H2Rescue: Design and Deployment of PEM Fuel Cell-Battery Powered Hybrid Emergency Relief Truck Annual Merit Review

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DOE Award #: W9132T2020006

DOE Hydrogen Program
2022 Annual Merit Review & Peer Evaluation Meeting

June 8, 2022

Project Goals

- Design, build, test and demonstrate PEM fuel cell-battery powered hybrid emergency relief truck that can complete 180-mile round-trip to relief destinations and provide up to 25 KW of load following exportable power for a sustained period of up to 72 hours once on-site.

Expected goals and outcomes:

1. One Department of Transportation (DOT) road-certified (for demonstration purposes) hydrogen fuel cell Class 7 emergency truck with a primary power PEM fuel cell-battery hybrid power system capable of providing both propulsion and stationary export power
2. Fuel cell-battery powered hybrid emergency relief truck performance data through the required data templates. Test data report will include comprehensive performance data, safety data, and a listing of issues identified during operation of the unit

Relevance
The prototype fuel cell emergency relief truck developed in this project can be evaluated at the federal, state, and local levels across multiple emergency responder communities and if successful, could accelerate development and commercialization for a new vehicle product with improved capability for supporting emergency relief crews and the DoD.

Potential Impact

Life Cycle Costs & Emissions

- The fuel cell engine lifecycle costs will be primarily driven by the powertrain capital cost and the fuel operating costs.
- This hydrogen fuel cell emergency relief truck is estimated to reduce GHG emissions by 2.5 metric tonnes CO2e annually compared to the diesel truck and genset combination.
- An estimated 1,825 gallons of diesel fuel will be displaced per truck annually.

Commercialization Opportunity

- Successful demonstration of this project will provide proof of technical feasibility for a fuel cell powertrain system to be adapted to a mobile power generator for export power.
- Critical 1st step in identifying improvements and enhancements that can be explored in moving towards full production.
- This vehicle technology is directly applicable to any electric utility seeking to minimize impacts of planned outages and improve unplanned outage resiliency

Economic/ Market Opportunity

- Emergency Response
- Electric Utility Companies
- A 2017 Mckinsey report indicated that to achieve ambitious targets set for 2050, significant progress must be achieved by 2030:
  - With an estimated 50,000 buses & 350,000 trucks possibly by 2030, the projected fuel cell powertrain cost is approximately $120/kW. At a size of 90 kW per system, this results in market opportunity of >$430 million per year within 10 years (assuming 40,0000 units/year sales volume).

Overview

Timeline

- Project Start Date: October 1, 2020
- Design complete: November 2, 2021
- Build complete: July 15, 2022
- Project End Date: December 31, 2022

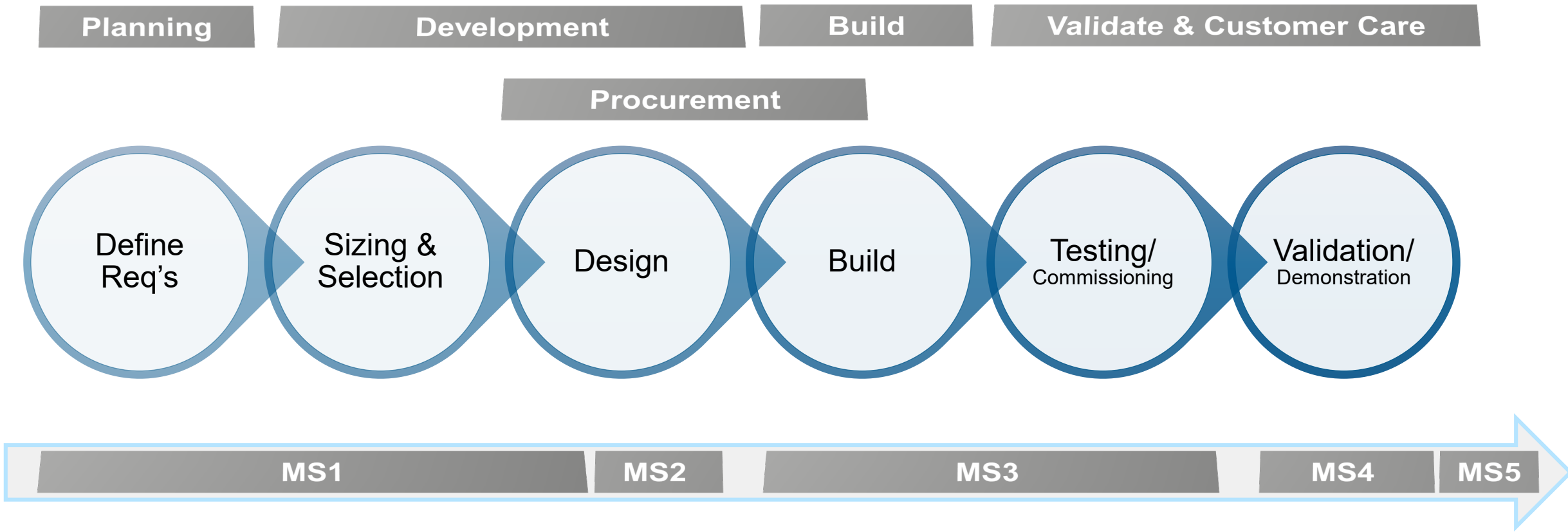
Budget

Total Project Budget: $2,408,558.38

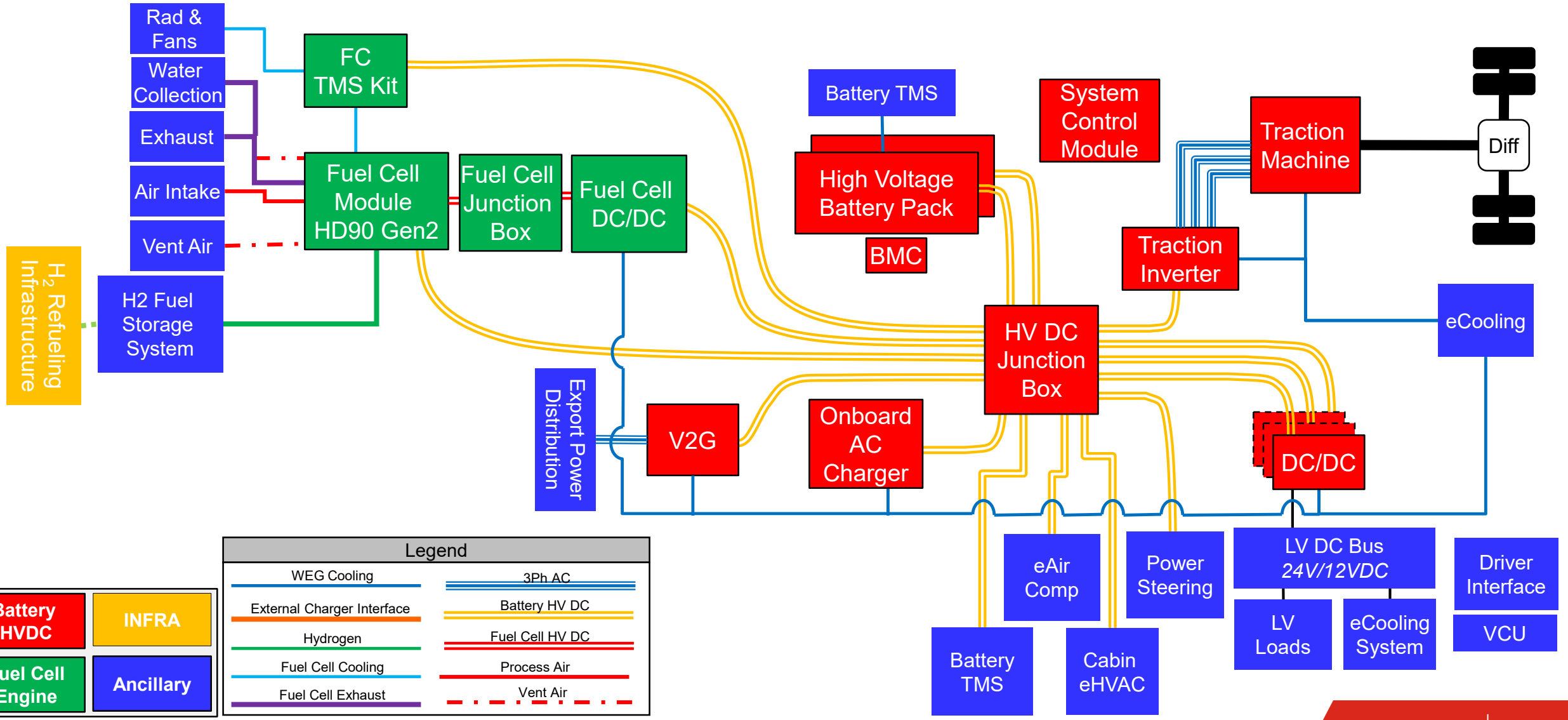
- DOE Share: $1,083,851.28
- Cost Share: $1,324,707.10
- DOE Funds Invoiced: $258,816.08
- Cost Share Funds Spent as of 3/31/2022: $538,543.29

Partners	Role
U.S. Army Corps of Engineers ERDC-CERL	FC Technical Lead & Contracting Officer Representative
U.S. Department of Energy- Hydrogen and Fuel Cell Technologies Office (HFTO)	DOE Team Lead & ORISE Fellow
U.S. Department of Energy - Vehicle Technologies Office	Technical Leads
U. S. Army Ground Vehicle Power and Mobility (GVSC)	Technical Leads
Science & Technology Directorate- U.S. Department of Homeland Security	Technical Lead & Sr. Science Advisor
Federal Emergency Management Agency	Technical & Program Leads
U.S. Naval Research Laboratory	Technical Lead
Cummins Electrified Power NA Inc- Recipient	Agreement & Technical Leads

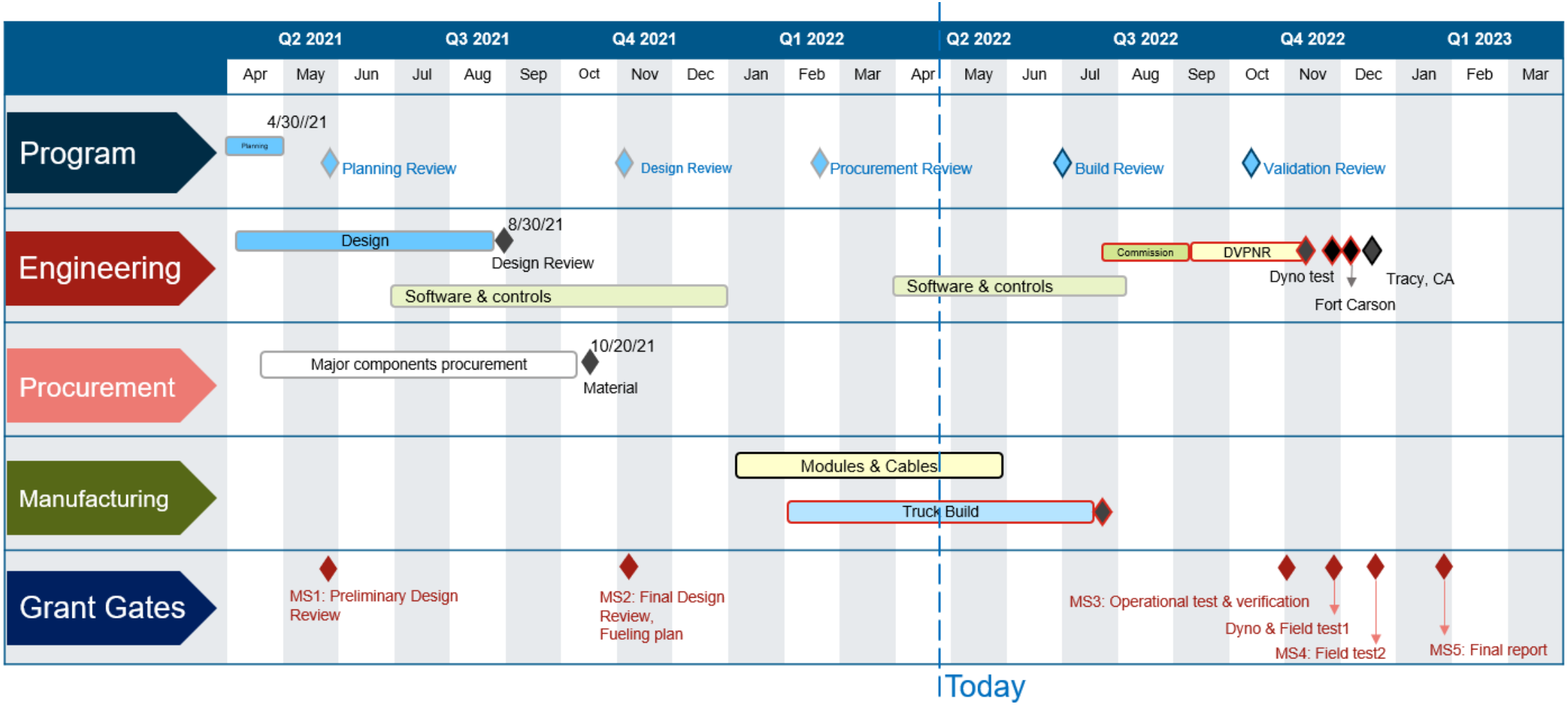
Approach



Powertrain Architecture



Program Schedule



Accomplishments & Progress

Accomplishments

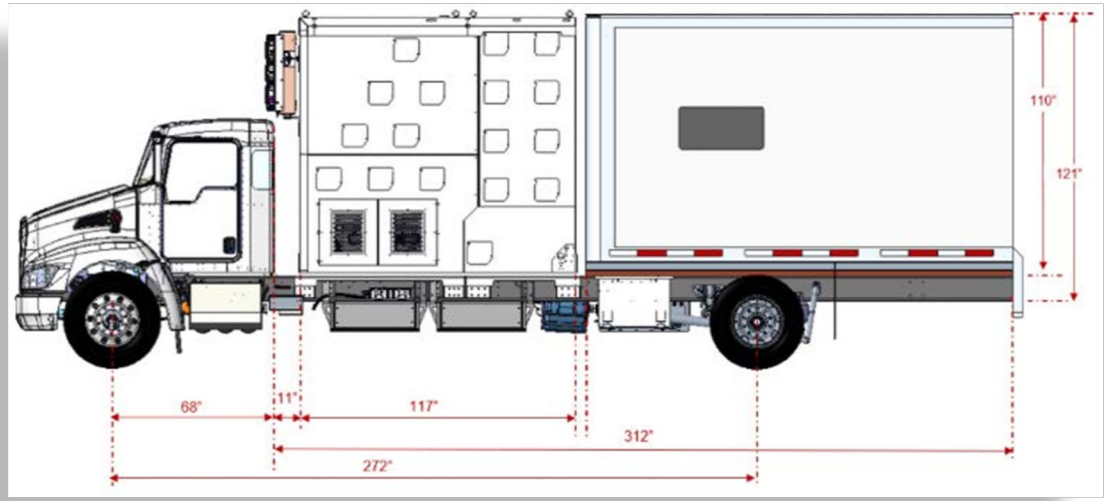
- ✓ Submitted Final Vehicle Design Report in February ‘22
- ✓ Completed Emergency Relief Center build & installation
- ✓ Received majority of long-lead items

Progress

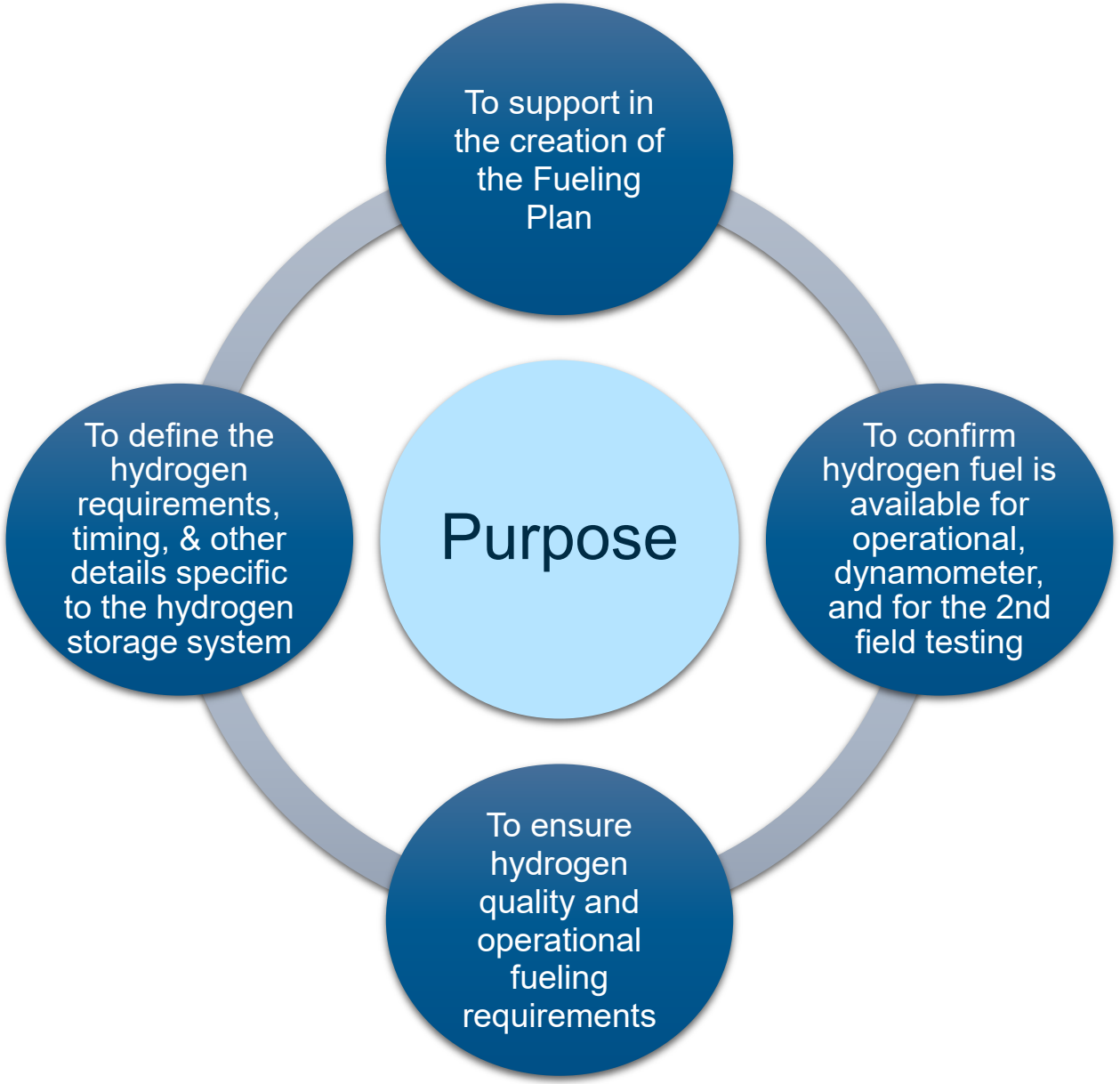
- Started wire harness builds
- Began NREL discussions on Fuel Plan
- Began discussions on Dyno Test Plan
- Vehicle Titling/ Registration/ Plating

Vehicle Specifications & Vehicle Concept

Vehicle Specifications	
Make/Model	Kenworth/T370 MY2020
Classification	Class 7 Medium Duty Conventional
Application	Rescue Vehicle with Mobile Command Center
Truck Dimensions:	
Length	421”
Height	121” (from bottom of frame rail)
Width	108”
GVWR	33,000 lbs
Wheelbase	272”
Powertrain	Cummins PowerDrive PD7500FC
Traction Motor:	
Rated Power	245 kW (350 kW peak)
Rated Torque	3400 Nm (2507 lb-ft)
Transmission	Direct Drive
Hydrogen Fuel Cell	Cummins HD90 PEM Fuel Cell (90kW)
High Voltage Battery	155kWh (2 pack); 500-700Vdc
Hydrogen Storage	176.4kg @ 700bar, 18 tank system
Target Range	180 miles +72 hours of Export Power up to 25kW
Emissions	Zero emissions Fuel Cell Electric Hybrid



Collaborations: NREL



Remaining Challenges & Barriers

Material Readiness

Supply chain delays pushed out scheduled tasks to build/ integrate the truck

Mitigation:
Monitoring the supply chain delays & reprioritizing the tasks

Testing & Hydrogen Availability

175kg H2 availability @700bar in California

Mitigation:
Use 350bar as needed based on availability for testing/validation

Proposed Future Work: FY ‘22

- We are on target to complete the remaining grant milestones MS3 -5 as shown below by year end.
- Continue and complete the following reports:
  - Monthly & Quarterly Status Reports
  - Quarterly SF425 Reports
  - US Manufacturing Plan
  - Fueling Plan
  - Draft & Final Report

Major Tasks	Milestones		Status
1) Administration & Project Management	MS5	Final Report	0%
2) Vehicle Design	MS1	Preliminary Vehicle Design	100%
	MS2	Final Vehicle Design (Go/No-No Decision)	100%
3) Build Vehicle Prototype	MS3	Vehicle Prototype	40%
4) Vehicle Demonstration	MS4	Vehicle Demonstration & Testing Complete	0%

Any proposed future work is subject to change based on funding levels*

Project Summary

Q4 ’21	Q1 ’22	Q2 ’22	Q3 ‘22	Q4 ‘22
✓ Completed Design Review	✓ Finished Emergency Relief Build Center	➢ Harness and sub-assembly build in process	➢ Complete Vehicle Build	➢ Begin Dyno and Field Tests (Fort Carson, CA & Tracey, CA)
✓ Completed MS2: Final Vehicle Design & Obtained Go/No-No Decision	➢ Stock truck preparation for upfitting	➢ Begin H2 Storage Tank Installation	➢ Begin Vehicle Commissioning	➢ Begin & Complete MS4: Data Collection & Analysis
✓ Started Emergency Relief Build Center		➢ Begin Vehicle Build	➢ Complete MS3: Vehicle Integration & Verification	➢ Begin MS5: Final Report

Continue to submit Monthly & Quarterly Status Reports, submit Quarterly financial reports, and conduct monthly project updates meeting.

Potential Impact:

1. Life Cycle Costs & Emissions: pathway to provide competitive operating costs to HD diesel engines, reduce GHG emissions, displacing diesel fuel
2. Commercialization Opportunities: mobile power generator, enhancements towards full production, & minimizing impacts of planned/ unplanned outages
3. Economic/ Market Opportunities: Emergency Response, electric Utility companies, & $430M in market opportunity

Current Mitigations on:

1. Material Readiness
2. Testing & Hydrogen Availability

Any proposed future work is subject to change based on funding levels*

Q+A

Technical Backup & Additional Information

- NA


Cummins