Inexpensive Delivery of Cold Hydrogen in High Performance Glass Fiber Composite Pressure Vessels

**Andrew Weisberg, Salvador Aceves,
Blake Myers, Gene Berry,
Francisco Espinosa, Tim Ross,
Elias Ledesma-Orozco
Lawrence Livermore National Laboratory**

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PDP8

This presentation does not contain any proprietary or confidential information

Overview

Timeline

- Start date: **June 2008**
- End date: **June 2011**
- Percent complete: **0%**

Budget

- Total project funding
  - DOE: **$1500 k**
  - Spencer: **$375 k**
- Funding received in FY08:
  - **$500 k**
- Funding for FY07:
  - **New project**

Barriers

- **F. Gaseous hydrogen storage and tube trailer delivery cost**

Targets

- **700 kg tube trailer delivery capacity**
- **$300 k purchase cost for 700 kg trailer**

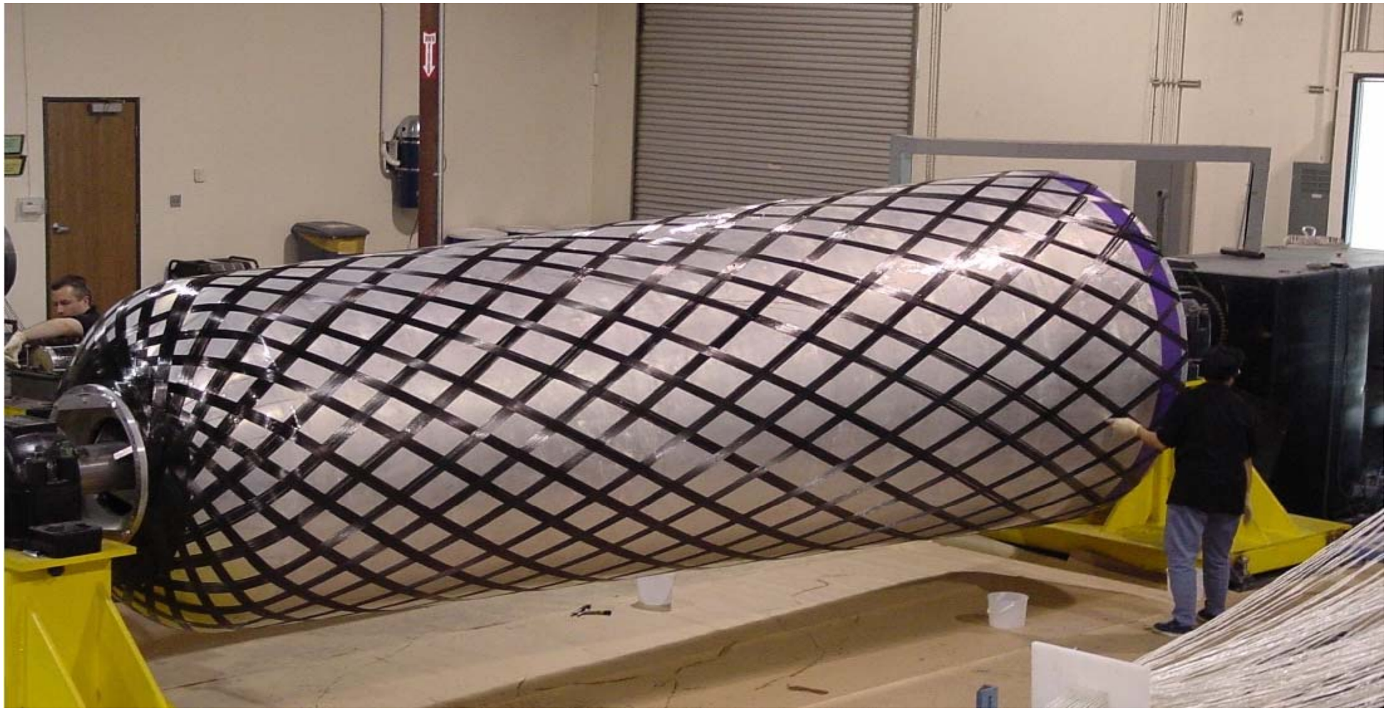
Partners

- **Spencer Composites provides manufacturing expertise and cost share**

Objective: Demonstrate inexpensive hydrogen delivery through synergy between low temperature (200 K) hydrogen densification and glass fiber strengthening

- Colder temperatures (~200 K) increase density ~35% with small increases in theoretical storage energy requirements
- Low temperatures are synergistic with glass fiber composites
  - higher glass fiber strength (by 50%?) at 200 Kelvin (vs. 300 K)
  - higher gH_2 density increases mass-limited trailer capacity
- glass composites (~$1.50/kg) minimize material cost
- Increased pressure (7,000 psi) minimizes delivery costs
- Dispensing of cold hydrogen reduces vehicle vessel cost ~25%

Milestones: We have established a detailed work plan leading to reduced hydrogen delivery cost



- *Produce Generation 1 cryogenic glass fiber vessel*: **June 2009**
- *Fabricate 3 Generation 2 pressure vessels with improved performance:* **October 2010**
- *Conduct performance tests on Generation 2 vessels:* **April 2011**
- *Write final report:* **June 2011**

Approach: Build and test inexpensive glass fiber pressure vessels that reduce hydrogen delivery cost to below $1/kg

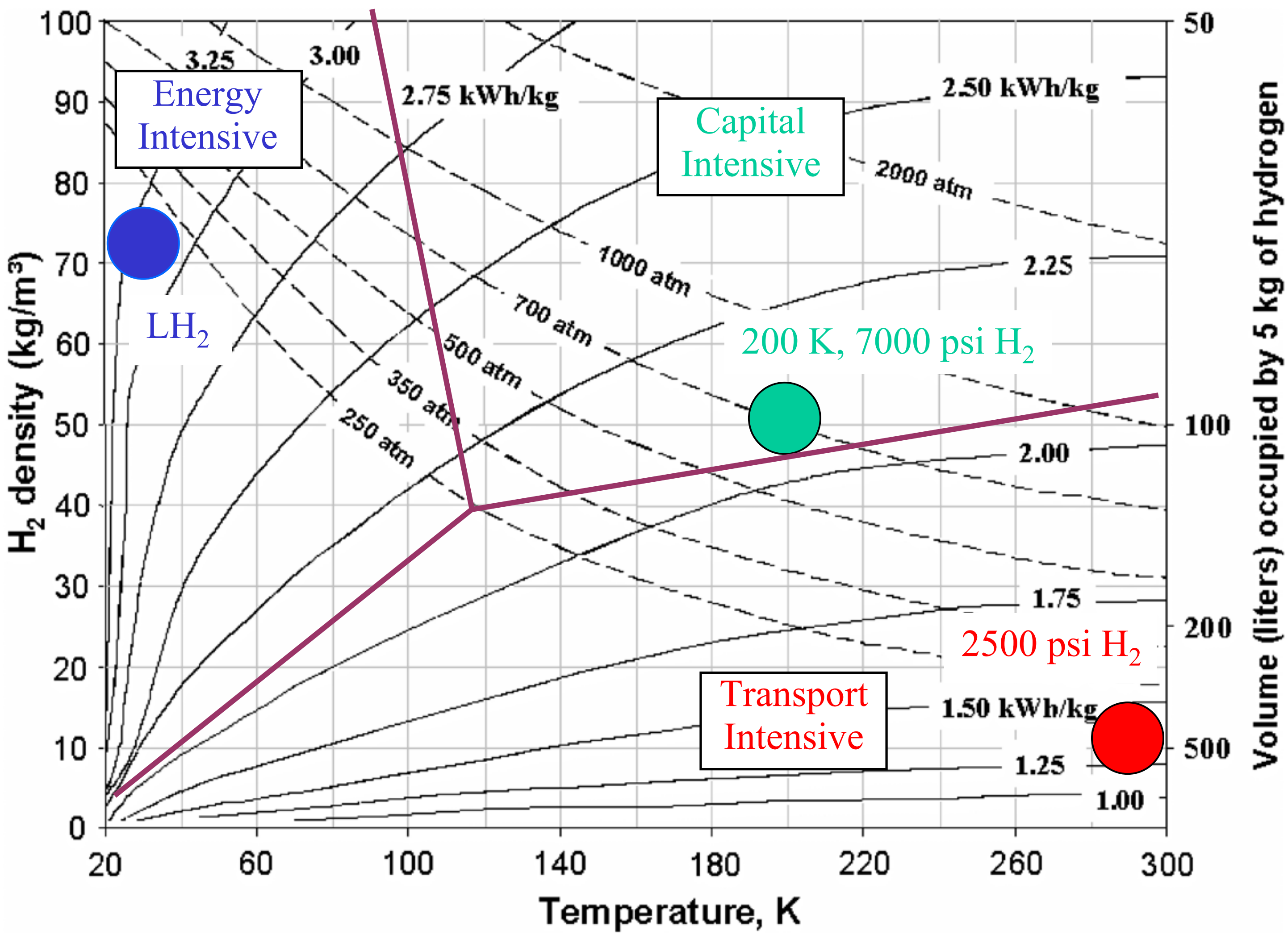
Wind vessels

Test at cryogenic conditions

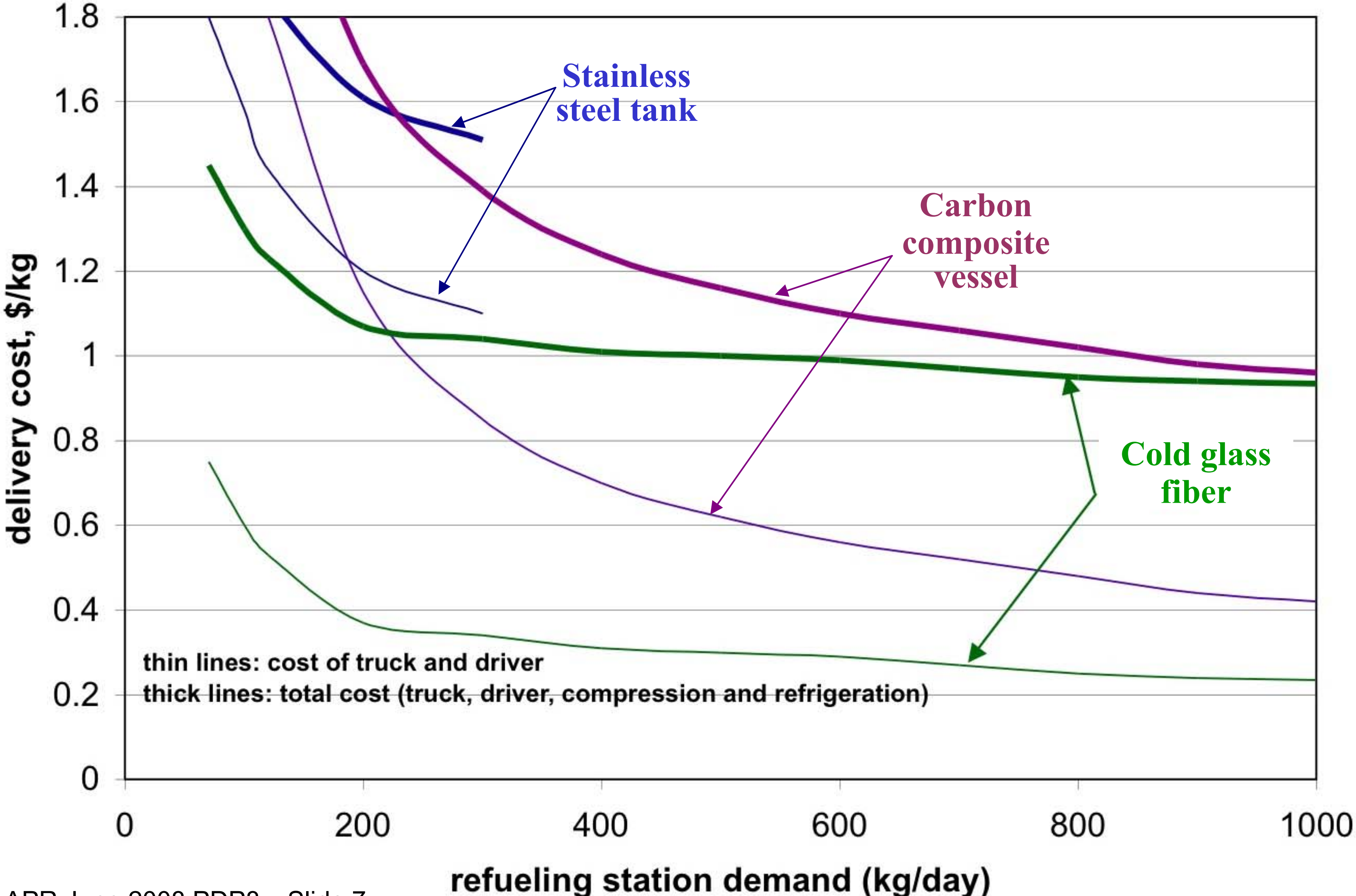
Burst tests

Cycle test

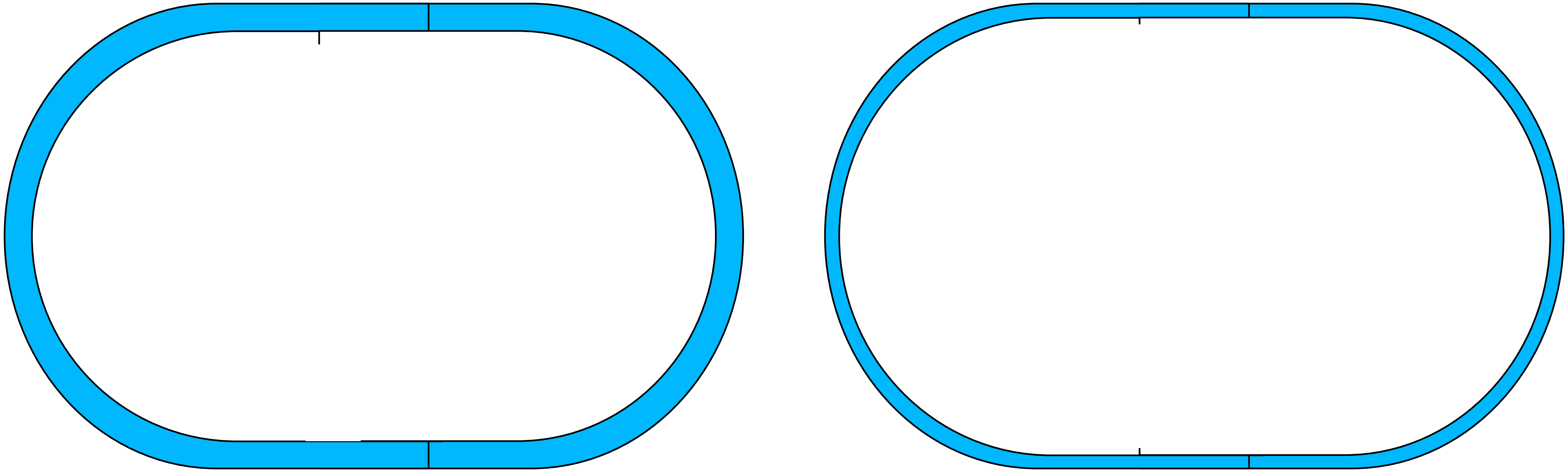
Accomplishments: we have identified an operating regime (200 K, 7 ksi) that shows promise for minimizing delivery cost



Cold glass fiber pressure vessels minimize tanker truck cost, enabling inexpensive hydrogen delivery



Dispensing cold hydrogen avoids overpressure during fill, reducing vessel cost by 25%
Reduced vessel cost saves a driver $0.20/kg H_2
(assuming a vessel that meets the 2010 DOE goal of $4/kWh)



Today's automotive vessel

- Filled with warm hydrogen
- Service pressure: 5000 psi
- Fill pressure: 6250 psi
- Burst pressure: 11,250 psi
- Cost: $ 1333 (2010 goal)

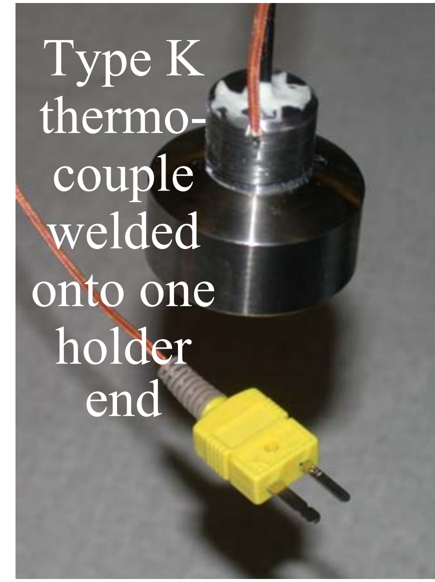
Future automotive vessel

- filled only with cold H_2
- Service pressure: 5000 psi
- Fill pressure: 5000 psi
- Burst pressure: 9000 psi
- Cost: $ 1066

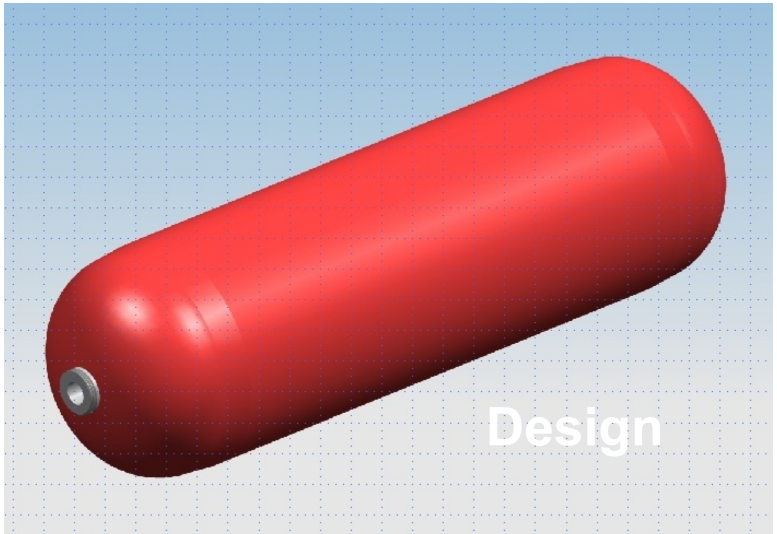
We have demonstrated the feasibility and practical advantage of cryogenic pressure vessels in an experimental vehicle

- ***The high capacity of liquid hydrogen without the evaporative losses:*** **~10X longer thermal endurance than low pressure LH_2 tanks essentially eliminates boil-off.**
- ***Less expensive than compressed hydrogen vessels:*** **LH_2 capable vessels use 2-3x less carbon fiber than conventional compressed H_2 vessels.**
- ***Infrastructure and driver advantages from refueling flexibility:*** **Meets real time driver priorities (range, cost, ease, energy), saves energy of cooling and liquefaction and increases fuel availability.**

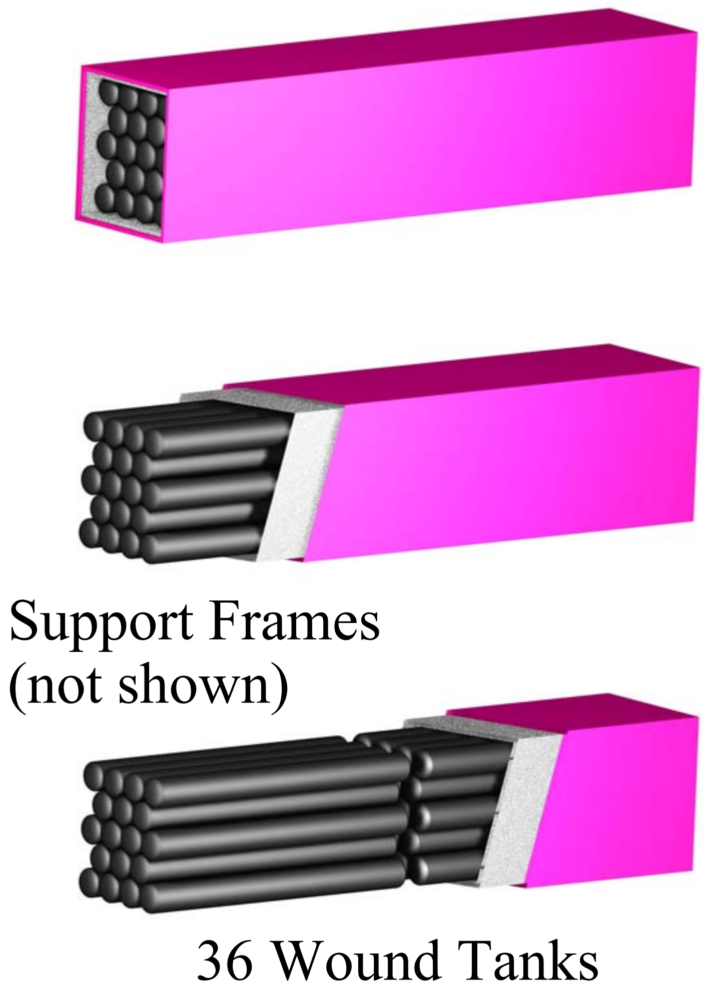
In a parallel effort, we are measuring the strengthening of glass fiber at reduced temperature



Future work: Build and test inexpensive glass fiber pressure vessels that considerably reduce the cost of hydrogen delivery



Summary: Our synergistic approach to hydrogen delivery considerably reduces distribution cost



- ***Hydrogen cooled to 200 K densifies by 35% at low energetic cost***
- ***Inexpensive glass fiber strengthens by ~50% when cooled to 200 K***
- ***Cryo-compressed vessels have considerably larger thermal endurance (~10x) than liquid hydrogen tanks***
- ***Dispensing of cold (200 K) hydrogen reduces vehicle vessel cost by 25%***