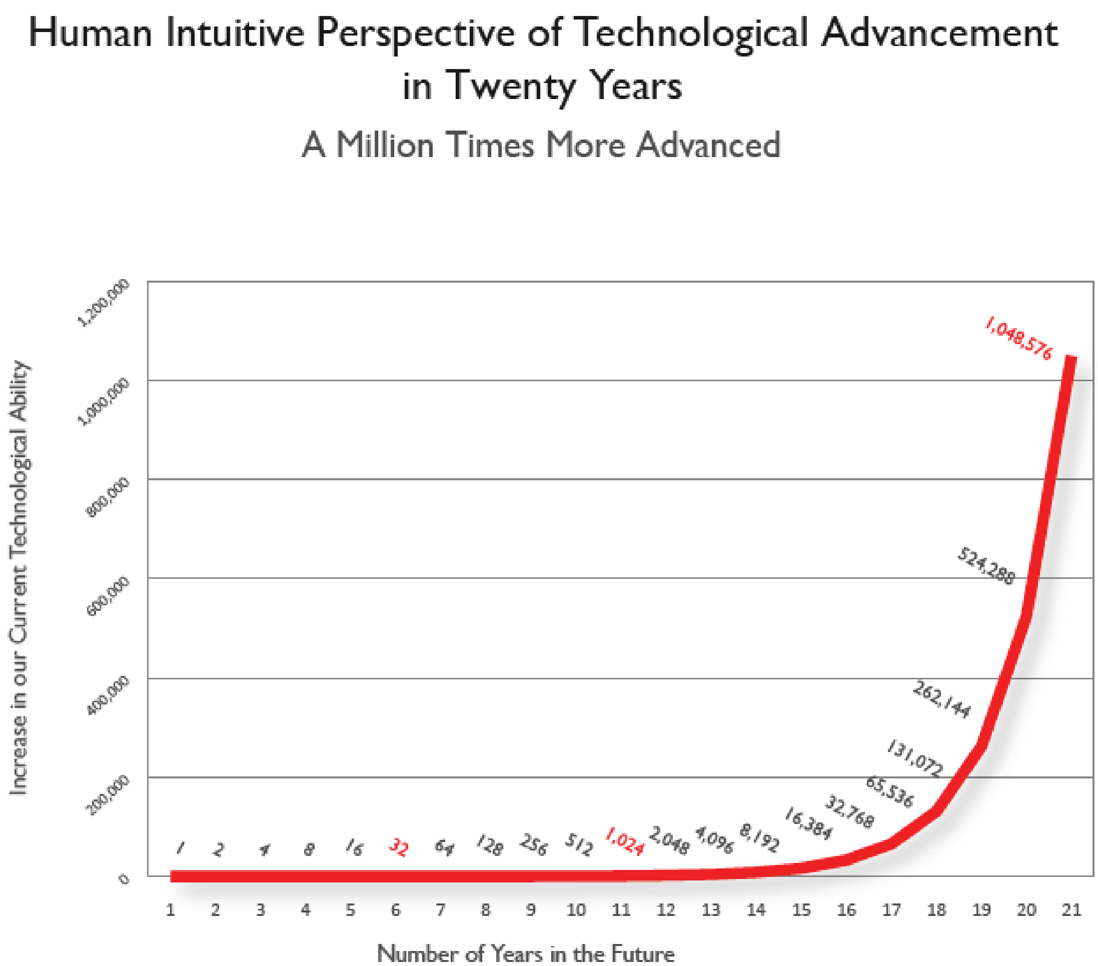


Figure 2: Technology Advancement in 20 Years

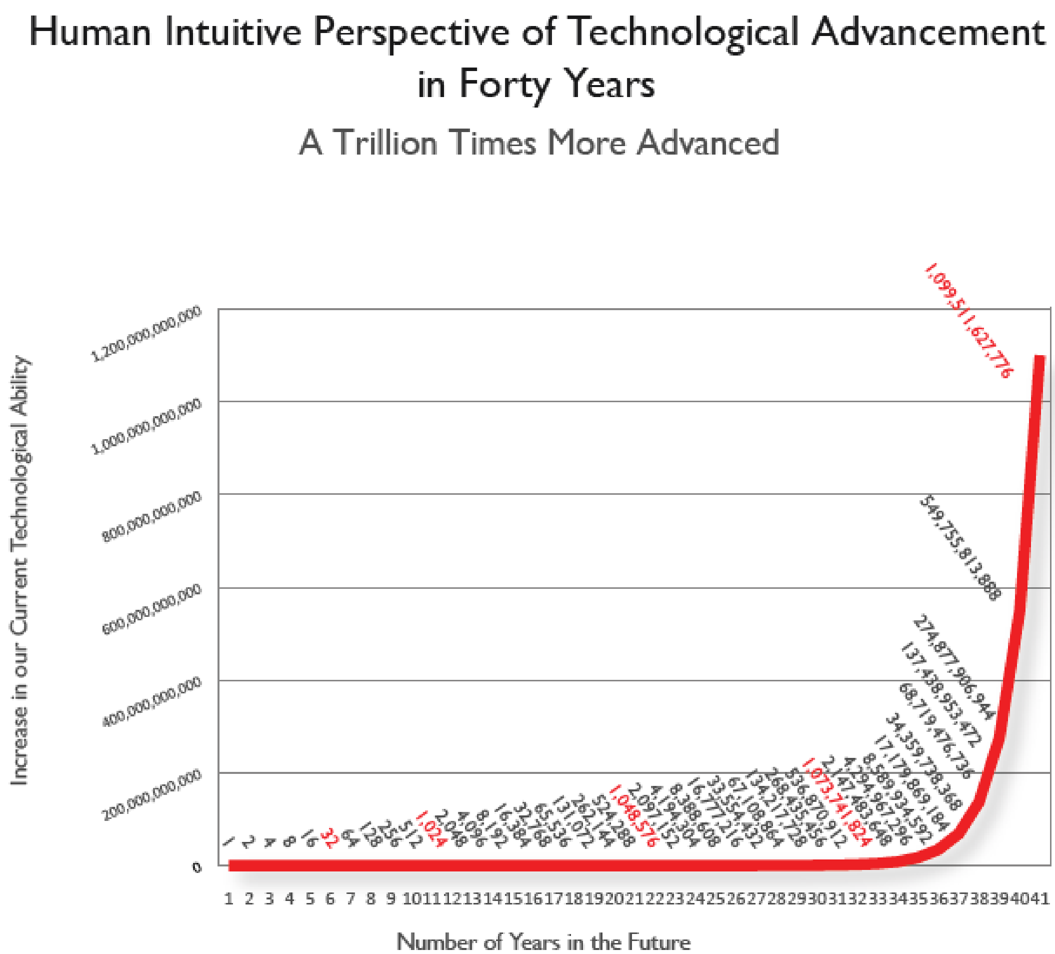


Figure 3: Technology Advancement in 40 years

CRRC proposes to proactively bring state-of-the-art technology to the rolling stock industry for delivering the highest quality system with minimal overhaul downtime and cost.

One example of a currently developing technology within the Transit Vehicle industry is the use of carbon fibers. Carbon fiber is a technology developed for the aircraft industry and now being applied to Rail Transit Vehicles. As a comparison, a typical truck is made of steel with a tensile modulus of about 29000 Kip/Square Inch (200 million kPa), the strongest carbon fibers are ten times stronger than steel and eight times that of aluminum, not to mention considerably lighter than both materials, by 5 and 1.5 times, respectively. That same material could be researched and developed for car body applications to greatly reduce car weight and lower operational costs.

Below are some examples of current developing technology[2]

- **Carbon Fibers**
  Carbon fibers are a new material already used in rolling stock truck applications. As a comparison, typical truck is made of steel and it has a tensile modulus of about 29 million psi (200 million kPa), the strongest carbon fibers are ten times stronger than steel and eight times that of aluminum, not to mention much lighter than both materials, by 5 and 1.5 times, respectively.

  The same material has the potential to be developed into carbody structural members to reduce weight for greater energy efficiency and lower operational cost.

- **Train Aircraft Protection (ATRP) System (note: acronym not matching)**

  The Train Aircraft Protection (ATRP) system is the first international and domestic use of the aerospace field of secondary radar technology conversion, applying on the rail communications in the field of security products. For the system is capable to overcome the influence of external complex electromagnetic environment, the system can detect and provide, with high reliability and under any weather condition, an early warning of the train speed and distance within a wide range of detection.

  The system can overcome complex external electromagnetic interferences, while reliably detecting and providing early train-speed and distance warnings within a wide range of detection and under any weather condition.

  Train radar protection system uses an independent design concept. The system does not rely on the signal system equipment to complete the independent operation of the train during the safe distance protection. Thus, it removes the complication of interfacing with the current signal system during overhaul service.

[1] Data from http://theemergingfuture.com/speed-technological-advancement.htm
[2] It is understood that more development and testing shall be required to validate the technology. This is demonstrated as an example how rolling stock could be benefit from the current technology

- **<u>Inverter</u>**
  The evolution of inverter technology for propulsion systems has changed rapidly with the use of new high-power semiconductor devices, from the earliest development of GTO, IGBT, IPM, and IGCT thyristors. The goal of inverter development is miniaturization, weight reduction, energy savings, environmental protection, reliability and economy. With the modularization, serialization and miniaturization of the inverter, a new trend of integrating the design and manufacture of the inverter with the auxiliary power converter and the train-supplied converter is being realized. Inverter cooling is another key technology, which requires the device to have better cooling efficiency, smaller size, easier maintainability, and be more environment-friendly. The current cooling methods are mainly air-cooled, oil-cooled, water bath, ebullition cooling and heat pipe cooling.

  Graphene integrated circuit is one of the next generation of transistor.
  Graphene is the narrowest electronic material which is composed of a single layer of carbon atoms arranged in a honeycomb formation. It possesses exceptional electrical, mechanical, optical and thermal characteristics that potentially make it less costly and power-consuming. Many universities and companies, such as IBM, are currently developing the next generation transistor based on graphene. This technology could be considered for the Propulsion system VVVF in the near future.

Following are some ideas to demonstrate how the state-of-the-art technology can potentially enhance the car quality and reduce the operational cost if car design can keep up-to-date with technology.

Modular Design
CRRC proposes to define a new design standard that allows the car to be designed under a completely modular methodology. This is done by minimizing the correlation between vehicle systems.

This modular design brings advantages such as:
- Ease of design & installation
- Ease of overhaul
- Ease of replacement with newer technology

The modulation involves standardizing mechanical interconnection such as coupler interface, and standardizing electrical interconnection such as CAB area control to simplify the interface, ensure the interchangeability among different suppliers, and minimize the single source challenge. Modulation will alsogreatly enhance the flexibility of the design and maintenance as well as reduce the cost for the Authority.

2. Does your solution interface with our existing system? If so, please explain how.

This is a completely new procurement standard to build the next generation vehicles. The interface with the existing system would remain minimal given the current track profile and condition.

3. Does your solution include proprietary technology? If so, would it allow interoperability with other vendors' solutions and to what degree?

Not yet. CRRC has started the planning in third quarter of 2017. In 2018, we are planning to form an alliance with industrial experts to further explore application of new technology for this project.

4. What key assumptions must you validate (e.g.: environmental obstacles) for your solution to be viable? Describe how your solution will address them.

To shorten the design and delivery cycle of vehicles, we need to lead the industry in development of a new standard that can meet the service life of vehicles with a 20-year life. There are couple of assumptions which need validation such as:

- Optimization of the car body can be obtained to realize a strong lighttight structure.
- A feasibility study must be conducted for the standardization of service life. The focus is the development of newer technology for systems that have a service life of less than 10 years.

5. What are the key benefits of your proposed solution?

Based on the new design and a 20-year life procurement standard, NYCT will be able to procure a car in a shorter time frame and to maintain a fleet of cars with the highest reliability, the latest technology, as well as with maximum availability and minimum overhaul service cost.

…..to procure cars more quickly and to maintain fleets with the…..

	Advantage
Newer Technology	Higher efficiency Lower operation cost
Modular Design	Flexible design Shorter design cycle Faster production Ease of maintenance and overhaul
Standardize Overhaul Service Schedule	Maximize car usability Minimize overhaul service cost Minimize risk of defect More sourcing opportunity

6. Supplemental Materials: Please provide any technical drawings, renderings or schematics that will help describe your solution.

Not Applicable

D) Implementation Detail

1. Please identify your solution's phase of development and deployment. Is it in commercial use? Is it in a testing phase? Is additional research and development required?

This proposal is in the planning phase. CRRC is investigating with research and development and with industrial experts.

2. Please identify the city and country where your solution has been developed or deployed, and the result to date. If your solution has never been deployed commercially, please explain what resources you will need to successfully complete deployment for the MTA.

The proposed concept has not yet been deployed. The resources required for deployment are within the management scope of CRRC and industry experts. CRRC anticipates the participation of the MTA (NYCT Engineering) as partners in the development via joint working sessions.

3. Have you done any analysis on how your solution may address regulatory requirements and industry standards? If so, please describe.

CRRC has extensive and vast experience in vehicle production with large database on vehicle system performance and reliability. We also understand the intent of a 40-year life design and the difficulties in maintenance and operations due to this standard. CRRC continues to conduct studies in the field of safety, design, operation, maintenance and procurement with industrial experts to create a new 20-year car life standard based on safety, reliability, availability and cost.

4. What are the key risks that could hinder the implementation or operation of your proposed solution? What actions could the MTA or other project stakeholders undertake to mitigate those risks?

This proposal intends to lead the industry to a higher and more advanced standard. CRRC needs the cooperation of industry experts including major transit authorities such as the MTA and major vehicle system suppliers to achieve this new standard. Dedicated participation, data and input from industrial experts would accelerate the success of developing this new standard.

5. Given the urgency to effectuate change in New York City subway system, please provide an implementation schedule for your proposed solution, assuming work begins at the start of 2018. Please clearly state any assumptions necessary for the MTA to achieve that timeline.

CRRC has already started the planning phase of this proposal in the third quarter of 2017. In 2018, CRRC will conduct additional studies within the industry and will begin forming alliances with industrial experts to define this new standard. CRRC welcomes the MTA to join in this alliance and share its expertise, data and ideas in relationship to existing product and operational practices. In 2022, CRRC plans to deliver and complete this first car based on this new standard**.**

6. What additional information and support do you need from the MTA in order to implement your solution?

As stated in item 5 above, CRRC welcomes MTA to join the alliance in order to provide valuable data and feedback regarding your product and operational practice.

7. Supplemental Materials: Please provide a project plan with a timeline that includes key activities, deadlines, and milestones. If your solution has been deployed commercially, please provide at least three references who have direct experience with your product (Name, Title, Company, Email and Phone Number).

E) Cost Detail

1. How much will it cost to implement your solution?

[redacted]

2. What are the key cost components?

- **How are they phased throughout the implementation timeline?**

[redacted]

3. Supplemental Materials: Please provide a cost schedule including key cost types (labor, materials, etc.).

Not Applicable