U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND

Hydrogen Fuel Cell Project Overview and Update

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APPROVED FOR PUBLIC RELEASE

Fuel Cell Technologies Technical Paths

Core Funded

JP-8

Small Unmanned and Combat Platforms

Onboard Reformer

Solid Oxide Fuel Cell Electric Power

- *Focused on small unmanned and combat ground vehicles*
- *Enabling extended silent watch capabilities*
- *Military specific partnerships*

Non-core Funded

Standalone Reformer

GAS

Gaseous Hydrogen

Next Generation Fuel Cell Platforms

GAS

Gaseous Hydrogen

LIQUID

Liquid Hydrogen

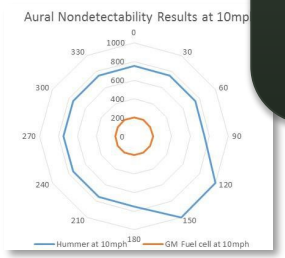
- *Leveraging automotive investments*
- *Accessing hydrogen use cases in Military and Commercial applications*
- *Partnering with external Government agencies*

Unique Funding Mix Enables Continued Exploration of Hydrogen Fuel Cells

Hydrogen Fuel Cell Operational Impact

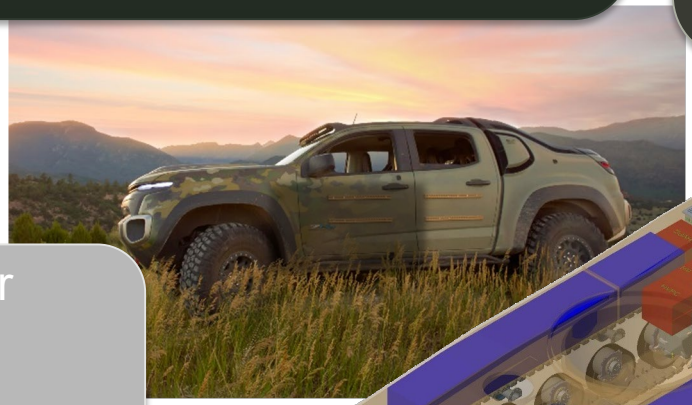
Reduced Signature

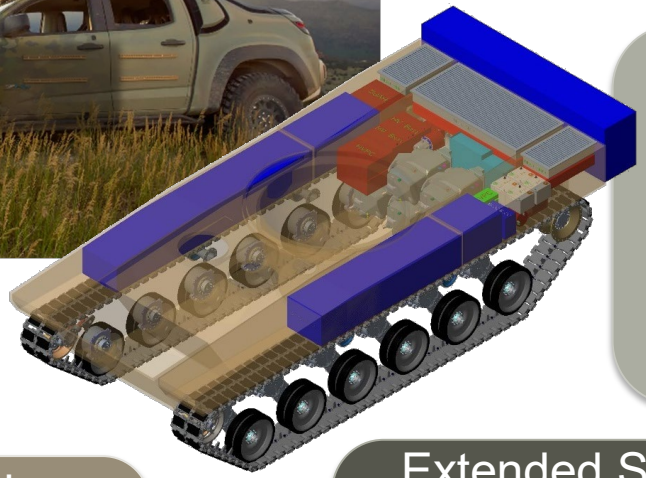
- 75%-90% Acoustic Improvement
- Thermal – Runs Cooler
- Remain undetected
- Place dismounts closer to objective
- Enables new TTPs, ex: closer support by fire



Enables Improved Silent Off-Road Mobility

- Extended duration
- Fast and instant acceleration
- Greater Terrain Access
- Increases survivability





Enables Water Generation

- 4.5L of water per kg of H2 consumed
- Water at point of need
- Improves self-sufficiency

Increased Onboard and Exportable Power

- Fuel Cells can export 100% of their power
- Enables Directed Energy
- Eliminates need for tow behind generators
- Decreases TOC footprint

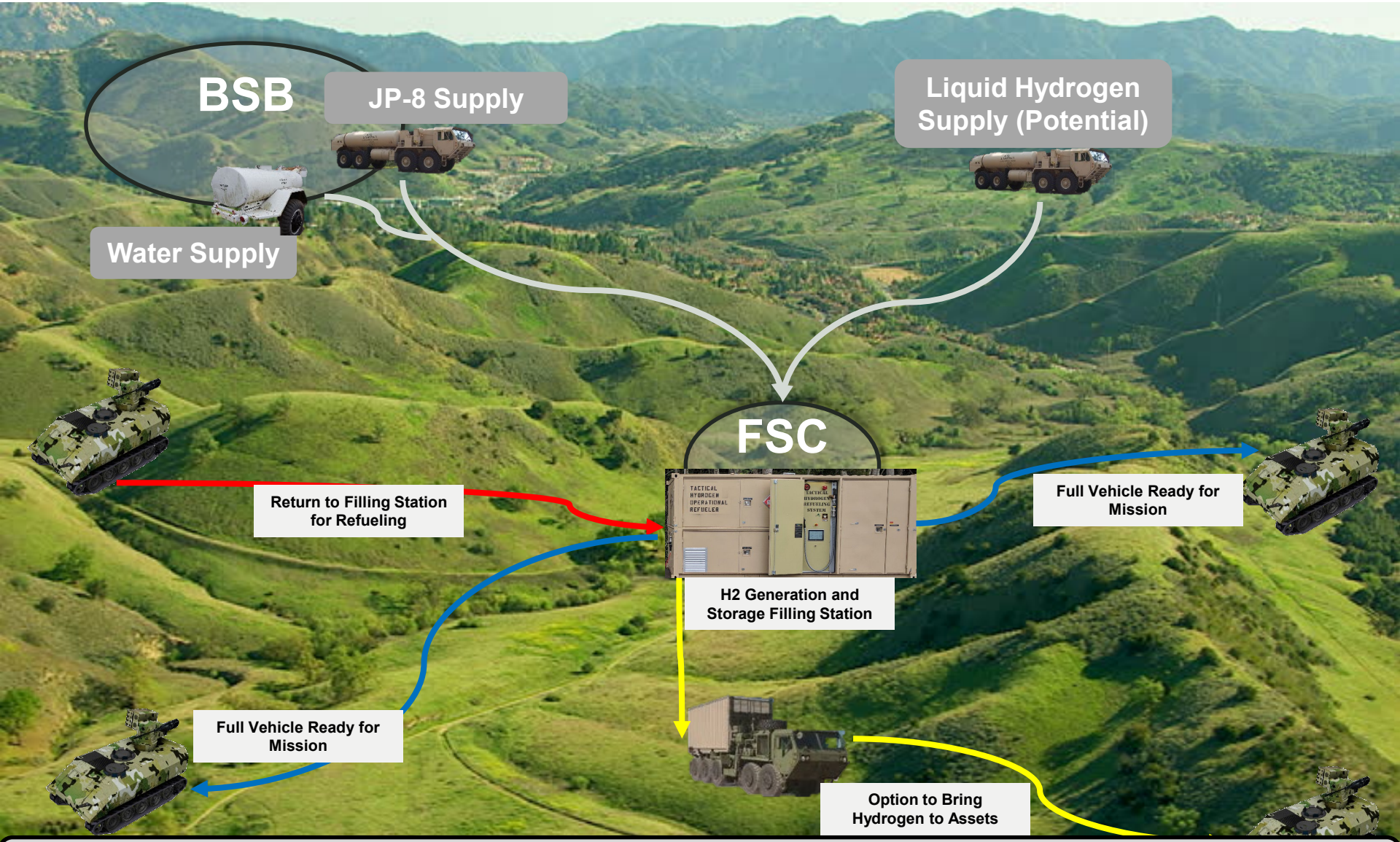
Extended Duration without Resupply

- Approx 72hr increase in ABCT endurance @ 70% combat power
- 50%-60% increased duration

Extended Silent Watch

- 16 kwh per kg of H2
- 4x duration compared to current fielded batteries
- Enables undetected reconnaissance

Operational Capability Overview



Extended Silent Operations and Range
Commercial Technology is not Designed to be Mobile

Overall Program Focus

1. Demonstrate to customers the benefits/advantages of using hydrogen and fuel cell-based systems
   A. Requirements development/informing and transition planning
      i. TMT for PEO STRI
      ii. Fuel Cell MAVRC for PM MCS RCV-M surrogate
      iii. Hydrogen Ecosystem MPGS for PM E2S2
      iv. H2@Rescue for DHS and PEO CS&CSS Tactical Vehicle Fleet Electrification
      v. Multi-Stack Fuel Cell Array for PEO CS&CSS Tactical Vehicle Fleet Electrification
      vi. FC MRZR & Hydrocan for SOCOM/Navy Emergency Refueling Needs
      vii. Hydrogen Ecosystem JP8 Reformer & Multi-Fuel Reformer for CASCOM & MSCOE

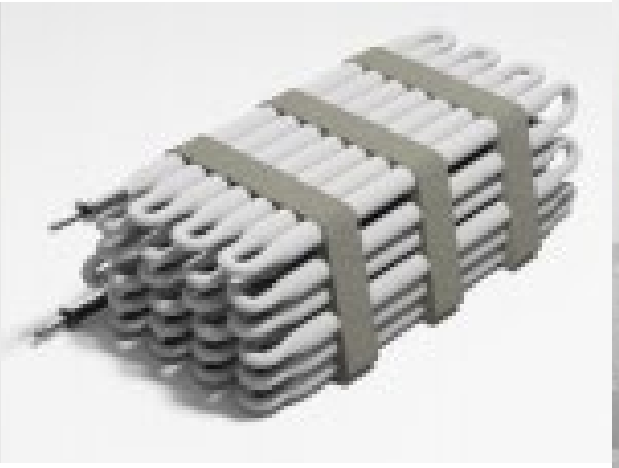
2. Increase fuel cell power output for larger applications
   A. Hydrogen Ecosystem MPGS
   B. Multi-Stack Fuel Cell Array

3. Increase hydrogen transportation efficiency (reduced logistics)
   A. Water collection / reuse
      i. Hydrogen Ecosystem MPGS
   B. Aluminum powder hydrogen generation
   ~~C. Liquifaction~~
   ~~D. Cryocompression~~

4. Increase on board hydrogen storage efficiency on weight and/or volume
   A. Metal/chemical hydrides
      A. SBIR / OSD Title III
   ~~B. Liquifaction~~
   ~~C. Cryocompression~~

Tactical Moving Target - Vehicle

Demonstrate feasibility and advantages of using hydrogen fuel cells and conformable hydrogen storage tanks on an unmanned training system

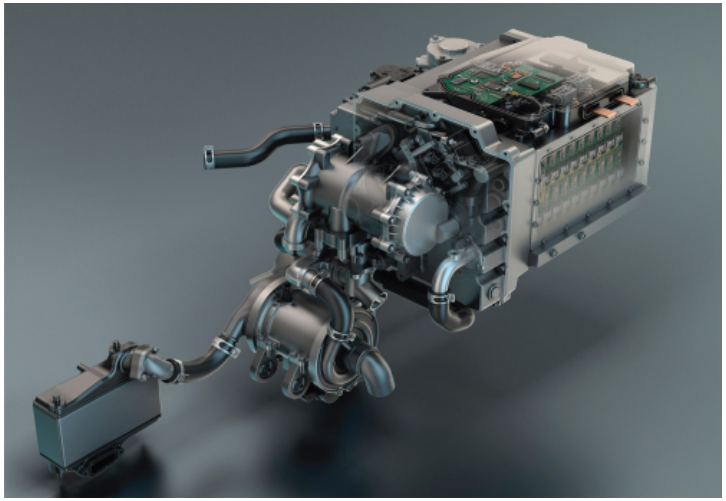


Courtesy of Noble Gas

Courtesy of Pratt & Miller

Fuel Cell Robotic Vehicle

Convert existing Expeditionary Modular Autonomous Vehicle (EMAV) into a hydrogen fuel cell powered system for full time silent operation



Courtesy of General Motors

Courtesy of Pratt & Miller

Mobile Power Generation System (MPGS)

60kW Fuel Cell Generator meeting the size specifications of the existing fielded generator (15kW of battery energy storage) to demonstrate silent power availability

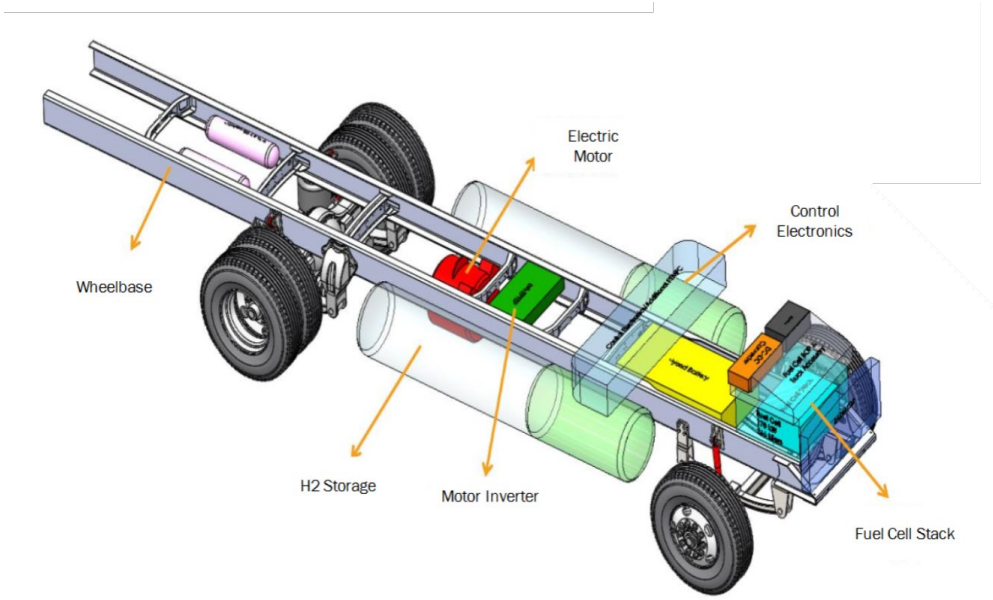
Benchmark	Dimensions
AMMPS 60kW	82 x 36 x 53 inches 2.1 x 0.9 x 1.3 m
AMMPS 100kW	106 x 40 x 65 inches 2.7 x 1.0 x 1.7 m

Courtesy of General Motors

H2Rescue Vehicle - DOE, DHS, CERL, NRL

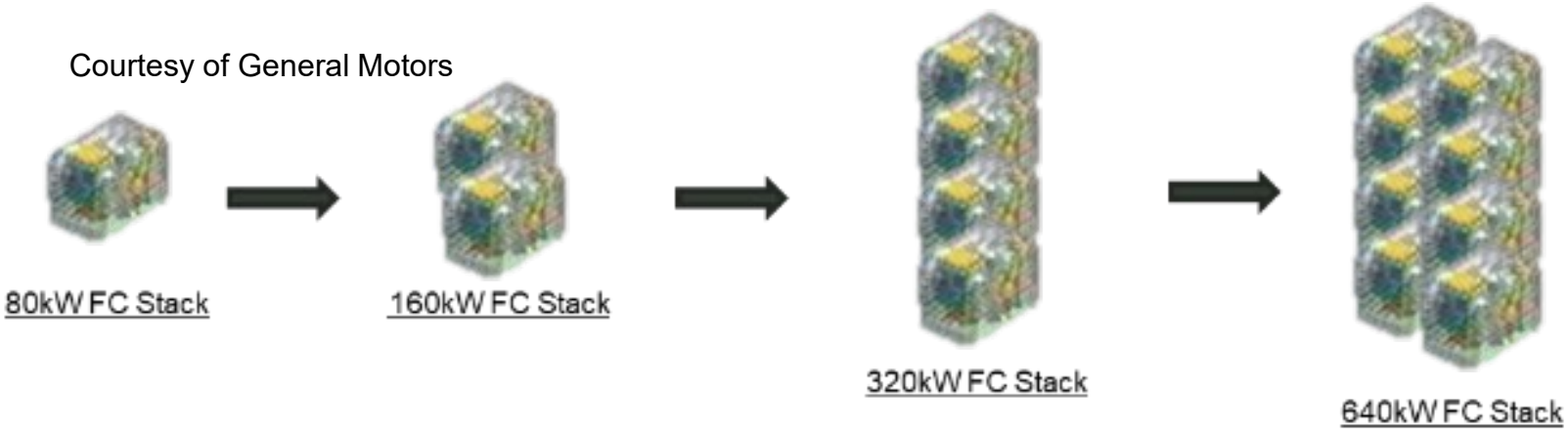
Design and fabricate a hydrogen fuel cell powered class 7 truck to understand the feasibility and advantages of using hydrogen fuel cell powertrain in disaster mitigation efforts
(180 mile range, 25kW export power for 72 hrs)

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY



Multi-Fuel Cell Array

Courtesy of General Motors



Array Design and Fault Analysis

An analytical study and conceptual design showing future multiplatform fuel cell systems be configured and controlled.

A demonstration of existing commercial fuel cell systems configured and controlled as an array showing some level of fault tolerance.

Fuel Cell Performance Under Extreme Conditions

Quantification of the impact of severe ambient conditions in hot, dry climates on the fuel cell stack through testing.

Predicting Field Support for Fuel Cell Power Systems

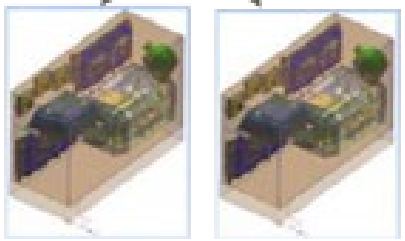
Field support projections and comparison with other conventional and alternative power systems

Enabling Hydrogen on the Battlefield

300 kg/day hydrogen production from JP-8
Mobile hydrogen refueling trailer (T20) and a storage trailer

Jp8 Reformation System (3 x 20' ISO)
- JP8 Reformer for 350kg H2/day
- Hydrogen Compression & Storage
- Refueling Pump

Mobile Refueling Trailers



Mobile Power Generation System (MPGS)

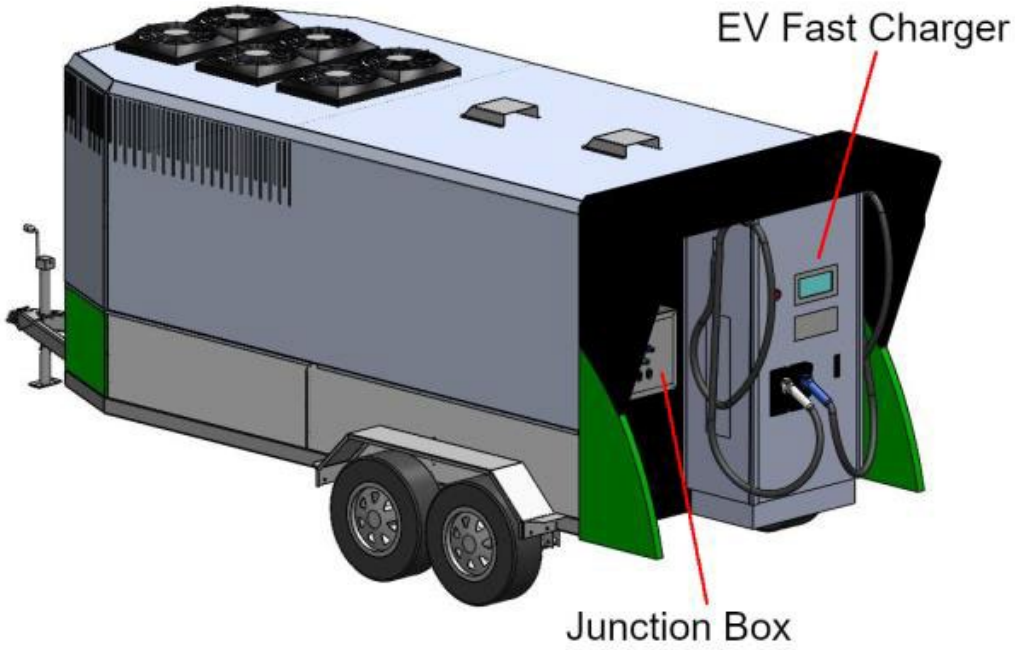
Courtesy of General Motors

In-house MRZR and HydroCan

Convert Polaris MRZR to a fully functional fuel cell vehicle
Collaboration with NSWC-Crane on motor and gearboxes
HydroCan development by Skyhaven – Emergency hydrogen source carried in existing ‘Jerry Can’ shape (lithium hydride)

Gridless DC Fast Charger – Fuel Cell Based

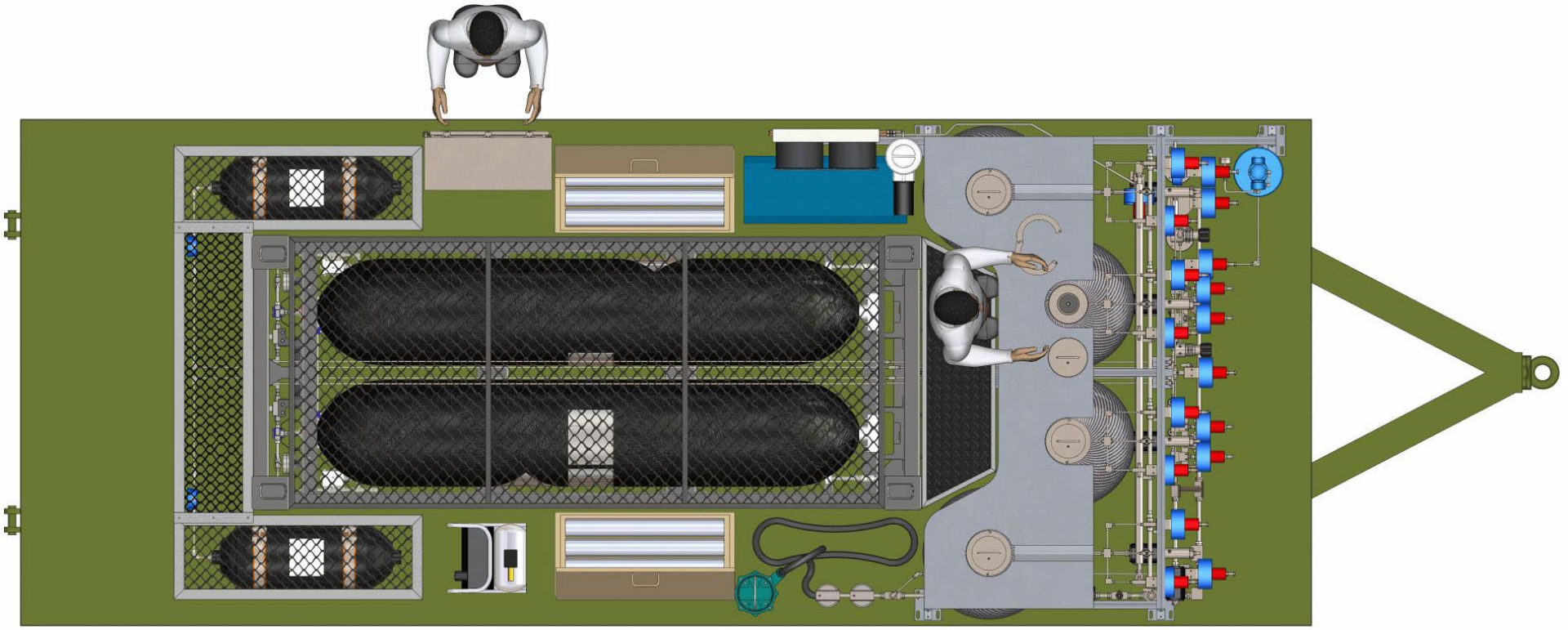
Gridless DC fast charger trailer and generator capable of 150kW with onboard hydrogen storage, fuel cell, batteries, and power conditioning and electric vehicle charger interface



Courtesy of General Motors

Hydrogen Generation and Refueling

Hydrogen refueling trailer that generates hydrogen from aluminum alloy and water and chemically compresses it to 900 bar, no mechanical compressor needed (No external power needed)



Courtesy of General Atomics

Detroit Arsenal H2 Storage Concept

Work with utility partners and industry to demonstrate resilience and meet Army Installation energy requirements using hydrogen for large scale energy storage. Create transition ready nodes that can be replicated across the State and DOD CONUS and OCONUS.

Thank You!

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