Fuel Cell Mobile Light Project

Al Sorkin & Lennie Klebanoff

NASA TEERM-ITB Inc. & Sandia National Laboratories

National Aeronautics and Space Administration

Technology Evaluation for Environmental Risk Mitigation Principal Center

Sandia National Laboratories

Advances in Hydrogen Energy Technologies
4th. International Seminar
Viana do Castelo – Portugal
November 2011

A Strong Development Team is in Place

New Technology Experts + Manufacturing Partners + End Users

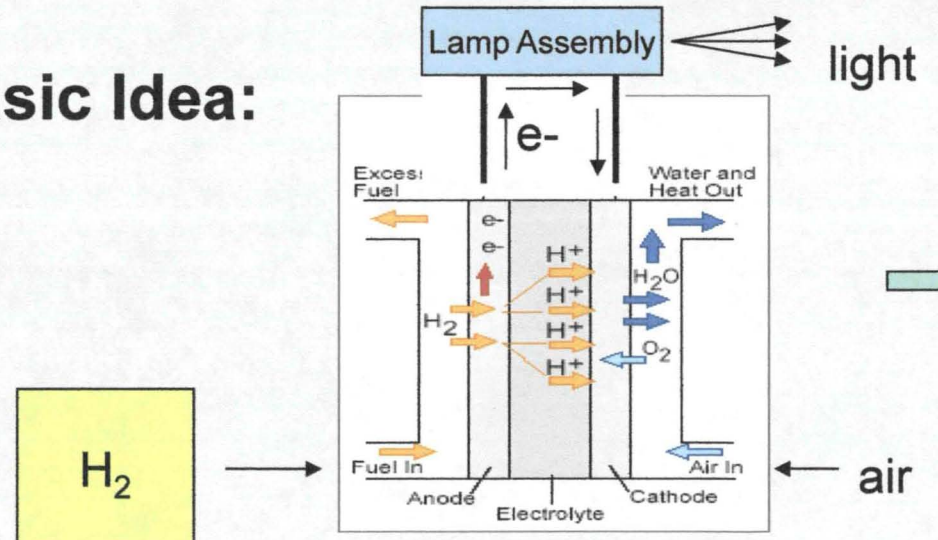
Origin: Boeing Interested in Bringing Fuel Cell Technology to Ground Support Equipment (GSE)

3/1/2008:

"We (Boeing) would like Sandia to lead an effort with us to bring hydrogen fuel cell technology to airport ground support equipment" -- **George Roe, Manager Boeing Research and Technology**

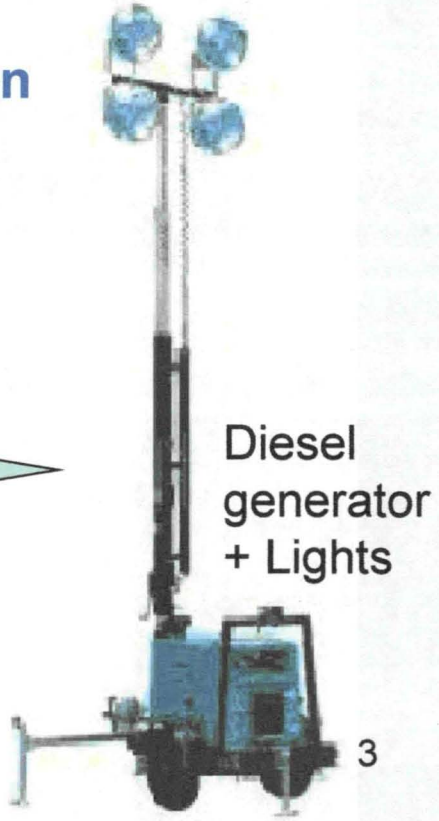
Initial discussions settle on a H_2 fuel cell demonstration for mobile 5 kW aircraft maintenance lighting:

Basic Idea:



Proton Exchange Membrane (PEM) Fuel Cell

replaces....

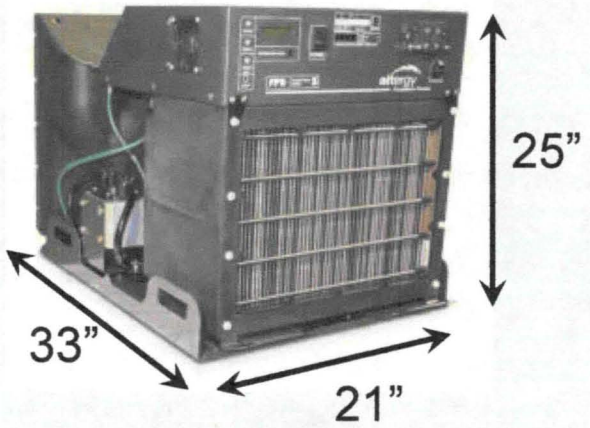


Diesel generator + Lights

Combining Fuel Cell Power with Plasma Lighting

PEM Fuel Cell

Altergy FPS-5 (5kW)

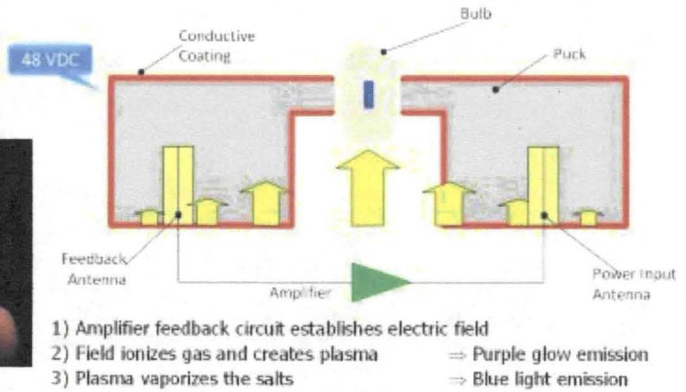


$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

- Already in use for cell-tower backup power
- Fast start, excellent durability
- Uses pure H_2 from storage system
- Oxygen obtained from ambient air
- 47% efficiency (diesel lighting ~ 27% efficient)
- No CO_2, NO_x or particulates emitted
- No moving parts, very quiet operation

Plasma Lighting

plasma light bulb



- High efficiency – 120 lumens/watt
- 50,000 hour lifetime
- Color Rendering up to 96 CRI
- 30 second turn-on time
- Rapid Re-strike
- Compact source (1/4"x1/4")
- No Audible Noise or Flicker
- Programmable
- Indoor and Outdoor Use
- Already in use for arena, street lighting

"Alpha" H_2/Fuel Cell Mobile Light (10/2009)

Alpha system built by Multiquip, Altergy Systems, Luxim, Stray Light

-- funded by Multiquip, Luxim, Stray Light Altergy Systems and Boeing

Employs two 5000 psi tanks of H_2 (4kg)

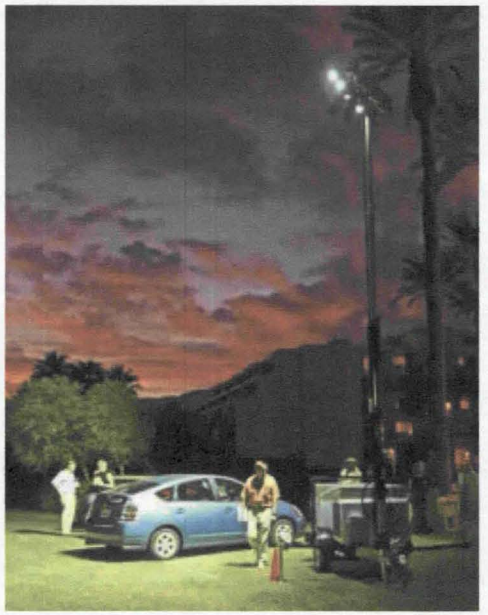
Altergy 5kW PEM fuel cell

8 Luxim Plasma Lights (~2.1 kW total)

Multiquip Trailer

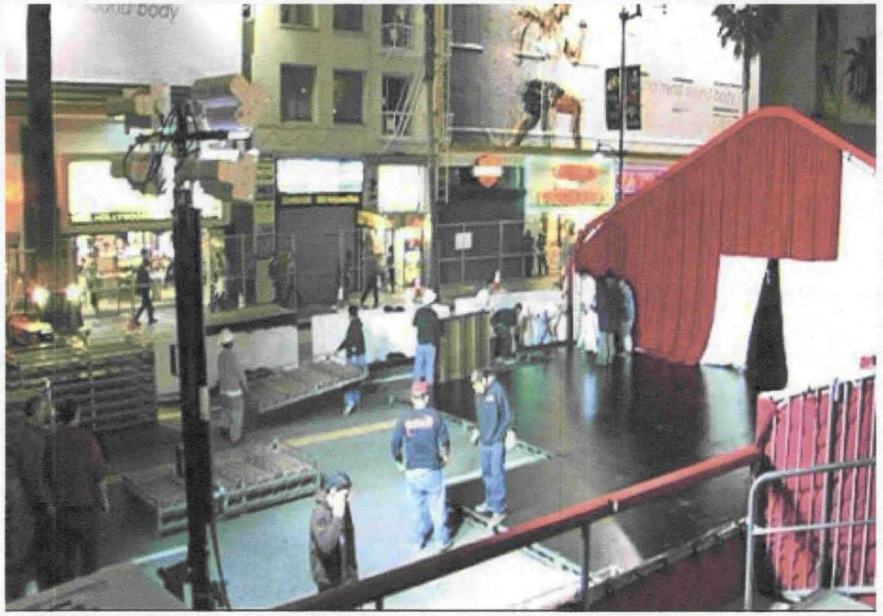
~ 30 hour duration

The Alpha system provided critical early learning and allowed Multiquip to gain familiarity with the technology.

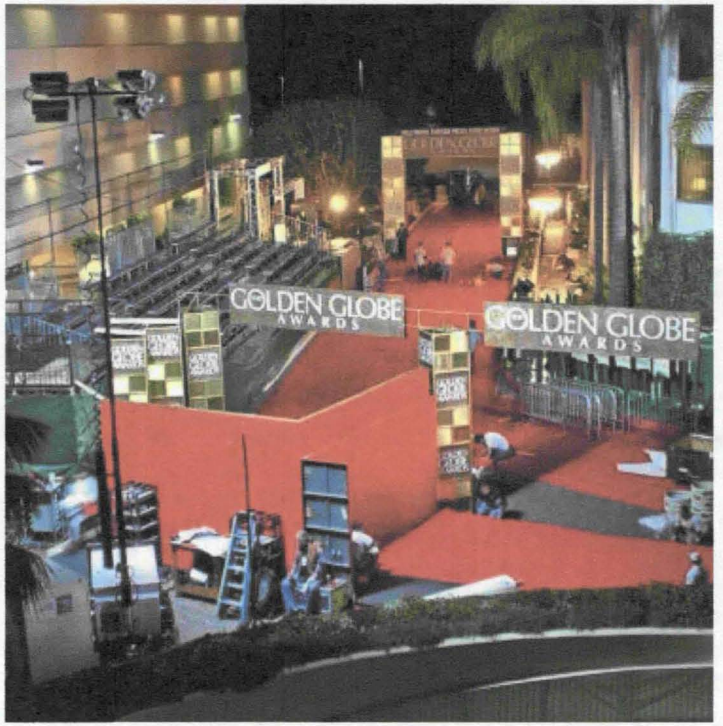


at the 2009 AASHTO Meeting

Use of Fuel Cell Light at Entertainment Events



2010 Academy Awards



2011 Golden Globes

Alpha Fuel Cell Mobile Light was also used on the Red Carpet at the 2011 Screen Actors Guild (SAG) Awards, and at the 2011 Grammys

Introduction of the technology to these industries, through use by Saunders Electric and entertainment construction personnel, will naturally lead to the development of the entertainment early market.

First Beta Unit Constructed 1/2011

World of Concrete Show
January 2011

Beta is a near-commercial unit

Employs four 5000 psi tanks of H_2 (~8kg)

One Altergy 5kW PEM fuel cell

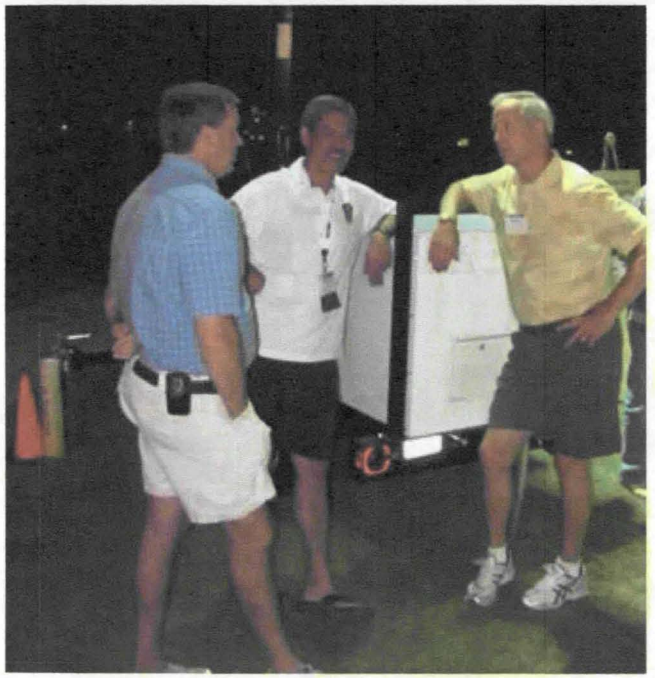
8 Luxim Plasma Lights (~2.1 kW draw)

Multiquip Trailer

Fully integrated controls for fuel cell, lights

Fuel Cell Mobile Light Capabilities

Beta Fuel Cell Mobile Light Running at World of Concrete 2011



- ~66 hour duration (lighting)
- Indoor or outdoor use
- Area of illumination: 50 yds x 75 yds
  (at 3.5 foot candles)
- ~ 3 kW of AC power as option
- Easily moved
- Quiet: 43 dB noise level at 23 feet
  (--- and can be reduced)
- 30 foot tower height, fully rotatable

Alpha Fuel Cell Mobile Light at the 2009 AASHTO Meeting

H_2LT Gives > 73% Reduction in GHG Emissions

Current Diesel Light Towers: 4000W lights, 48 hour run time on 30 gallons of diesel

Fuel Cell Mobile Light: Same light output, same duration time, on 7.5 kg of H_2

--efficiencies from fuel cell AND lighting

So, the questions are:

a. How much CO_2 (equivalent) is released in making and burning 30 gallons of diesel fuel in a conventional light tower?

b. How much CO_2 is released in making 7.5 kg of 5,000 psi H_2 from Natural Gas (NG) and using it in the Fuel Cell Mobile Light?

Using the GREET Model, the total CO_2 (equiv.) emission associated with making (65kg CO_2) and burning (295kg CO_2) 30 gallons of diesel is 65 + 295 = **360 kg CO_2**.

For b) If you make 7.5 kg of 5,000 psi hydrogen from NG, GREET indicates that you release **98 kg** of CO_2 equivalent. Zero CO_2 is released at point of H_2 use.

GHG decrease = 98 kg/360 kg = 0.27… ∴ 73% GHG savings
-- Greater decrease if H_2 is made from low-C sources.

Deployment Partners

With DOE funding, we are deploying 5 units *to gather testing data and to reduce diesel use at these sites:*

Caltrans (Sacramento), exposure to heat, snow, cold, road work

Kennedy Space Center (Florida), exposure to heat, humidity, salt air

Boeing (Washington State), exposure to sleet, ice, rain and fog

Paramount Pictures (LA), performance for noise reduction

San Francisco International Airport (SFO), performance of Hybrid system

Note: One unit is being devoted to display and demonstration at equipment trade shows.

Caltrans/UC Davis to Perform Formal System Eval.

-- A joint activity between Sandia, Caltrans, The California Highway Patrol, and the U.C. Davis Advanced Highway Maintenance and Construction Technology Research Center (AHMCT)

-- Funded by Caltrans

AHMCT

Evaluation Topics:

Lighting Efficacy: (Illumination uniformity, glare, visibility, coverage area)

Emissions: (compare with diesel system, assess H_2LT)

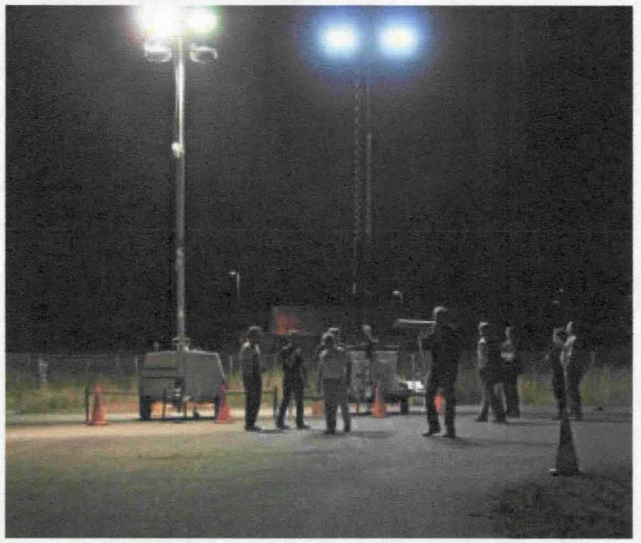
Refueling Efficacy: (refueling time, ease of operation, costs)

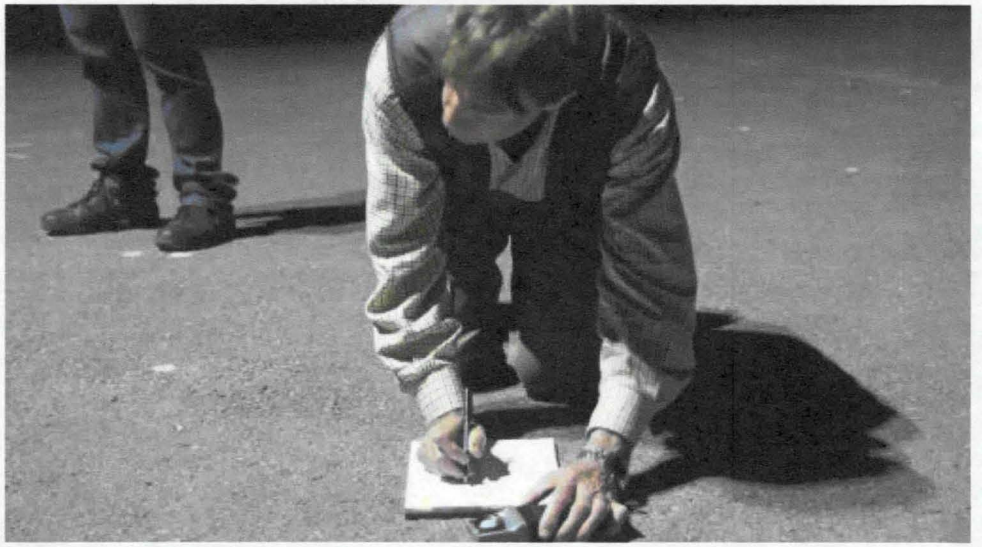
Design Robustness: (engineering analysis of performance, other testing)

Performance Evaluation and Recommendations

Caltrans, UC Davis

Delivered: 4/14/11, Training 4/19/11, Characterization Ongoing

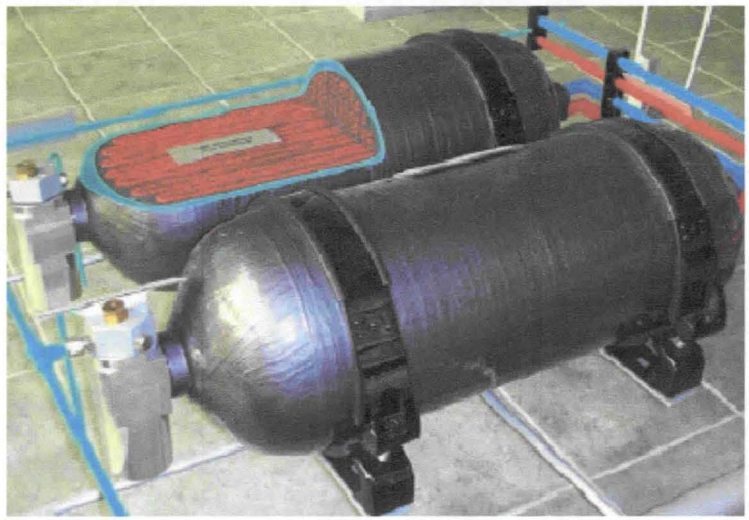




The System for SFO will combine HP tanks and Metal Hydride (MH) Storage of Hydrogen

H_2 stored in "reversible" AB_2H_3 MH from Ovonic Hydrogen Systems

A = Ti, Zr ; B = V, Cr, Mn



Advantages:

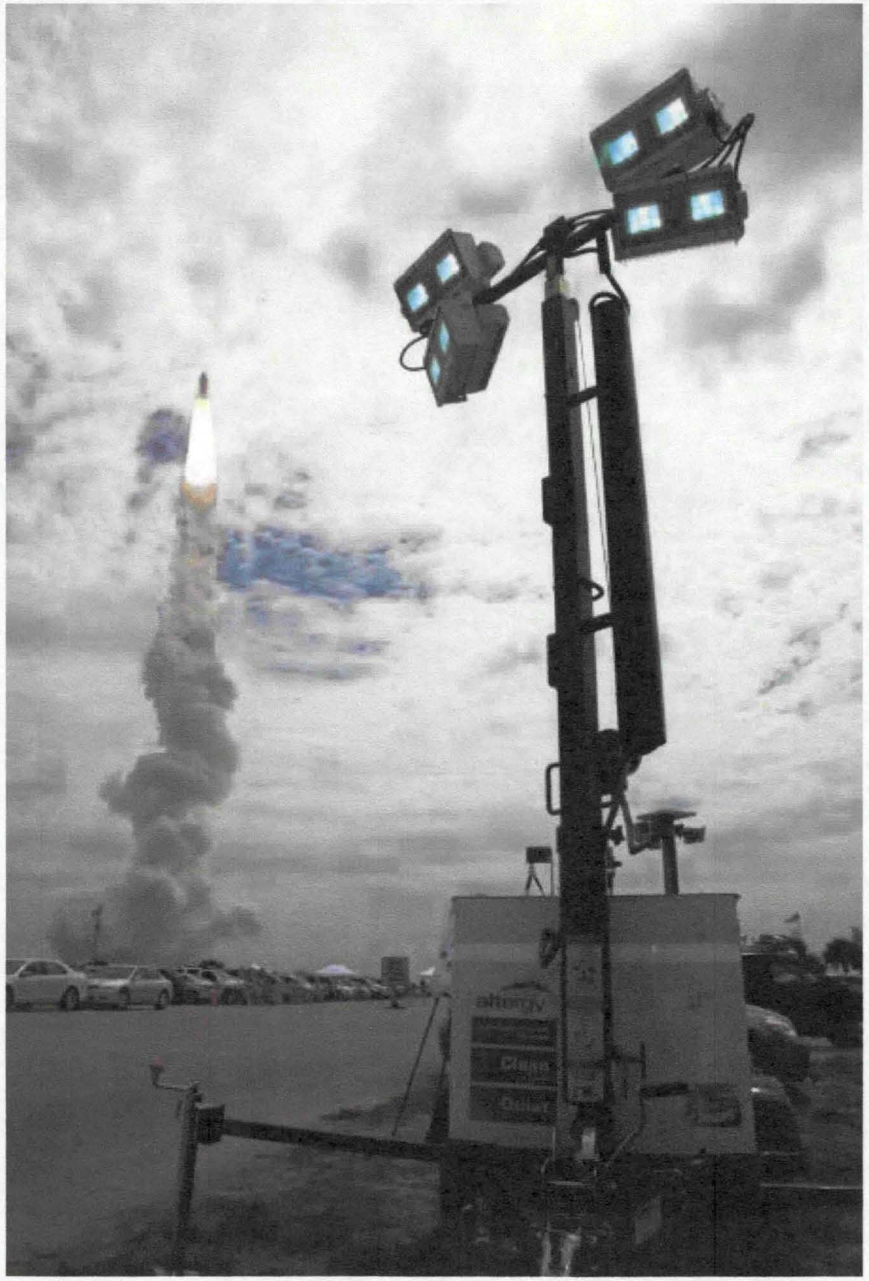
- **Smaller volume needed for storage**
- **Storage at low pressure (~200 psi)**
- **Fueling from low pressure sources (< 1000 psi)**

Disadvantages: **heavier tanks, more complex system**

For SFO we are going to build a "Hybrid" system, combining 2 High Pressure H_2 tanks with one MH Tank (funded by DOE and Boeing).

Advantages of the Hybrid Approach:

Allows Multiquip to get learning on MH technology
Allows system to be filled at SFO station which requires HP tankage
Minimizes cost, while permits learning
Andrew Socha (Sandia) performing design



Fuel Cell Mobile Light In Support of Last Shuttle Launch

Fuel Cell Mobile Light Team with Shuttle Astronaut George Zamka


NASA

Acknowledgements– Fuel Cell Mobile Light

Boeing: Joe Breit, George Roe, Ty Larsen

DOE (EERE): Pete Devlin, Nancy Garland, Greg Moreland (SRA)

Sandia-CA: Jay Keller, Terry Johnson, Andrew Socha, Marcina Moreno, Nitcha Bunpachart

Other Fuel Cell Mobile Light Project Partners:

NASA Kennedy Space Center: Al Sorkin, Rusty McGlaughlin, Chuck Griffin
Caltrans: Larry Orcutt, Steve Prey, Randy Woolley
California FC Partnership: Bill Elrick, Nico Bouwkamp, Jen Hamilton, Jordan McRobie
Altergy Systems: Mickey Oros, Chris Radley, Paul Schuttinger, Terry Carlone
Multiquip Inc.: Torsten Erbel, Steve Wingert, Jonathan Cuppett, Bruce Coleman
Ovonic Hydrogen Systems: Mike Zelinsky, Ben Chao
San Francisco International Airport: Roger Hooson, Derek Fliess
Golden State Energy: Tom Damberger
Stray Light Optical Technologies: Gerald Rea
Luxim: Geoff Brown
Lumenworks: Thomas Skradski
Saunders Electric Inc.: Russ Saunders and Candace Saunders

Questions?