SOFC APU Update

and

Technology Challenges

DELPHI

Automotive Systems

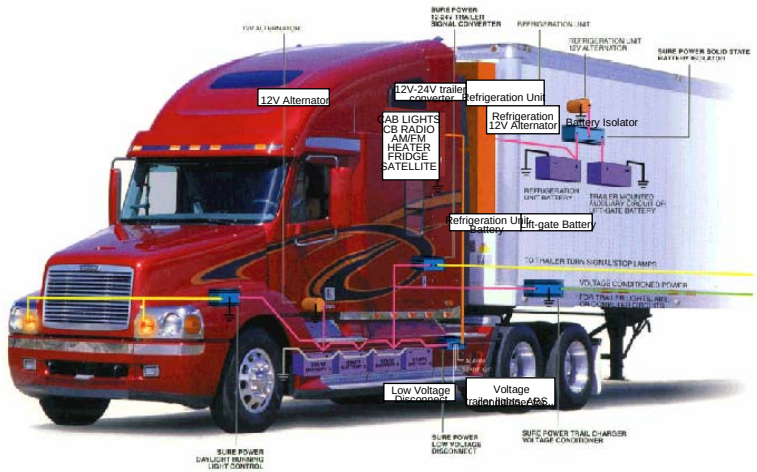
Battelle

. . . Putting Technology To Work

SOFC APU Markets

- SOFC SYSTEM as an AUXILIARY POWER UNIT (APU)
  - Markets: stationary, passenger automobiles, trucks, recreational vehicles, military

Delphi Gasoline APU for passenger automobiles



Heavy Duty Truck Application

Diesel Truck APU

Stationary applications - Natural gas or diesel power generators

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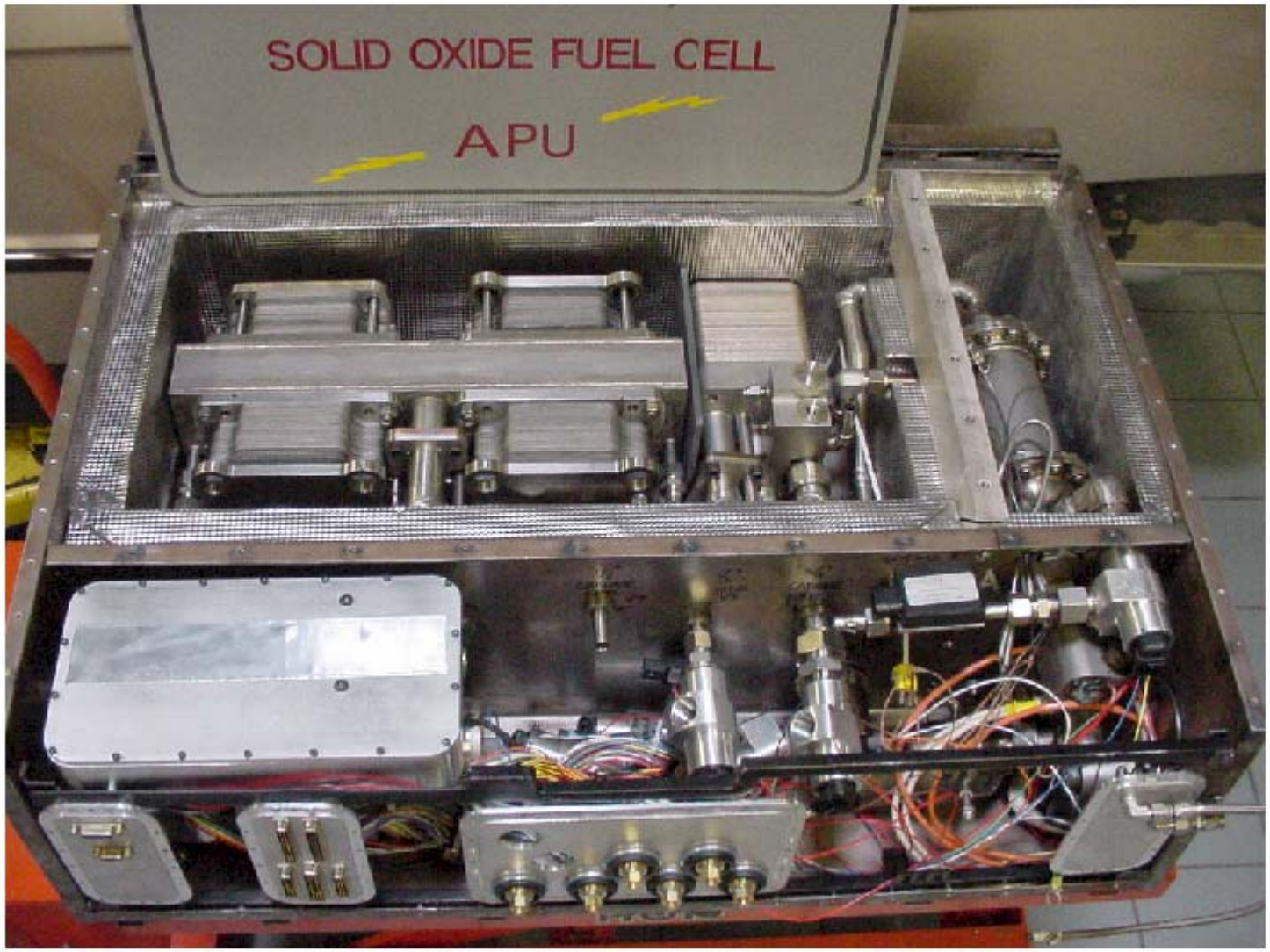
Layout of PoC SOFC APU

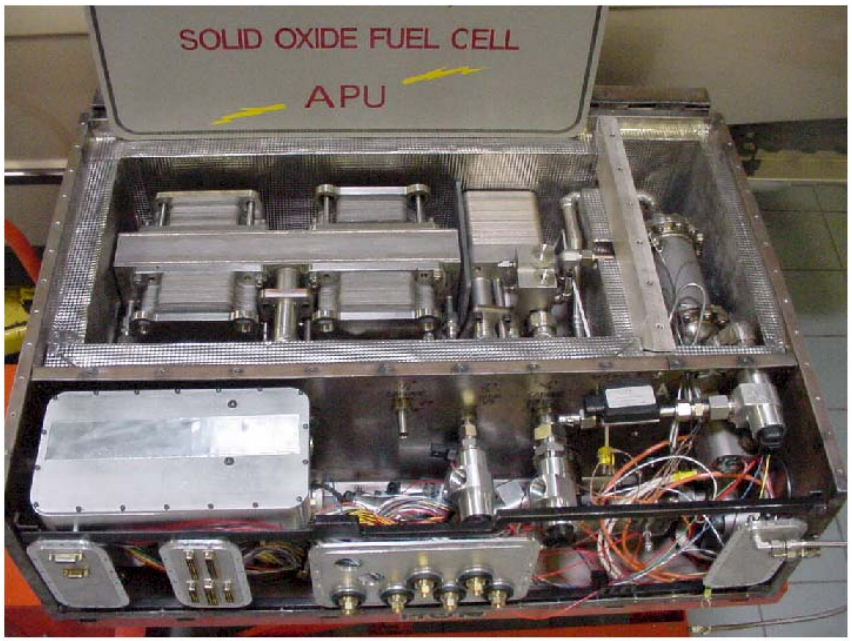


Next Generation APU System

- Areas of system level development necessary to meet APU requirements
  - Packaging
  - Weight
  - Start up times
  - Power density
  - Durability
  - Efficiency / fuel utilization
  - Emissions

Next Generation APU System

Proof of Concept (PoC) APU



Mass reduction:
PoC: 200 + kg
Next Generation: 50 kg

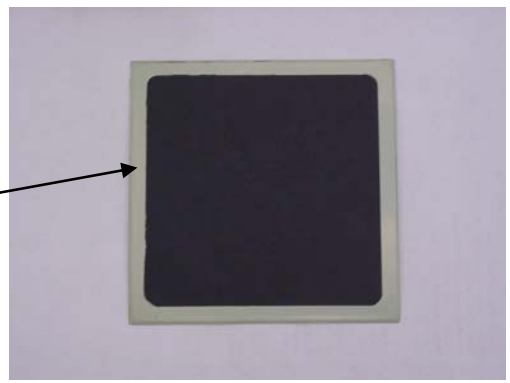
Size reduction:
PoC: 152 Liters
Next Generation: 50 Liters

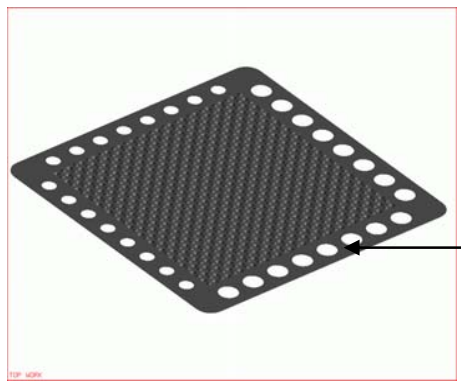
Next Generation APU Mock-up

Recommendations for Core Technology Program

- SOFC Cells and Materials
  - Develop an understanding of the degradation mechanisms that occur during cell lifetime for anode supported cells
    - » Based on these degradation mechanisms, develop cells with optimized electrode compositions and microstructures that will exhibit the required lifetime
  - Development of anode materials that can tolerate exposure to an oxidizing atmosphere at elevated temperatures
  - Develop an understanding of the degradation mechanisms in interconnects
    - » Based on these degradation mechanisms, develop interconnect material that is relatively inexpensive, easy to fabricate, thermally and chemically compatible with other stack components, and stable in both fuel and air environments throughout the lifetime of the stack

12 cm x 12 cm cell manufactured by Delphi/Battelle

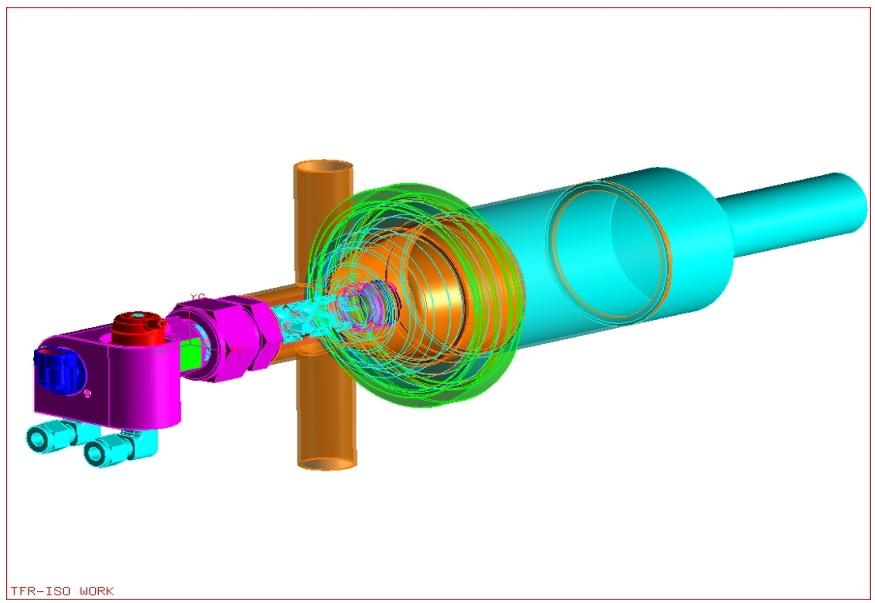




Stamped, thin metal interconnect

Recommendations for Core Technology Program

- Fuel Processing
  - Develop a reaction model for steam reformer processes with complex hydrocarbon fuels. Temperature control and solid carbon formation and regeneration are very important.
  - Develop an understanding of catalyst poisoning effects using known fuels, additives, and contaminants.
    - » Develop rapid aging tests to allow for catalyst comparisons at simulated high mileage performance



Recommendations for Core Technology Program

- Modeling and Simulation
  - Develop computational tools to simulate transient and steady-state phenomena occurring during system operation
    - » Thermochemical and thermomechanical models are needed to predict thermal gradients and stresses
    - » Models should allow for changes in stack geometry, fuel utilization, fuel composition, fuel flow rate, and air flow rate
    - » Thermomechanical modeling of stack and system heat-up and cool-down will assist in developing stacks and systems that can have rapid start-up and survive repeated thermal cycling
- Thermal Systems
  - Develop low cost, high performance thermal insulation, electrical passthroughs, and gas passthroughs that will allow for efficient thermal management
    - » High cost solutions do exist, therefore this activity should include technologies and manufacturing processes for cost reduction