The New Seattle Streetcar
With Onboard Energy Storage

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Overview

- First Hill Streetcar Project
- Wireless Operation Study
- Procurement Process
- Vehicle Description
- Schedule
First Hill Streetcar Project (FHSC)
Downtown Seattle Rail Transit
FHSC Alignment

- 2.5 miles double track
  - Average grade 2.4%
  - Maximum grade 9.0%
  - Sustained grade 3.4%
- Uphill outbound
- Downhill inbound
- In-street running
- 10 passenger stations
Wireless Operation Study
Why Wireless Operation?

- Mitigate or reduce potential conflicts
  - Electric trolley bus (ETB) overhead wires
  - New streetcar OCS

- Preserve opportunity for aesthetic mitigation of future streetcar routes

- Provide emergency recovery capability
Purpose of Study

- What is the state-of-the-art in wireless technology?
- What parameters affect sizing and capability of the hardware?
- What onboard hardware is required?
- Where are the most challenging locations?
- What locations benefit the most?
- How feasible is it?
Study Methodology

• Research
  – Current active wireless operations
  – Prototype vehicles
  – OESS types
    • Battery
    • Capacitor
    • Combination
  – OESS charging technologies
  – Industry literature

• Characterize intersections
  – Difficulty in introducing streetcar overhead wire
Study Methodology

• Developed alignment energy profiles as a function of performance parameters
  – Acceleration rate
  – Auxiliary power load (HVAC)

• Combined the intersection analysis with the energy profiles identifying favorable areas for wireless operation
Example Energy Profile
AW2 Vehicle, Round Trip

Outbound, running on OCS

Inbound, running on OESS

Alignment (miles)

Energy kWh

Traction Energy (kWh)

APS and Traction Energy (kWh)

Outbound/Inbound
Example Wireless Profile
AW2 Vehicle, Inbound

~ 8% grade down hill

~ 5% grade up hill

20 m curve
~ 3% grade up hill
Conclusions

- Wireless operation is an emerging technology, being tried in several places.
- Performance requirements significantly affect feasibility of wireless operation:
  - Alignment profile
  - Duty cycle
    - Charging and discharging OESS
    - Acceleration rate
  - OESS technology
  - OESS life
- Operation should be from Station-to-Station.
- OESS voltage at least 500 Vdc.
Conclusions

- First Hill Streetcar alignment appears feasible for wireless operation
- Desirable wireless regions
  - Outbound
    - Pioneer Square Terminus to Jackson and 5th
    - Broadway and Pine to the Capitol Hill Terminus
  - Inbound
    - Jackson and 7th to the Pioneer Square Terminus
- Possible wireless region
  - Complete Inbound route
    - Large up hill grade in beginning of region
Procurement Process
Vehicle Procurement Approach

- 6 cars
- Two step best value—RFP and RBAFO
- Quantitative assessment
- Technical 60%
  - Vehicle description
  - OESS
  - Management approach
  - Schedule
  - Qualifications
  - Buy America capability
- Price 40%
  - 6 Vehicles
  - System support
  - Spare parts
  - Option vehicles
  - Option services
Vehicle Procurement Schedule

- Issue RLOI: June 2010
- Issue RFP: March 2011
- Receive proposals: June 2011
- Evaluate/rank proposals: June 2011
- Meet with Proposers: July 2011
- Issue Request for BAFO: August 2011
- Receive BAFOs: October 2011
- Evaluate/rank BAFOs: October 2011
- Issue Notice of Intent to Award: October 2011
- Issue NTP: March 2012
RFP
Reevaluating Wireless Operation

- The first step (RFP) produced proposals in excess of the vehicle procurement budget

- Key Factors
  - Cost of the Onboard Energy Storage System
  - Excessive wear on equipment due to having 3 wireless regions
    - 2 Outbound
    - 1 Inbound
• Added alternate extended wireless region
  – Inbound line completely wireless

• Permitted two separate BAFOs
  – Conventional car
  – OESS car

• Evaluation involved selecting
  – Best value Conventional
  – Best value OESS
  – Determining the best value overall
BAFO Results

- **OESS**
  - Inekon Group
  - KinkiSharyo
  - Oregon Iron Works

- **Conventional**
  - Inekon Group
  - Oregon Iron Works

- Contract awarded to Inekon Group (IG) of Czech Republic
  - $26.7M
  - 6 OESS cars
  - System support, spare parts, etc.
Wireless Requirements

• Wireless segment is entire inbound route
  - 2.5 miles
  - Predominately downhill

• Performance requirements are reduced
  - Acceleration rate 1.34 m/s^2 (AW2)
    • Rate rolls off at 12 km/h
  - Maximum speed at least 32 km/h
  - HVAC, ventilation only
    • Currently, looking into adding AC and heating
Wireless Requirements

• Recharging occurs
  – Pantograph is connected to the OCS
  – OESS mode, during regenerative braking

• OESS safety
  – OESS is interlocked with the pantograph
  – Pantograph status, up/down, is communicated to the wayside
  – NFPA-130 requirements
  – OSHA requirements
Vehicle Description
IG Vehicle Overview

- Based on existing SLU design
- 50% low floor, three car sections, two trucks
- 66 ft in length
- 30 seats
- Welded steel construction, bonded stainless steel side cladding, FRP front end
- 69,000 lbs AWO estimated
- Liquid cooled, microprocessor-controlled AC inverter
- Onboard energy storage system (OESS)
- Hydraulic brakes
- Coil spring secondary suspension
- Bridgeplates, for ADA accessibility
Major Suppliers

- Carbody: Inekon (Ostrava)
- Truck frames
- Final assembly first car: Inekon (Ostrava)
- Final assembly cars 2-7: Pacifica (Seattle)
- Propulsion: ABB
- OESS: ABB/SAFT
- Network: ABB/Selectron
- Friction brakes: Knorr
- Doors: Bode
- HVAC: Meran
General Arrangement

VEHICLE WEIGHT TABLE

<table>
<thead>
<tr>
<th>LOADING</th>
<th>No. OF PASSENGER</th>
<th>VEHICLE WEIGHT (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AW0</td>
<td>0</td>
<td>30 700±5%</td>
</tr>
<tr>
<td>AW1</td>
<td>39 + OPERATOR</td>
<td>32 870</td>
</tr>
<tr>
<td>AW2</td>
<td>113 + OPERATOR</td>
<td>38 680</td>
</tr>
<tr>
<td>AW3</td>
<td>155 + OPERATOR</td>
<td>41 620</td>
</tr>
<tr>
<td>AW4</td>
<td>167 + OPERATOR</td>
<td>42 460</td>
</tr>
</tbody>
</table>

No. OF SEATS ........................................... 30
STANDEE AREA ........................................ 28.9 m²
MAXIMUM WIRE HEIGHT ................................. 6250 mm (246.1”)
PANTOGRAPH MINIMUM OPERATING HEIGHT ............ 3950 mm (155.9”)
WHEELCHAIR PLACE ..................................... ☻
BRIDGEPLATE ............................................. BP
General Arrangement
Unitized Propulsion Inverter

- 2 Traction inverters
- OESS charger
  - Integrated into Traction Inverter
- 1 Auxiliary converter
- 1 LVPS
  - Battery charger
- Braking resistors
- Liquid cooled
  - Traction inverter
  - Auxiliary converter
  - LVPS
Schedule
Schedule Highlights

- NTP: March 2012
- Start carshells: November 2012
- Start final assembly car 1: March 2013
- Compression test car 2: February 2013
- Combined propulsion/OESS test: February 2013
- Ship carshell 2 to Pacifica: April 2013
- Ship car 1 to SDOT: December 2013
- Ship car 2 to SDOT: February 2014
- Ship cars 3-7 to SDOT: March to June 2014
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