Progress and Challenges for PEM Transit Fleet Applications

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This presentation does not contain any proprietary information.

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Agenda

- Brief company history in area of fuel cell buses
- Current fuel cell bus deployments
- Performance and life status, including reasons for forced outages
- Technology gaps/barriers to full commercialization of fuel cell buses
- Fuel cell bus R&D needs
- Future plans

UTC Fleet history

- 14+ yr experience integrating fuel cell technology into buses

1998

Georgetown University

40 Foot NOVA Bus

100 kW Phosphoric Acid

Methanol

FC/battery hybrid

2002

SunLine, AC Transit, LAMTA, Chula Vista

30 Foot Thor "Thunder Power" Bus

60 kW PEM

Hydrogen

FC/battery hybrid

2004

EMT Madrid, ATM Turino

40 Foot Irisbus

60 kW PEM

Hydrogen

FC/battery hybrid

2005

AC Transit/Sunline

40 Foot Van Hool Bus

120kw PEM

Hydrogen

FC/battery hybrid

UTC Fleet summary

- This report involves a total of six buses operated in California, Connecticut and Belgium.
- All buses are 40 ft A330 models manufactured by VanHool except DeLijn. DeLijn is a 43ft dual rear axle bus manufactured by VanHool.

Fuel Cell Hybrid Bus Fleet		#	Passenger Service	Total Fleet Hours Miles
	Total Fleet	**6**	**-**	**43,188** **434,720**
	AC Transit Oakland, CA ISE Corporation	**3**	March 20, 2006 to Present	24,120 241,505
	SunLine Transit Palm Desert, CA ISE Corporation	**1**	December 16, 2005 to Present	7827 99,775
	CT Transit Hartford, CT ISE Corporation	**1**	April 11, 2007 to Present	6791 44,359
	DeLijn Antwerp, BE VanHool & Siemens	**1**	June 18, 2007 to December 16, 2009	4451 49,081

Operating Data Through April 30, 2010

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UTC Fleet outlook

- Additional 16 buses slated for delivery through 2010

Current Programs

Power Plant	**PureMotion® Model 120**	
Bus OEM	Van Hool (Belgium)	
Customers:		
AC Transit	3 Buses	2 Running; 1 bus decommissioned
SunLine Transit	1 Bus	Running
CT Transit	1 Bus	Running
DeLijn	1 Bus	Retired; end of contract 12/2009

New Programs

Power Plant	**PureMotion® Model 120**	
Bus OEM	Van Hool (Belgium)	
Customers:		
AC Transit	12 Buses	May- December 2010 bus delivery
UTCP/NAVC	4 Buses	May- August 2010 bus delivery

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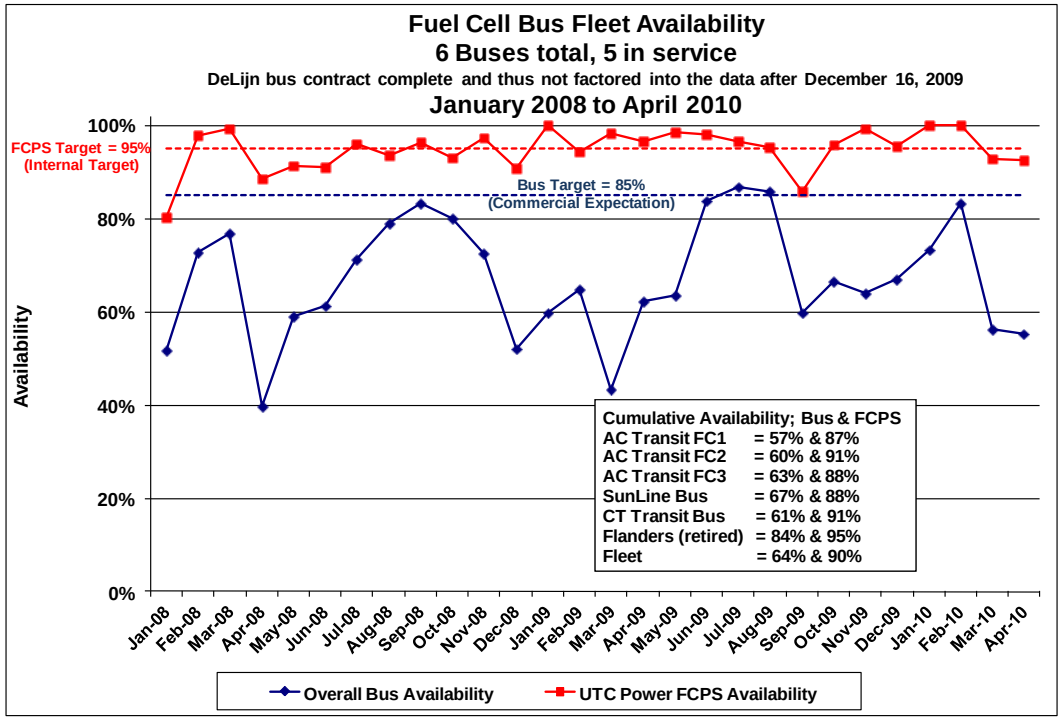
UTC Fleet availability

- Fuel cell power system (FCPS) roughly 95% available across fleet
- No cell-stack assembly (CSA) related causes for unavailability in the past 12 months



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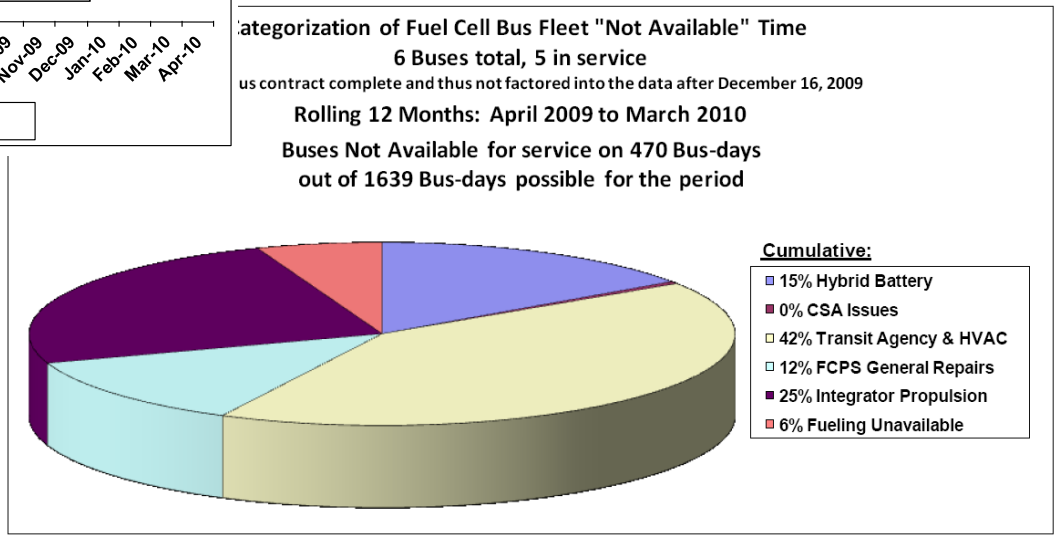

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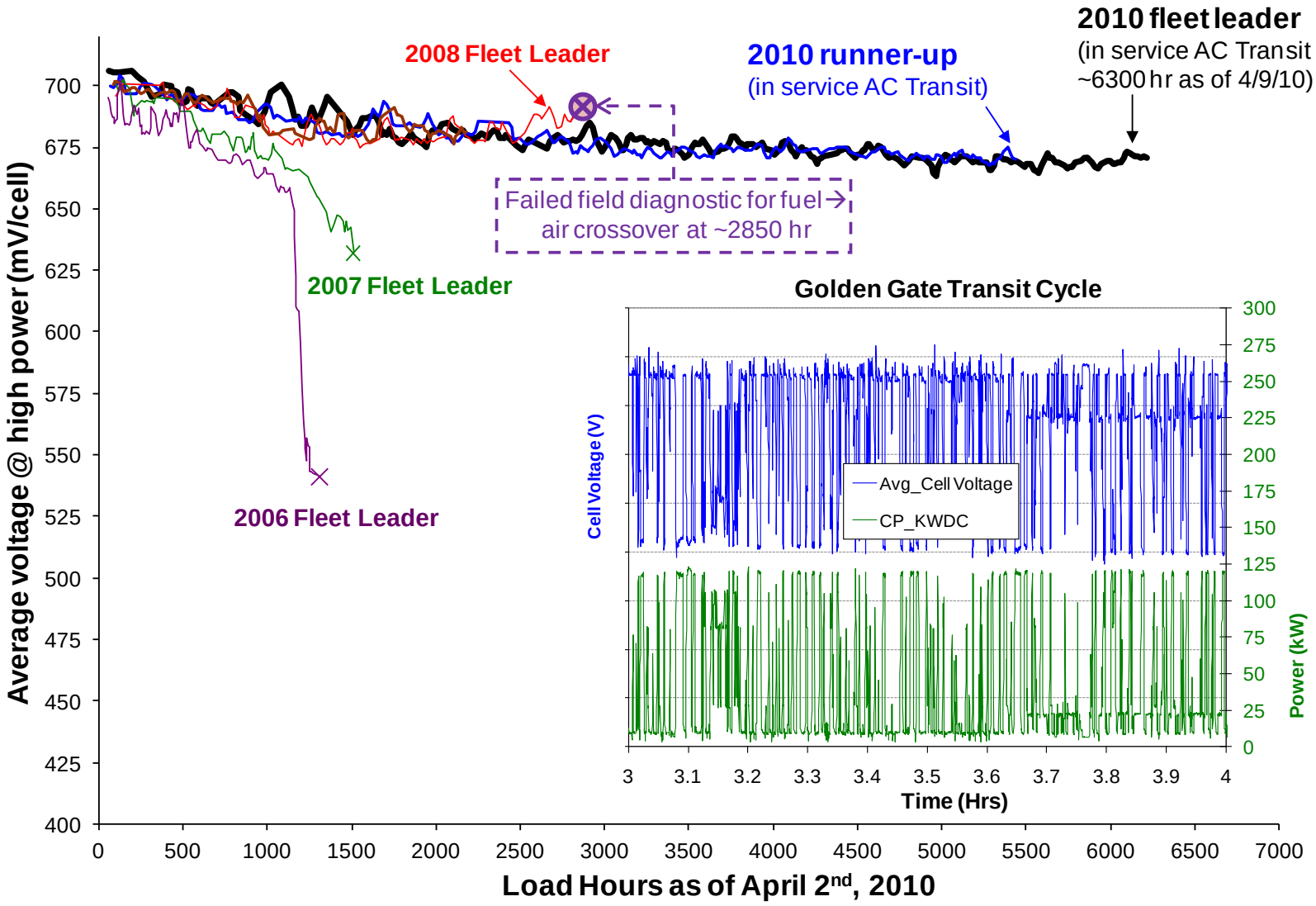
UTC Fleet performance

- 2010 fleet leader and runner-up have original stacks with no intervention or recovery procedures
- Performance decay and materials failure modes through 6500+ hrs addressed



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Key gaps for fleet implementation

• Need concerted effort to drive to targets tailored for bus fleet FCV technology

Area	**Auto Target** **(2007 RD&D plan)**	**UTC Bus fleet target** **(*preliminary)**
Durability with cycling	5,500 load hrs	18,000+ load hrs
Drive schedule	- FUDS - High S/S per load-hr - Low idle time	- Golden Gate transit cycle - Low S/S per load-hr - High idle time
FCPS Cost (stack, BOP, PCS)	$30 / kW at 500,000 units / yr	- $200-350 / kW* at 1000's / yr -Need $/kW at 10's – 100's / yr
Pt loading	0.1 – 0.2 mg PGM / cm^2 total	0.3 mg PGM / cm^2 total*

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Fuel cell bus R&D needs

Area	UTC Bus fleet target (*preliminary)	Required areas for technology development
Durability with cycling	18,000+ load hrs	Accelerated life tests - Need to fund additional efforts to accelerate field failure modes in breadboard units
Pt loading	0.3 mg PGM / cm^2 total*	Low Pt-loading durability - Need to fund TRL maturation of approaches to preserve high power performance at low PGM loading
Drive schedule	- Golden Gate transit - Low S/S per load-hr	Optimize hybridization - Need to fund optimizing hybridization strategy for minimizing combined CSA and battery life-cycle costs
FCPS Cost (stack, BOP, PCS)	$200-300 / kW * at 1000's / yr	Designs for cost, manufacturing -Need to fund new cell designs that incorporate cost-effective designs (design-for-manufacturing, improved processes for high cost components, e.g. porous bipolar plates) -Need to generate opportunities where 100's of units can be deployed to learn out cost effective designs

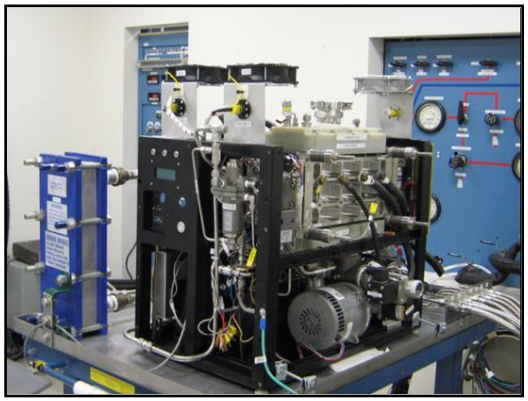
Future plans

Accelerated Life Test (ALT)

Field validation of 18,000 hr life is impractical / impossible

System effects and interactions on lifetime are significant

Mid-June 2010 start validation durability test



Hybrid Integration Lab at UTRC

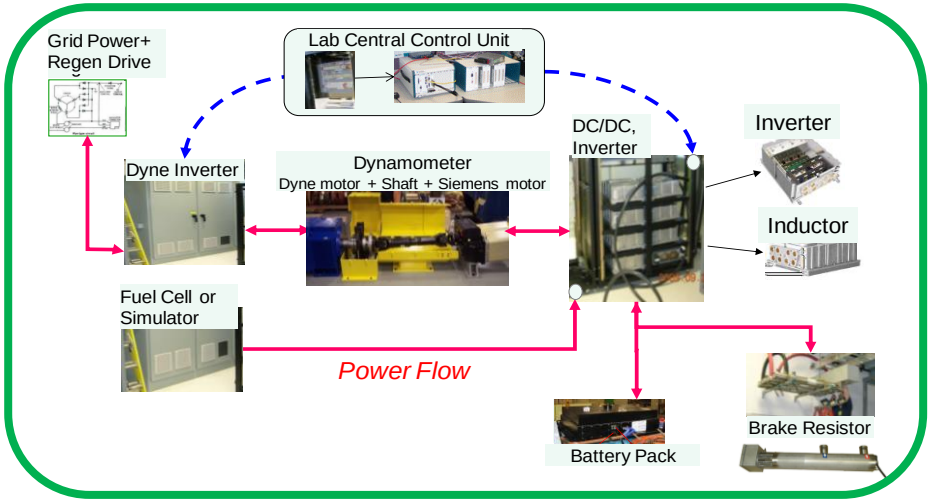
Funded internally

Have completed characterization of hybrid battery

Awaiting integration of FCPS into lab

Would like to explore multiple battery technologies and tailored strategies

Full Scale Fleet Hybrid Integration and Test Facility



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