CENTER FOR TRANSPORTATION
AND THE ENVIRONMENT

City of Tempe Wireless Streetcar Project
Technology Technical Analysis

Tempe City Council
January 21, 2016

Streetcar Route

Project Objectives

Goals

- Determine feasibility of operating a wireless streetcar on the Tempe Streetcar Alignment.
- Provide performance, operations, and cost data for technologies that support wireless streetcar service.

Methodology

- Perform market summary and examine current state of technology.
- Model potential technologies and simulate revenue service.
- Lean on CTE experience with advanced transit vehicle technologies and information from rail industry experts for cost data.

Industry Resources

Industry experts were contacted throughout analysis. Information used to:

- summarize available streetcar technology
- correlate and validate simulation results

Streetcar Original Equipment Manufacturers (OEM):

- Siemens
- Kinkisharyo
- Brookville Equipment
- Inekon
- United Streetcar
- Bombardier
- TIG/m
- Oregon Iron Works
- Alstom

Streetcar Operators:

- Atlanta Streetcar
- Dallas Area Rapid Transit (DART)
- Seattle DOT

Published Resources:

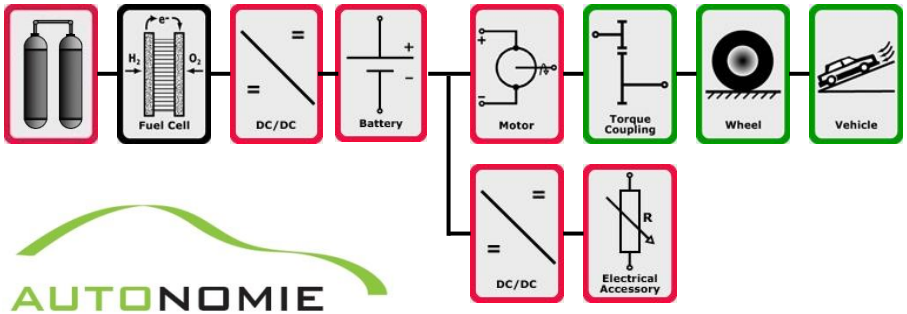
- ASHRAE, Marek, Thermo King
- APTA Procurement Guidelines
- Valley Metro Streetcar Technical Specification (draft)
- D.C. Streetcar feasibility studies
- Seattle FHSC feasibility studies
- National Transit Database
- WMG rail research

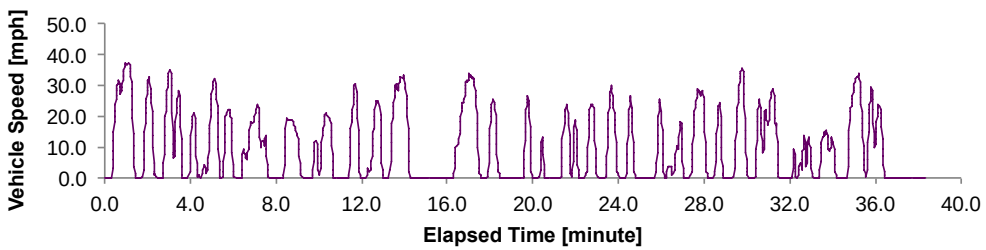
Additional Resources:

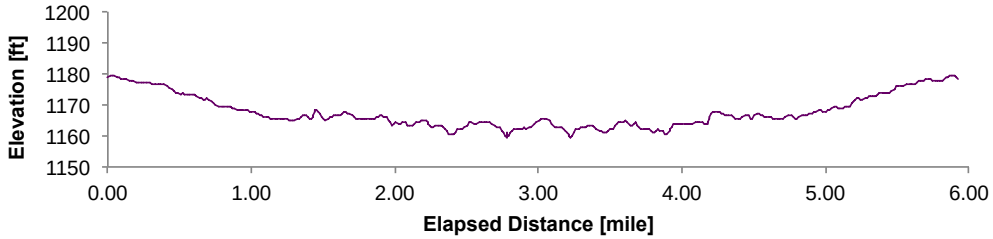
- LTK
- AECOM
- BAE Systems
- APTA/TRB 2015 LRV & Streetcar Conference
- Dr. Andreas Hoffrichter (Hydrail, WMG)

Modeling and Simulation

- Autonomie™ vehicle modeling software
  - DOE
  - Argonne National Lab
- Variable parameter simulations
  - vehicle weight
  - passenger loads
  - hotel loads (i.e., heating/cooling)
- Duty Cycle based on real-world GPS drive cycle data
- Tempe Streetcar specific study







Tempe Simulation Results Summary

	Off Wire for Entire Route	Off Wire for Route Segment
Battery Only (depot charge)	■	■
Battery Only (charge at stops)	◆	■
OCS with Battery	■	○
Hydrogen Fuel Cell (FC dominant)	◆	■
Hydrogen Fuel Cell (battery depleting)	■	■
OCS with Hydrogen Fuel Cell	■	■

Baseline Technology – Traditional Overhead Catenary System (OCS)

○ - feasible

◆ - feasible, with additional considerations

■ - not appropriate / non-applicable

OCS with Battery – Route Segment

Description:

- on-board battery allows off-wire operation for a segment of route
- good candidate for wireless section begins at Mill & 9th, continues northbound to Rio Salado & Hayden Ferry or Marina Heights

Pros:

- no overhead wires in the downtown district
- proven propulsion system… deployed by Dallas Streetcar
- batteries increasingly more common transit applications
- batteries can be stored without impacting passenger capacity
- provides more flexibility for route expansion

Cons:

- limited history in rail applications
- OEM may limit vehicle acceleration when off wire to protect the batteries

Battery Only (Charge at Stops) – Entire Route

Description:

- on-board batteries power streetcar along entire route
- streetcar may stop at on-route charging stations to replenish battery energy

Pros:

- no overhead wires along route
- batteries and on-route charge strategy increasingly more common transit applications
- provides more flexibility for route expansion

Cons:

- no streetcars with this charge strategy currently deployed in North America
- headways will be affected by charging time, or more streetcars may have to be deployed to maintain frequency
- high charge rate may be detrimental to battery life
- real estate for large battery packs on low-floor streetcar may be limited
- OEM may limit vehicle acceleration when off wire to protect the batteries

Hydrogen FC (FC dominant) – Entire Route

Description:

- fuel cell is used as primary power source for motor
- a small battery is used as a peaking power source and energy bank for regenerative braking

Pros:

- 100% wireless route
- quick re-fueling
- proven propulsion system – deployed in heavy-duty on-road vehicles
- provides more flexibility for route expansion
- leading edge technology

Cons:

- no hydrogen-powered modern streetcars delivered in North America to date
- leading edge technology
- real estate for fuel cell and hydrogen tanks on low-floor streetcar may be limited
- acceleration at high speeds may be limited by FC size

Traditional OCS – Entire Route

Description:

- overhead contact system along entire route

Pros:

- long history of successful deployments
- vehicle acceleration not limited by power supply
- predictable cost

Cons:

- overhead wires along entire route, including Mill Ave downtown district
- construction and wayside infrastructure required along route
- reduced flexibility for route expansion

Attribute Summary

	Technical	Headway Impact	Project Timeline	Aesthetic	Costs (capital*)	Costs (fuel)	Costs (total*)	Overall Risk
OCS with Battery Route Segment					- 3%	+/- 0%		low
Battery Only (charge stop) Entire Route					- 16%	+/- 0%		high
Hydrogen FC (FC dominant) Entire Route					- 8%	+ 174%		high
Traditional OCS Entire Route					+/- 0%	+/- 0%		low

* Cost forecasts are preliminary estimates. Forecast does not include FTA SCC 60: right-of-way, land and existing improvement

Recommendations

An OCS with an on-board battery system is the most suitable wireless option for the Tempe Streetcar project. This limits deployment risk, ensures reliable revenue service, and can eliminate overhead wires in the downtown district.

Recommended additional analysis

- total cost of ownership analysis for feasible technologies (in comparison to OCS)
- additional specification input for RFP
- support technical evaluation of RFP responses (modeling and simulation of proposed vehicles)