Tempe Streetcar

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So, Why Streetcar?

- Tempe is one of the highest public transit ridership centers in the region
- City circulator in one of the highest employment & residential density areas in Arizona
- 190K residents; 320K daytime population
- Helps to preserve historic neighborhoods
- Complements Orbit & bus system; rail attracts new riders & new development
• MAJOR EMPLOYERS
ASU, Wells Fargo, State Farm, US Airways, SRP, JP Morgan Chase, Honeywell

• EVENTS & ATTRACTIONS
Ironman, Rock N Roll Marathon, MLB Spring Training, Tempe Town Lake, Tempe Butte, Papago Park, Mill Ave

• Mill Avenue was named one of America’s Great Streets in 2008 by the American Planning Association

• Tempe Town Lake opened in 1999 after over 30 years of planning and coordination

• Over 2.4 million people visit the lake annually

Source: downtowntempe.com
The Vehicle

Manufactured by Brookville
Out of Brookville, PA
Project Schedule

Design Milestones

<table>
<thead>
<tr>
<th>100%</th>
<th>Issued For Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2018</td>
<td>August 2018</td>
</tr>
</tbody>
</table>

Utility Relocation & CNPA
Track Construction
Civil & Roadway
Stops & Artwork
Operations Training Vehicle Testing
Opening

2018
2019
2020
2021
Design Challenges

- Track Section
- Utility Relocation Requirements
- Number and location of TPSS
- Feeder Cables
- Landscaping
- Stops
- Alignment
- CNPA (Concurrent Non-Project Activity)
Single track – Apache Terminus
Single Track – Marina Heights Terminus
Tempe streetcar roundabout
Operational Challenges

Capability Needs for Day-to-Day Operation

- Communications (mix of fiber, wireless, VDSL, leased lines, none)
- Controller HW/SW
- Signal Timing/Transit Signal Priority
- Situational Awareness
  - CCTV Cameras
  - Real-Time Tracking
- Vehicle Detection
- Streetcar Detection

“Value Engineering”
Tempe Streetcar CIP Projects

Systems & Communications – AECOM Under Contract
• Review streetcar 60/90/100% PSE
• Coordination with VMR and BEC
• **Identify system alternatives for TSP w/RTT**
• Evaluate signal controllers
• **Develop VISSIM model (Baseline/No TSP, With TSP) – Now SOP!**
• Develop signal timing and phasing

Fiber Installation – Final Design
• Install fiber along Mill/Ash downtown loop and Rio Salado

ITS Infrastructure – In Progress
• TSP w/RTT System (EMTRAC)
• Signal Controllers (McCain ATC eX2 w/D4)
• CCTV Cameras, Video Detection
EMTRAC – Operation

The EMTRAC system tracks vehicle positions and progress as they travel through their routes. As vehicles move along these routes, they enter pre-defined virtual detection zones and transmit data via secure 900 MHz FHSS radio to appropriate wayside equipment.
EMTRAC – Virtual Detection

The EMTRAC system eliminates the need for embedded loops in the trackway and reduces the need for other wayside detection equipment. This is done by creating virtual detection zones, which are defined by GPS coordinates and allow system data to be sent only when pre-defined conditions (such as position, speed and heading) are met.
**EMTRAC – Detection Zones**

Virtual detection zones have many uses, can be placed anywhere, can be any size, can be used as often as desired, and can be easily moved or changed based on current needs to optimize the system’s operation.

- **Zone 1**: Activates in advance of the train reaching the intersection.
- **Zone 2**: Activates when the train is at the platform or station.
- **Zone 3**: Activates when the train leaves the platform or station.
- **Zone 4**: Activates the crossing gate control at the upcoming intersection.
- **Zone 5**: Requests signal priority for the upcoming intersection.
- **Zone 6**: Records any instances of trains over-running the stop signal bar.
- **Zone 7**: Activates when the train has cleared the intersection.
EMTRAC – Onboard Equipment

- One Vehicle Computer Unit (VCU) and RF/GPS antenna per cab
- VCU requires power, speed sensor, ignition sensor, **battery SOC**, **silent alarm**, etc.
- Antenna is mounted on roof
EMTRAC – Wayside Equipment

- Priority Detector in cabinet (Tx/Rx data, communicates with signal controller)
- Omni-directional antenna (mounted at 15’ or higher near signal cabinet)
- Existing IR EVP detectors can be wired in and accepted as inputs
EMTRAC Functions

Transit Signal Priority (TSP)
- Priority request monitoring and logging
- Traffic signal phase logging

Real-Time Tracking (RTT)
- Speed
- Latitude and longitude
- Bearing

Battery State of Charge (SOC) Monitoring and Logging

Data Archiving

Silent Alarm

Vehicle/Station Estimated Time of Arrival (ETA)

Communications Backhaul on Tempe Streetcar Alignment
Off-wire segments
<table>
<thead>
<tr>
<th>ESS SOC (%)</th>
<th>Vehicle Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>ESS Fully Charged.</td>
</tr>
<tr>
<td>38</td>
<td>First Load Shed: HVAC units operate in partial power except the active cab HVAC remains at full power.</td>
</tr>
<tr>
<td>30</td>
<td>Second Load Shed: Between 30% and 20% the vehicle propulsion operates normally. All HVAC units off.</td>
</tr>
<tr>
<td>20</td>
<td>ESS mode disabled.</td>
</tr>
</tbody>
</table>

- The ESS load shed control is based on the individual pack SOC levels.
- The A end loads follow the A end ESS SOC control scheme. Similarly the B end loads follow the B end ESS SOC control scheme.
- The loads on a per end basis are propulsion and two of the four HVAC units.
- AW2 Vehicle Weight
- Charge Rate 2C
- 74.4kW Hotel Loads (No Load Shedding)
- Regenerative braking energy recapture
- EoL

- Wireless Sections:
  - SB - Hayden Ferry to Ash Avenue and University Drive to 9th Street
  - NB - 9th Street to Hayden Ferry
- Dwell Time: (TS 2A.2.1)
  - 30 Seconds at Stations
  - 20 Seconds at Stop Lights
  - 30 Seconds at LRV Crossing
  - 3 Minutes at Marina Heights
- ESS acceleration: 3.0 mph/s to 7.5 mph

OESS
Traction Battery SOC vs Time & Location
Selected TSP Capabilities

**Early Green Return** – Terminate conflicting phases early to return to transit phase

**Green Extension** – Extend transit phase to provide longer green window for passage

**Left Turn Swapping** – Move leading left turn to lagging (one cycle only) for earlier return to transit phase

**D4 Features**

- Multiple priority levels
- Boolean logic for custom programming
- Peer-to-Peer communications using both local and upstream state
- Adaptive arrival times compensate for varying station dwell times
VISSIM Modelling

Data
• Existing signal timing and phasing, along with streetcar adjustments
• Opening day volumes
• Pedestrian, bus and LRT traffic are included
• In progress/planned development impacts
• Streetcar ridership estimates, by station/area
• Streetcar headway and layover requirements

Three Time Periods Modelled
• AM peak, Mid-Day and PM peak

TSP Levels
• Baseline – signals optimized, but no TSP
• Basic TSP – basic green extension/return
• Optimized TSP – advanced TSP options, including upstream P2P data
VISSIM Videos

Multiple videos were produced from the VISSIM Models

To review intersection operations in detail

To show the operations of the streetcar on the network as a whole
### Mid-Day Peak Period Events at the Marina Heights Station Terminal

<table>
<thead>
<tr>
<th>Event</th>
<th>Time (sec)</th>
<th>Train #</th>
<th>Departing Train Headway Achieved</th>
<th>Departing Train Layover Achieved</th>
<th>Arriving Train Headway Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) SB Train Departs</td>
<td>780</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) NB Train Arrives</td>
<td>1200</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) SB Train Departs</td>
<td>1380</td>
<td>2</td>
<td>10.0 min</td>
<td>3.0 min</td>
<td></td>
</tr>
<tr>
<td>4) NB Train Arrives</td>
<td>1770</td>
<td>3</td>
<td></td>
<td>9.5 min</td>
<td></td>
</tr>
<tr>
<td>5) SB Train Departs</td>
<td>1980</td>
<td>3</td>
<td>10.0 min</td>
<td>3.5 min</td>
<td></td>
</tr>
<tr>
<td>6) NB Train Arrives</td>
<td>2520</td>
<td>4</td>
<td></td>
<td>12.5 min</td>
<td></td>
</tr>
<tr>
<td>7) SB Train Departs</td>
<td>2700</td>
<td>4</td>
<td>12.0 min (120 sec late)</td>
<td>3.0 min</td>
<td></td>
</tr>
<tr>
<td>8) NB Train Arrives</td>
<td>3300</td>
<td>1</td>
<td></td>
<td>13.0 min</td>
<td></td>
</tr>
<tr>
<td>9) SB Train Departs</td>
<td>3480</td>
<td>1</td>
<td>13.0 min (180 sec late)</td>
<td>3.0 min</td>
<td></td>
</tr>
<tr>
<td>10) NB train Arrives</td>
<td>3990</td>
<td>2</td>
<td></td>
<td>11.5 min</td>
<td></td>
</tr>
<tr>
<td>11) SB Train Departs</td>
<td>4170</td>
<td>2</td>
<td>11.5 min (190 sec late)</td>
<td>3.0 min</td>
<td></td>
</tr>
<tr>
<td>12) NB Train Arrives</td>
<td>4515</td>
<td>3</td>
<td></td>
<td>8.75 min</td>
<td></td>
</tr>
<tr>
<td>13) SB train Departs</td>
<td>4770</td>
<td>3</td>
<td>10.0 min</td>
<td>4.3 min</td>
<td></td>
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</tbody>
</table>
# VISSIM Modelling

## Events at Terminals with Optimized TSP

### Mid-Day Peak Period Events at the Dorsey Station Terminal

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Time (sec)</th>
<th>Train #</th>
<th>Departing Train Headway Achieved</th>
<th>Departing Train Layover Achieved</th>
<th>Arriving Train Headway Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) NB Train Departs</td>
<td>300</td>
<td>2</td>
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<td></td>
<td></td>
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<tr>
<td>2) NB Train Departs</td>
<td>900</td>
<td>3</td>
<td>10.0 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) NB Train Departs</td>
<td>1500</td>
<td>4</td>
<td>10.0 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) SB Train Arrives</td>
<td>1825</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) NB Train Departs</td>
<td>2100</td>
<td>1</td>
<td>10.0 min</td>
<td>4.6 min</td>
<td></td>
</tr>
<tr>
<td>6) SB Train Arrives</td>
<td>2294</td>
<td>2</td>
<td></td>
<td>7.8 min</td>
<td></td>
</tr>
<tr>
<td>7) NB Train Departs</td>
<td>2700</td>
<td>2</td>
<td>10.0 min</td>
<td>6.8 min</td>
<td></td>
</tr>
<tr>
<td>8) SB Train Arrives</td>
<td>3121</td>
<td>3</td>
<td></td>
<td>13.8 min</td>
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</tr>
<tr>
<td>9) NB Train Departs</td>
<td>3300</td>
<td>3</td>
<td>10.0 min</td>
<td>3.0 min</td>
<td></td>
</tr>
<tr>
<td>10) SB Train Arrives</td>
<td>3603</td>
<td>4</td>
<td></td>
<td>8.0 min</td>
<td></td>
</tr>
<tr>
<td>11) NB Train Departs</td>
<td>3900</td>
<td>4</td>
<td>10.0 min</td>
<td>5.0 min</td>
<td></td>
</tr>
<tr>
<td>12) SB Train Arrives</td>
<td>4149</td>
<td>1</td>
<td></td>
<td>9.1 min</td>
<td></td>
</tr>
<tr>
<td>13) NB Train Departs</td>
<td>4500</td>
<td>1</td>
<td>10.0 min</td>
<td>5.9 min</td>
<td></td>
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<tr>
<td>14) SB Train Arrives</td>
<td>4872</td>
<td>2</td>
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<td>12.1 min</td>
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</tr>
<tr>
<td>15) NB Train Departs</td>
<td>5100</td>
<td>2</td>
<td>10.0 min</td>
<td>3.8 min</td>
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## AM Peak Hour Intersection Delay Comparison

<table>
<thead>
<tr>
<th>Int. Name</th>
<th>Approach</th>
<th>Base Model</th>
<th>Optimized TSP Model</th>
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<tr>
<td></td>
<td></td>
<td>Delay</td>
<td>LOS</td>
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<tr>
<td>Apache and Dorsey</td>
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</tr>
<tr>
<td>EB</td>
<td>8.9</td>
<td>A</td>
<td>17.5</td>
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<tr>
<td>WB</td>
<td>14.1</td>
<td>B</td>
<td>13.9</td>
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<tr>
<td>NB</td>
<td>22.3</td>
<td>C</td>
<td>22.5</td>
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<tr>
<td>SB</td>
<td>20.3</td>
<td>C</td>
<td>19.4</td>
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<tr>
<td>Total</td>
<td>13.6</td>
<td>B</td>
<td>15.7</td>
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<td>Apache and Terrace</td>
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<tr>
<td>EB</td>
<td>17.1</td>
<td>B</td>
<td>22.5</td>
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<td>WB</td>
<td>13.4</td>
<td>B</td>
<td>13.1</td>
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<tr>
<td>NB</td>
<td>46</td>
<td>D</td>
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<tr>
<td>SB</td>
<td>27.6</td>
<td>C</td>
<td>29.2</td>
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<td>Total</td>
<td>16.5</td>
<td>B</td>
<td>18.7</td>
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<tr>
<td>Apache Pedestrian Crossing</td>
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<tr>
<td>EB</td>
<td>0.2</td>
<td>A</td>
<td>0.2</td>
</tr>
<tr>
<td>WB</td>
<td>1.2</td>
<td>A</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>0.8</td>
<td>A</td>
<td>0.7</td>
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<tr>
<td>Apache and Rural</td>
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<td>D</td>
<td>28.2</td>
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<td>WB</td>
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<td>D</td>
<td>46.6</td>
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<td>48.1</td>
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<td>Paseo del Saber Pedestrian Crossing</td>
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<td>EB</td>
<td>9.5</td>
<td>A</td>
<td>10.6</td>
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<td>WB</td>
<td>6.3</td>
<td>A</td>
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<tr>
<td>Total</td>
<td>7.3</td>
<td>A</td>
<td>11.8</td>
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<tr>
<td>Apache and McAllister</td>
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</tr>
<tr>
<td>EB</td>
<td>7.9</td>
<td>A</td>
<td>7.5</td>
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<td>A</td>
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<td>C</td>
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</tr>
<tr>
<td>Total</td>
<td>9.3</td>
<td>A</td>
<td>11.1</td>
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</table>
VISSIM Modelling

The VISSIM model was used to evaluate the ability of the designed system to meet each agency’s operational goals:

• **VM** – 10 minute headways; layover requirements for operators
• **COT** – minimizing delay for all roadway users

VM’s goals were met in nearly every instance across all three time periods modelled with minimal impact to intersection LOS, but only under the Optimized TSP scenario.

The simulation modelling results clearly demonstrated the benefits and the need for a comprehensive TSP solution.

The model also provided useful information about upstream peers and detection zone placement TSP configuration.
Next Steps

• Create D4 controller databases and evaluate in test cabinets
• Install EMTRAC onboard equipment
• Integrate and test Brookville and EMTRAC onboard systems
• Install EMTRAC wayside equipment
• Install McCain/D4 controllers
• Install EMTRAC Central Monitor software
• Test communications link between Tempe TMC and VM OCC
• Monitor and test deployed signal timing/TSP and adjust as necessary
• System Extension
Questions?
Valleymetro.org/TempeStreetcar

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