Tempe Streetcar

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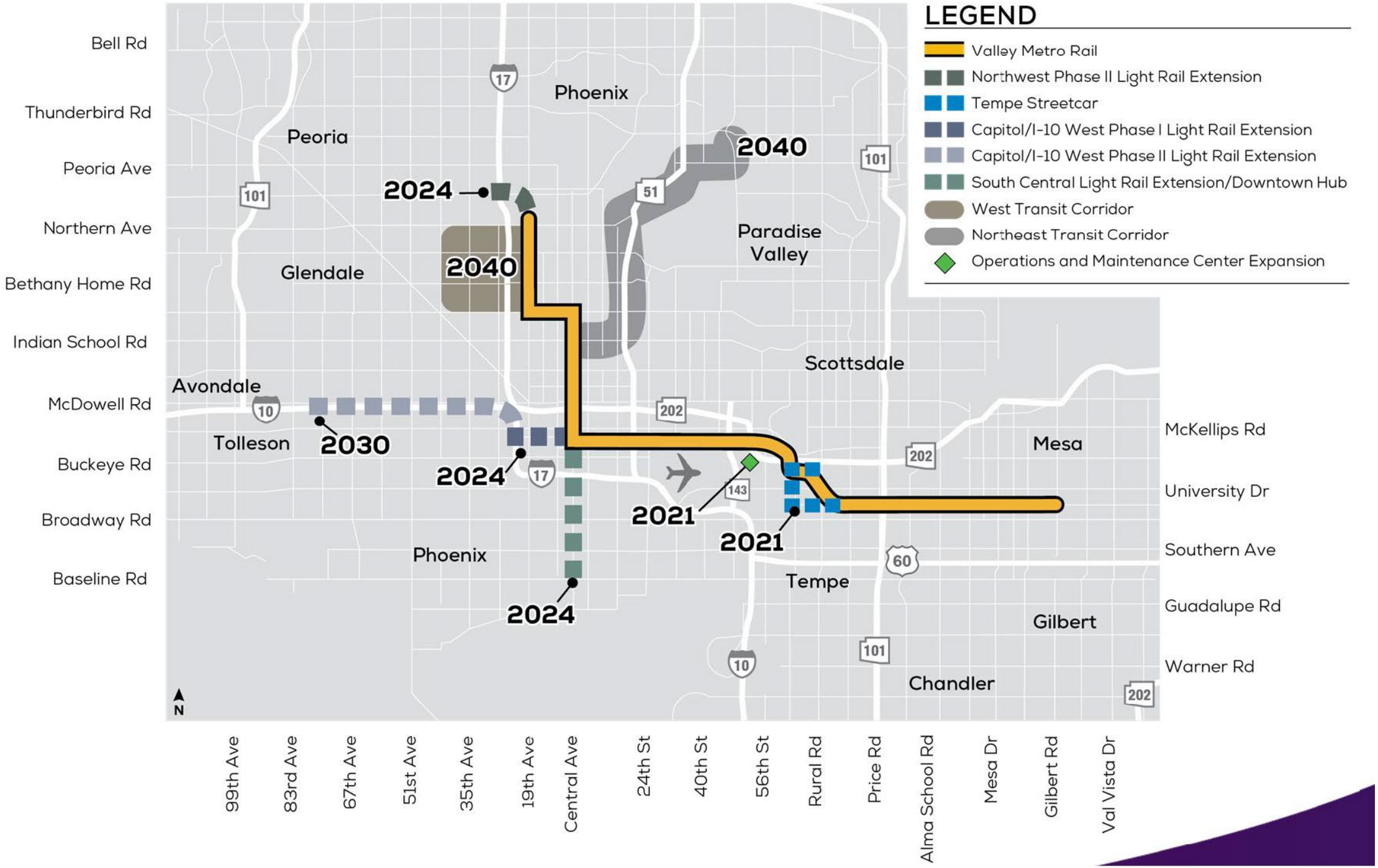
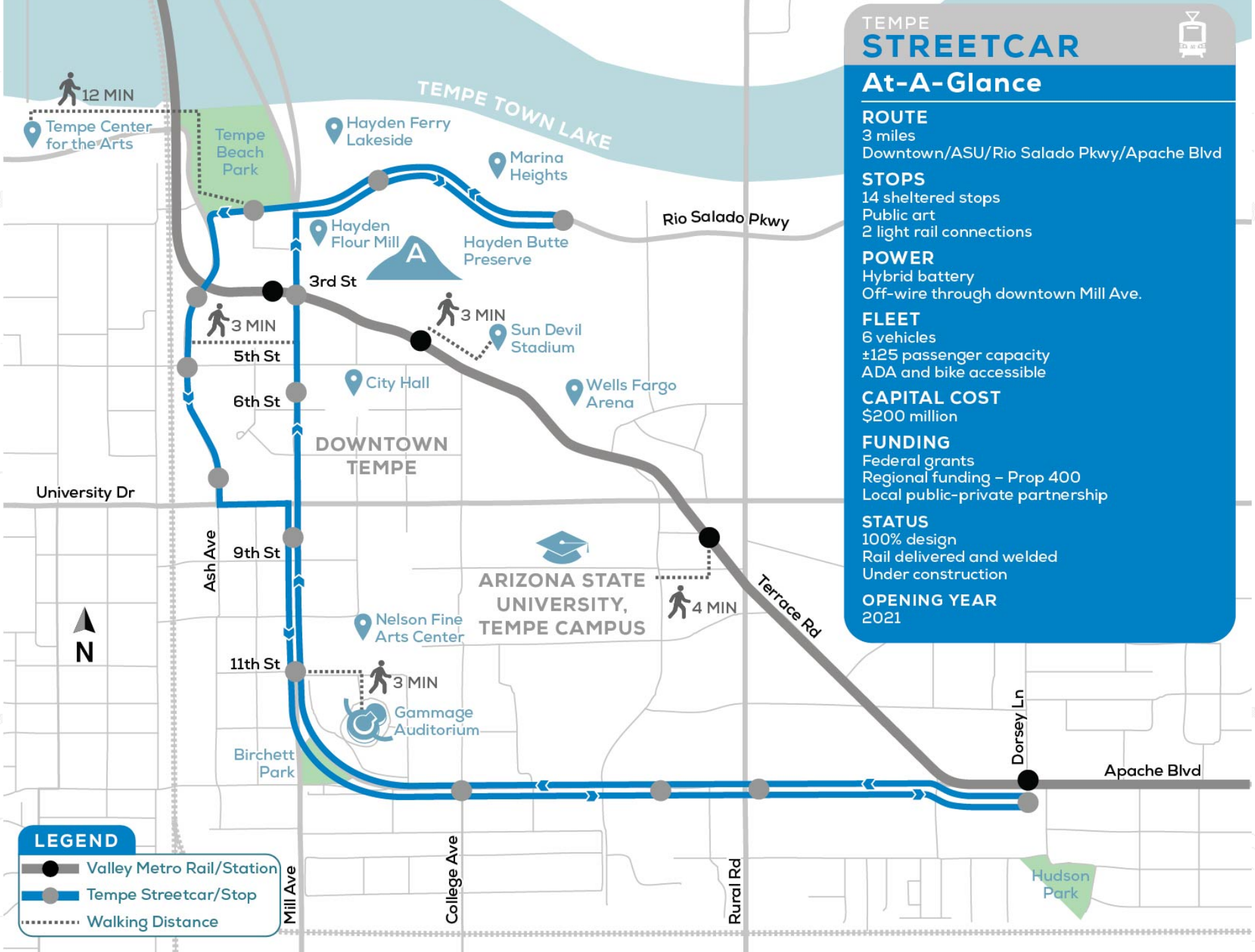

LEGEND
Valley Metro Rail
Northwest Phase II Light Rail Extension
Tempe Streetcar
Capitol/I-10 West Phase I Light Rail Extension
Capitol/I-10 West Phase II Light Rail Extension
South Central Light Rail Extension/Downtown Hub
West Transit Corridor
Northeast Transit Corridor
Operations and Maintenance Center Expansion
Bell Rd
Thunderbird Rd
Peoria Ave
Northern Ave
Bethany Home Rd
Indian School Rd
McDowell Rd
Buckeye Rd
Broadway Rd
Baseline Rd
McKellips Rd
University Dr
Southern Ave
Guadalupe Rd
Warner Rd
Peoria
Phoenix
Glendale
Paradise Valley
Scottsdale
Avondale
Tolleson
Mesa
Tempe
Gilbert
Chandler
2024
2040
2030
2021
N
99th Ave
83rd Ave
67th Ave
51st Ave
35th Ave
19th Ave
Central Ave
24th St
40th St
56th St
Rural Rd
Price Rd
Alma School Rd
Mesa Dr
Gilbert Rd
Val Vista Dr



TEMPE
STREETCAR

At-A-Glance

ROUTE
3 miles
Downtown/ASU/Rio Salado Pkwy/Apache Blvd

STOPS
14 sheltered stops
Public art
2 light rail connections

POWER
Hybrid battery
Off-wire through downtown Mill Ave.

FLEET
6 vehicles
±125 passenger capacity
ADA and bike accessible

CAPITAL COST
$200 million

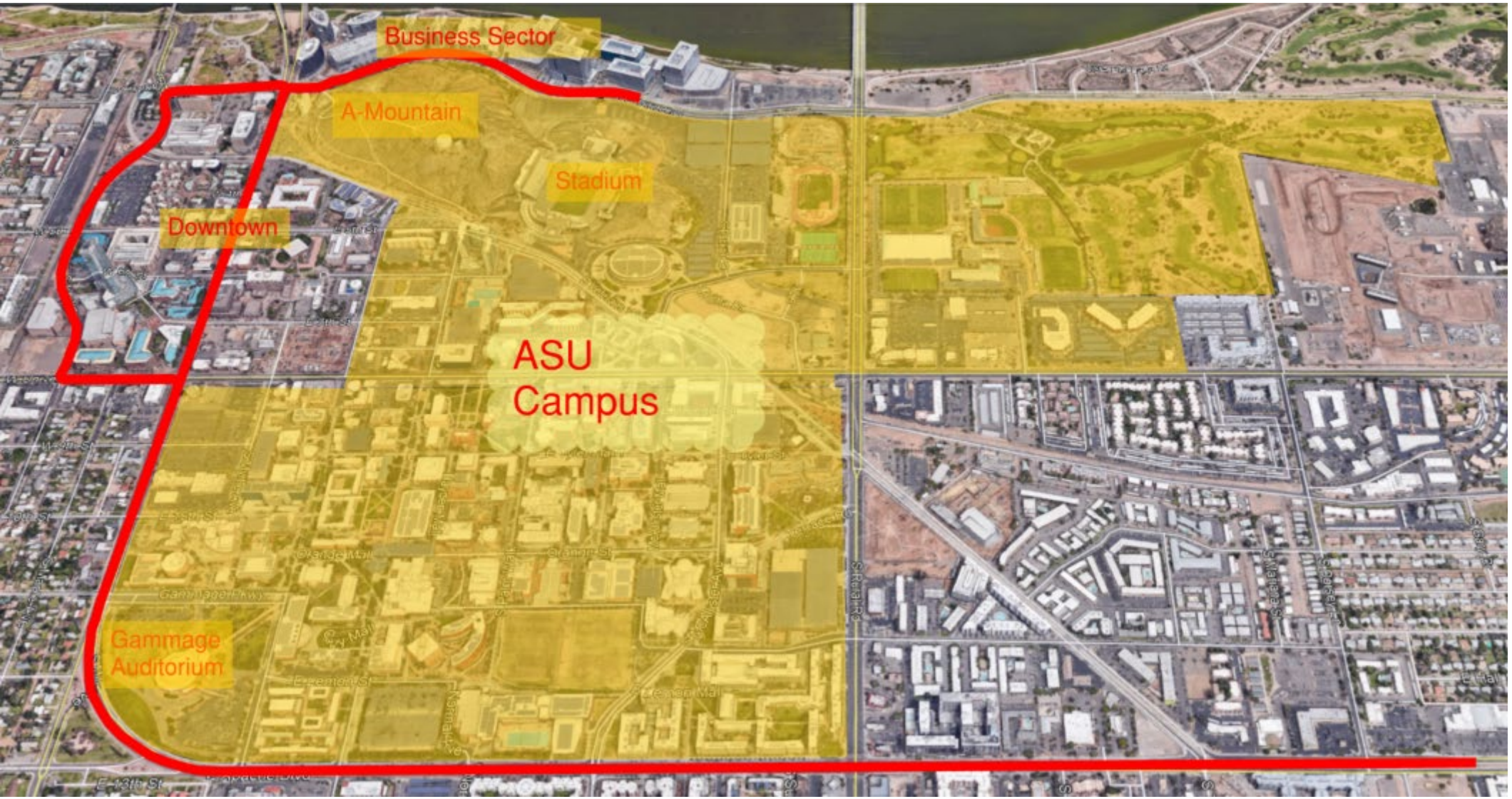
FUNDING
Federal grants
Regional funding – Prop 400
Local public-private partnership

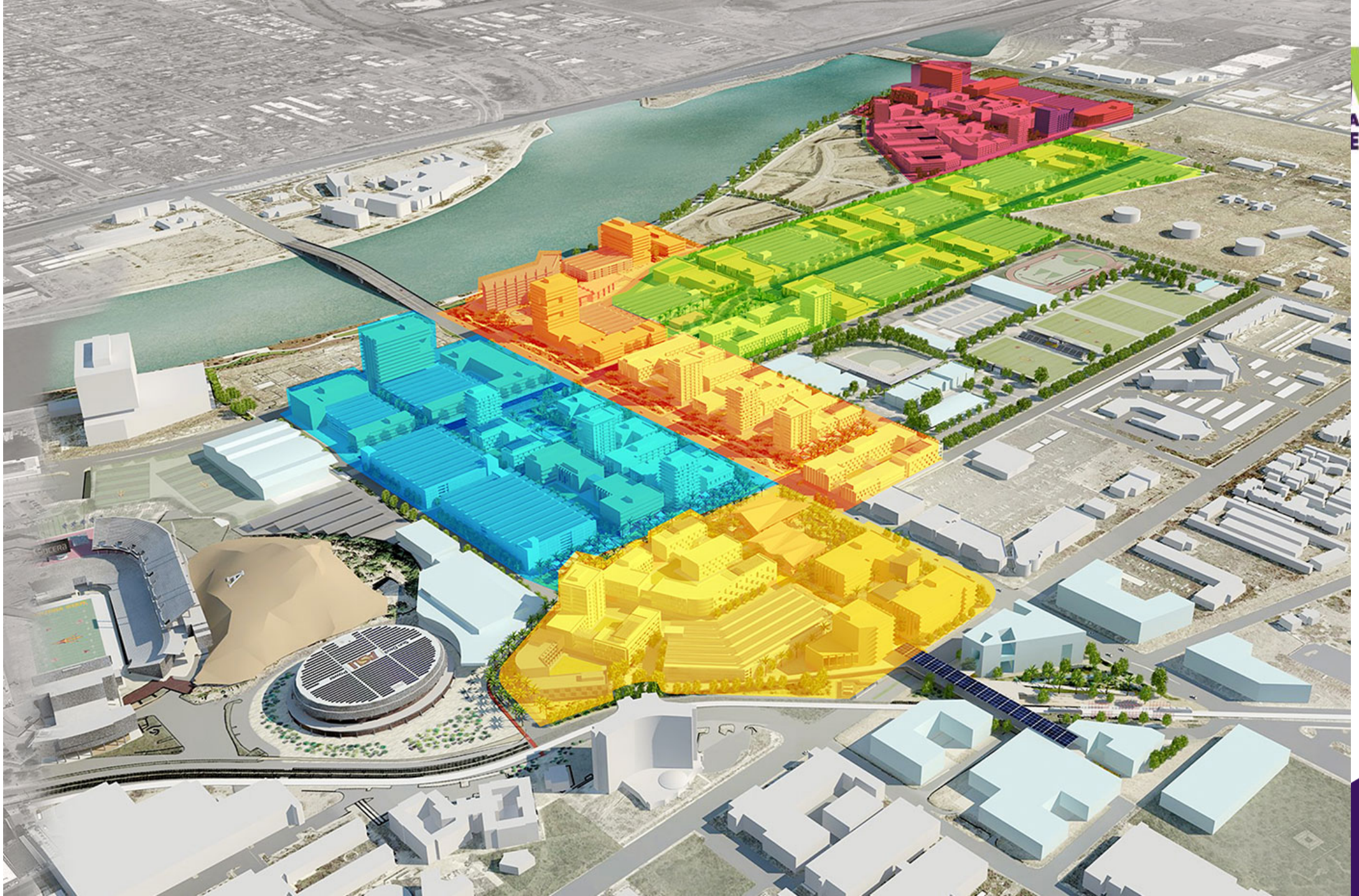
STATUS
100% design
Rail delivered and welded
Under construction

OPENING YEAR
2021

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


Business Sector
A-Mountain
Stadium
Downtown
ASU
Campus
Gammage
Auditorium



Source: downtowntempe.com

- 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

The Vehicle

Manufactured by Brookville
Out of Brookville, PA

Project Schedule

Utility Relocation & CNPA

Track Construction

Civil & Roadway

Stops & Artwork

Operations Training Vehicle Testing

Opening

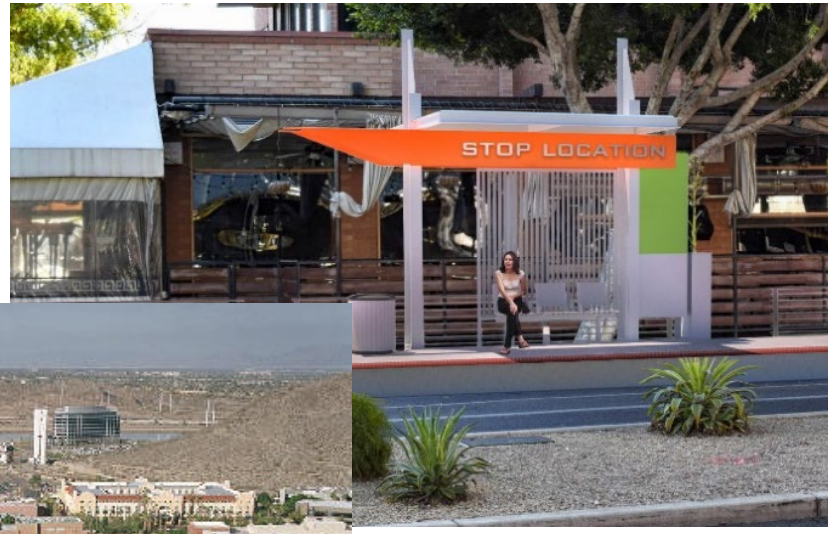
2018 | 2019 | 2020 | 2021

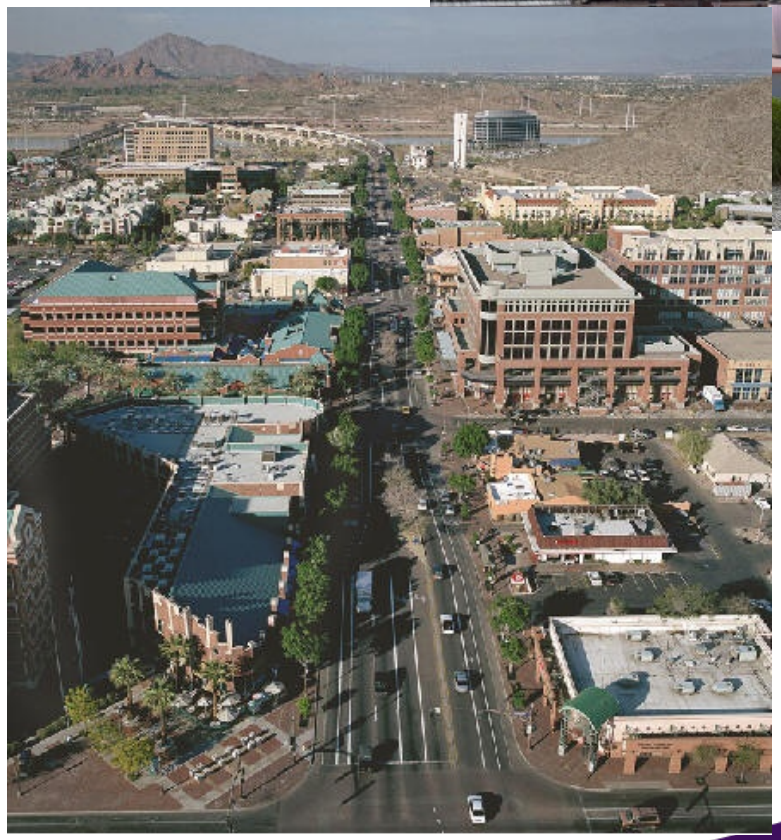
Design Milestones

100%	Issued For Construction
May 2018	August 2018

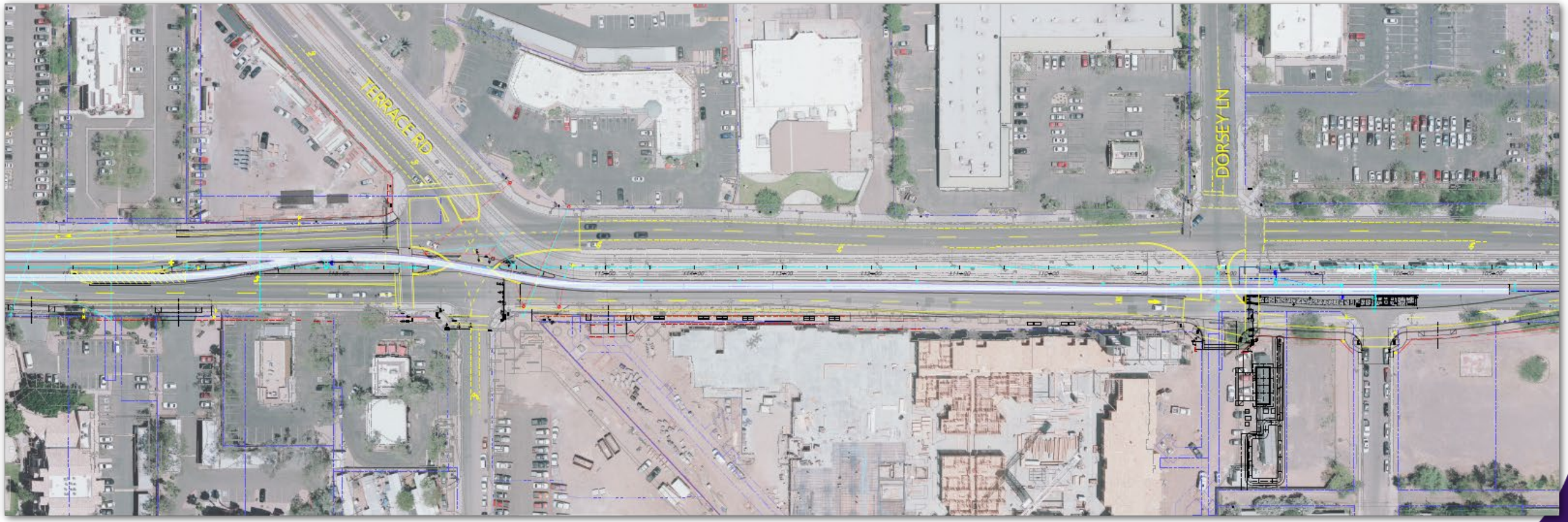
Design Challenges

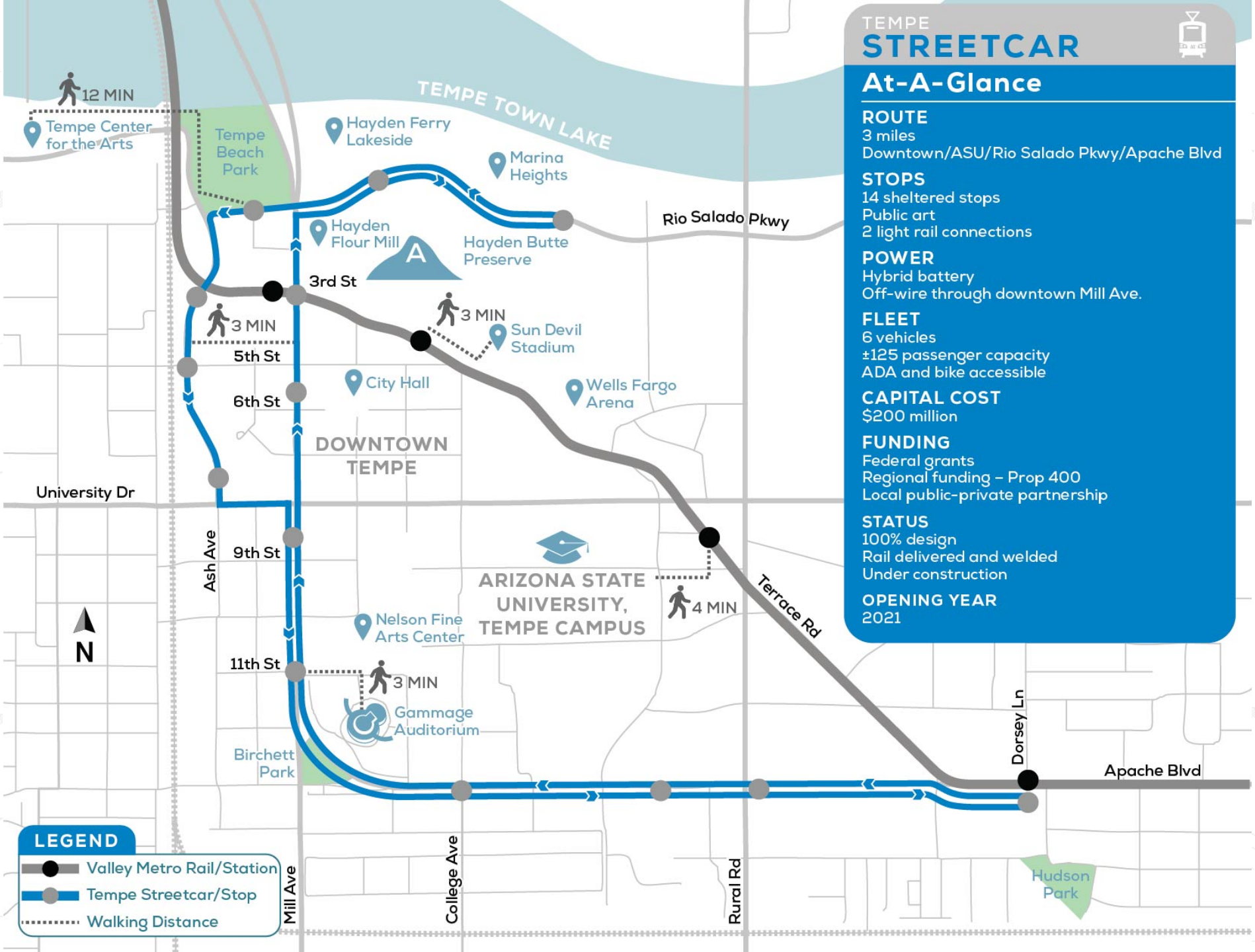
- Track Section
- Utility Relocation Requirements
- Number and location of TPSS
- Feeder Cables
- Landscaping
- Stops
- Alignment
- CNPA (Concurrent Non-Project Activity)





Single track – Apache Terminus





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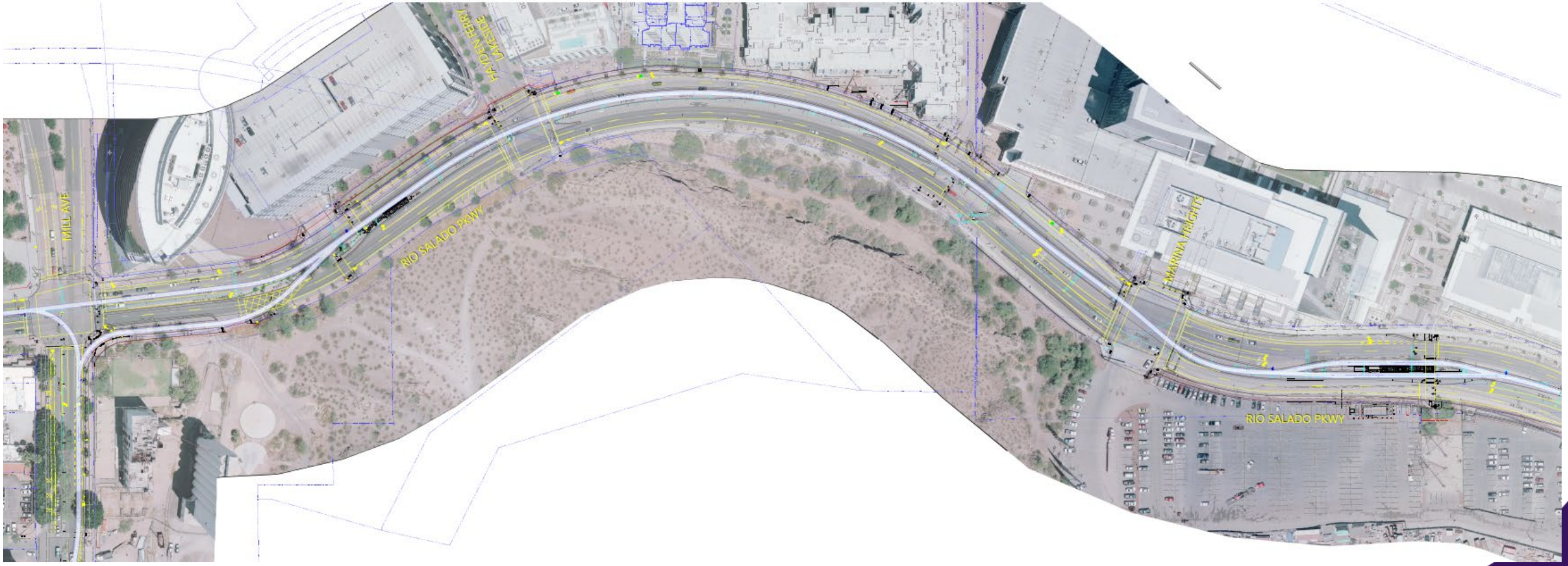
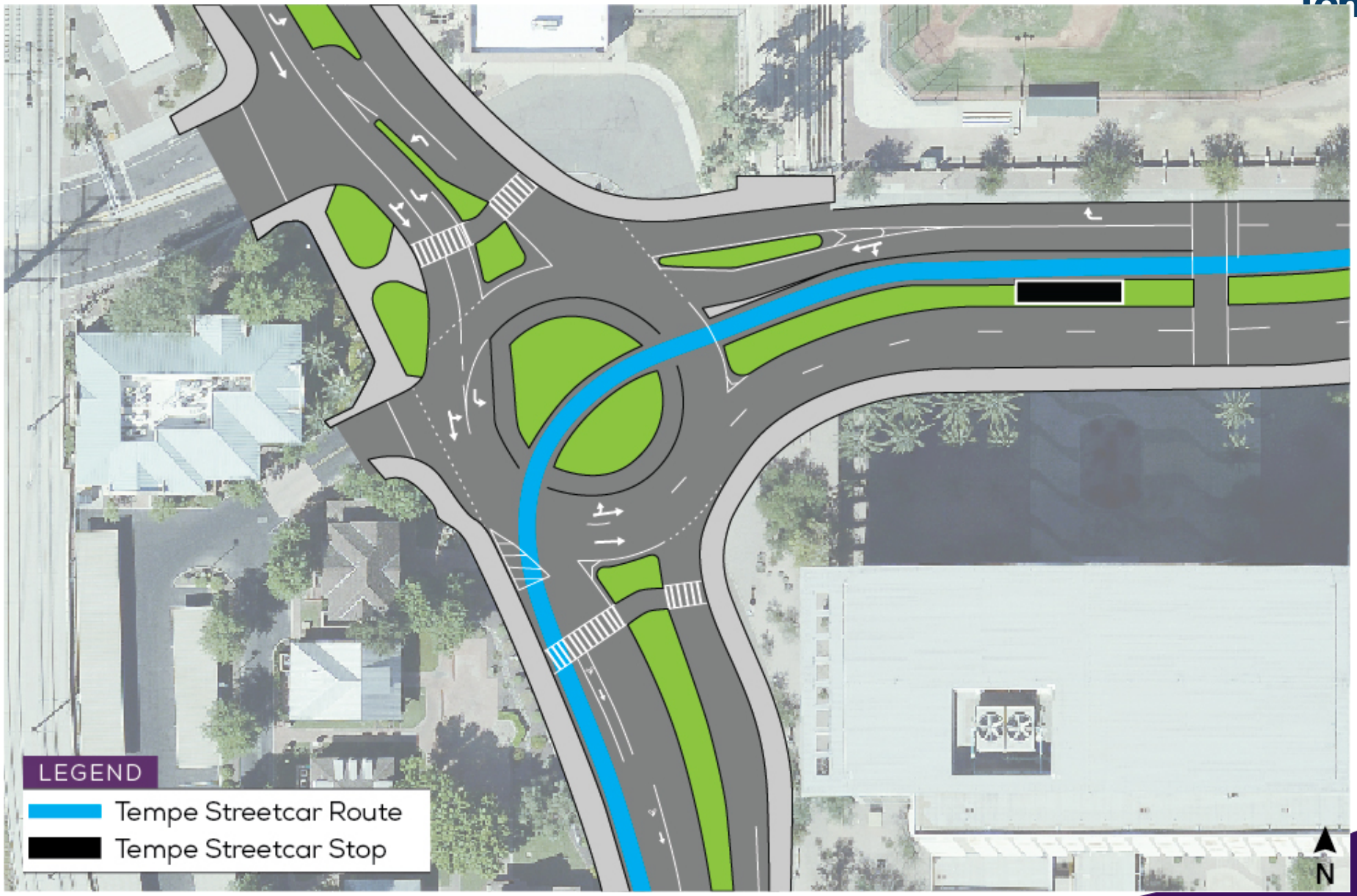
Single Track – Marina Heights Terminus



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**

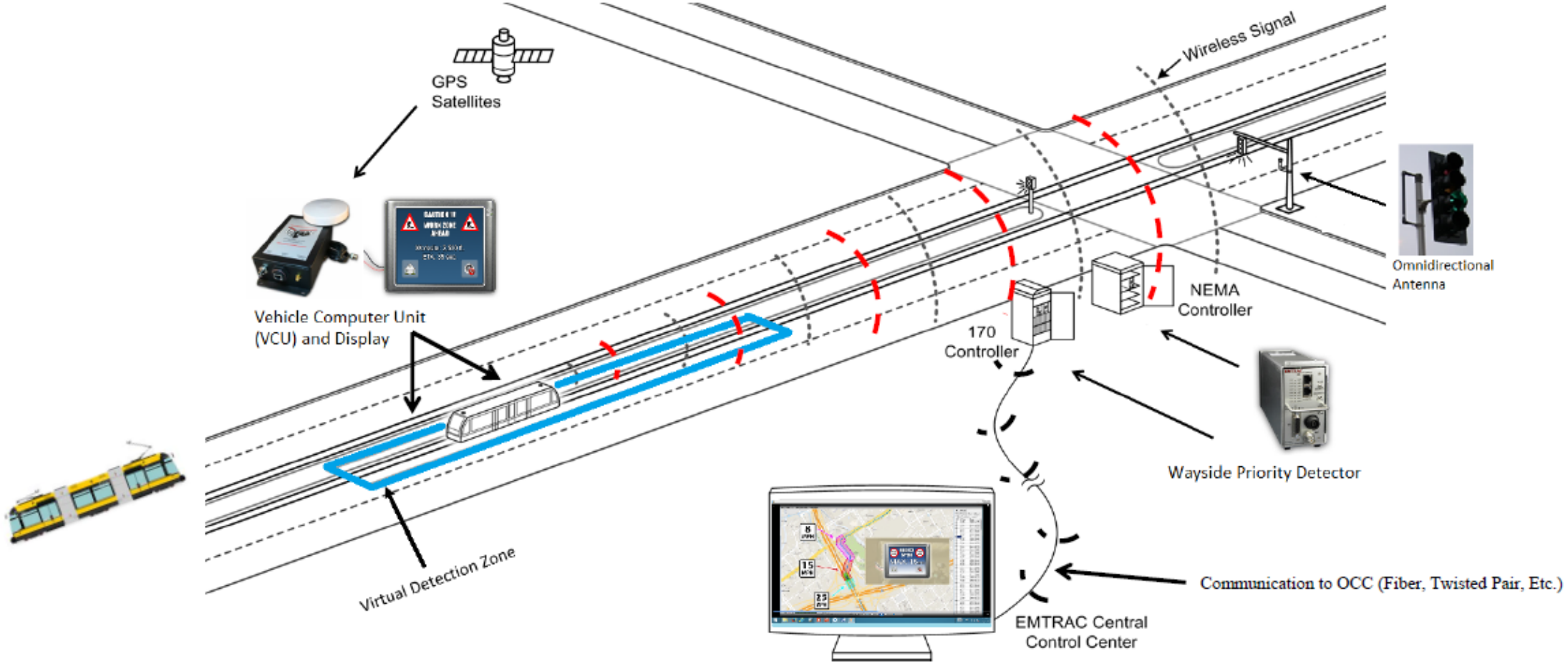
Fiber Installation – Final Design

- 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

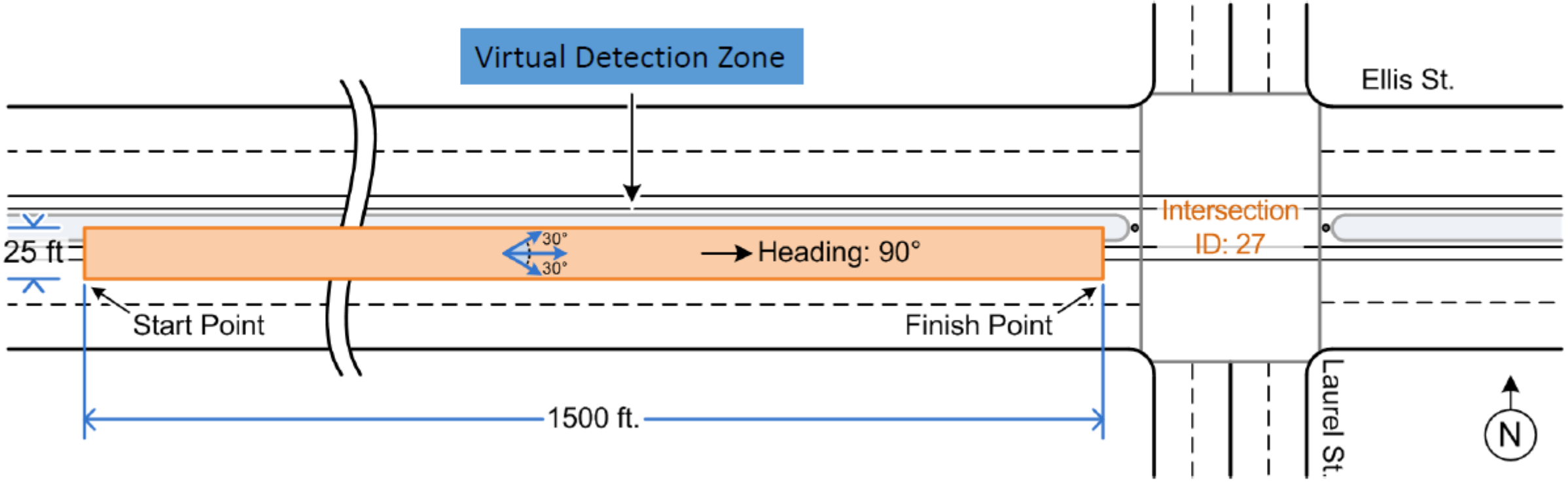
EMTRAC – Operation



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.

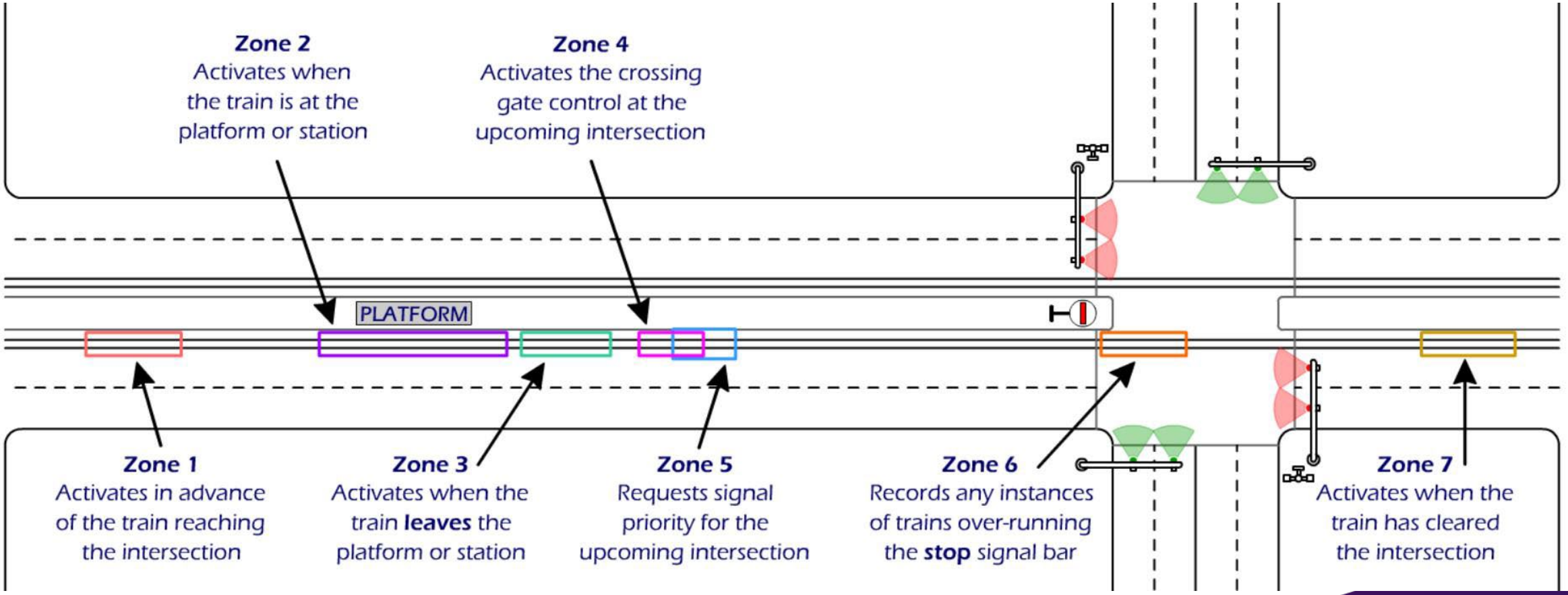
EMTRAC – Virtual Detection

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.

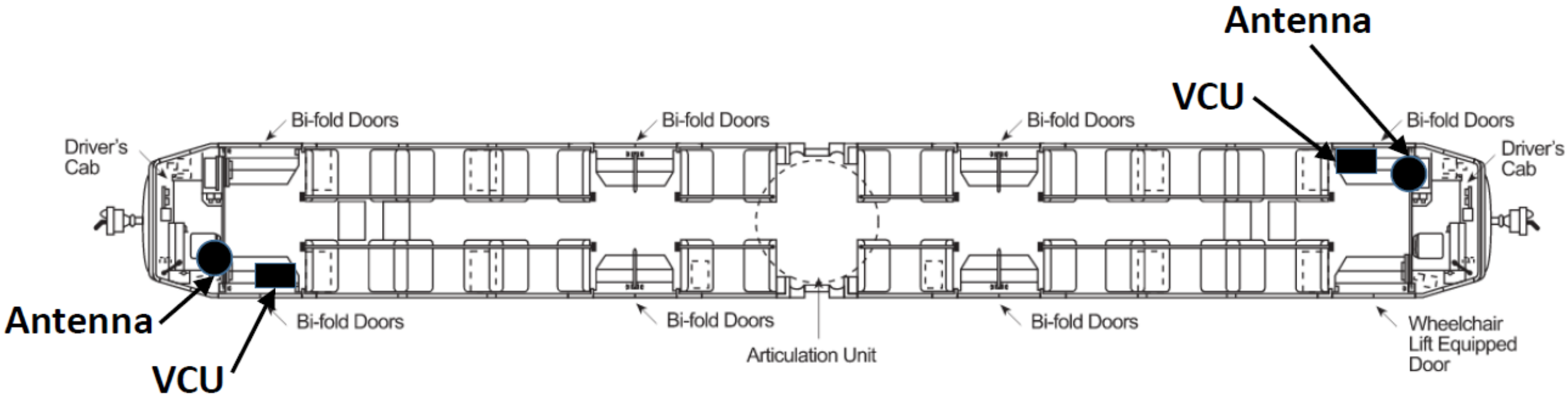


EMTRAC – Detection Zones

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.

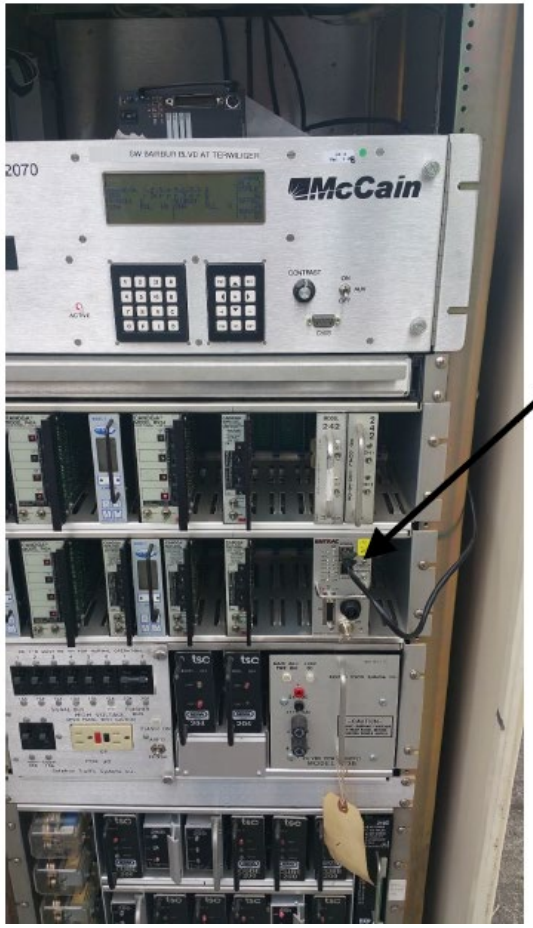


EMTRAC – Onboard Equipment



- 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

Omni-Directional Antenna at 15’ +

- 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

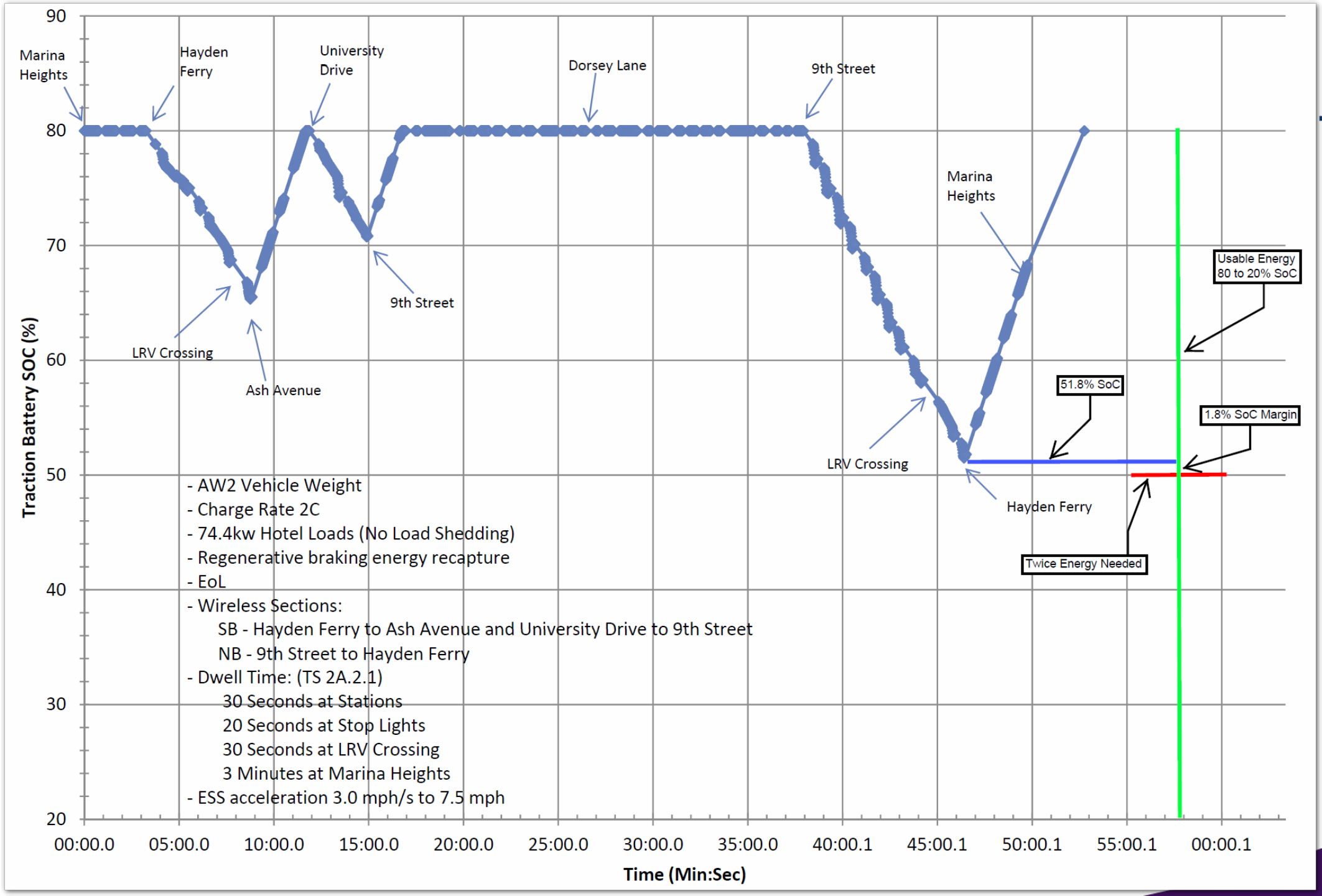
Vehicle/Station Estimated Time of Arrival (ETA)

Communications Backhaul on Tempe Streetcar Alignment

Off-wire segments

ESS SOC (%)	Vehicle Function
80	ESS Fully Charged.
	Between 80 and 38 % the vehicle is fully operational in ESS mode.
	If below 60% the ESS mode cannot be turned On. If already operating in ESS mode the vehicle continues to operate normally.
	This is an adjustable parameter by maintenance staff from 25% to 75% SOC. The default setting is 60%.
38	First Load Shed: HVAC units operate in partial power except the active cab HVAC remains at full power.
30	Second Load Shed: Between 30% and 20% the vehicle propulsion operates normally. All HVAC units off.
20	ESS mode disabled.

- 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.



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

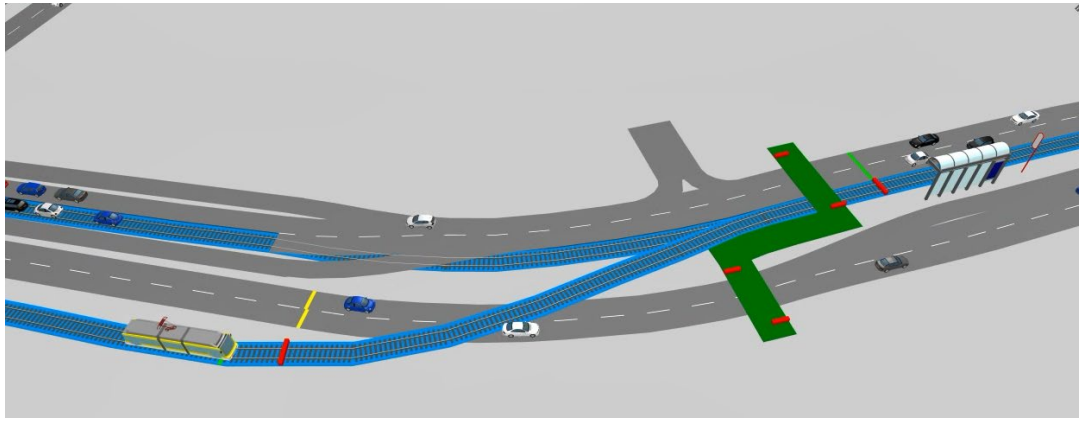
TSP Levels

- **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

VISSIM Modelling

Mid-Day Peak Period Events at the Marina Heights Station Terminal

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

VISSIM Modelling

Events at Terminals with Optimized TSP

Mid-Day Peak Period Events at the Dorsey Station Terminal

Event	Time (sec)	Train #	Departing Train Headway Achieved	Departing Train Layover Achieved	Arriving Train Headway Achieved
1) NB Train Departs	300	2			
2) NB Train Departs	900	3	10.0 min		
3) NB Train Departs	1500	4	10.0 min		
4) SB Train Arrives	1825	1			
5) NB Train Departs	2100	1	10.0 min	4.6 min	
6) SB Train Arrives	2294	2			7.8 min
7) NB Train Departs	2700	2	10.0 min	6.8 min	
8) SB Train Arrives	3121	3			13.8 min
9) NB Train Departs	3300	3	10.0 min	3.0 min	
10) SB Train Arrives	3603	4			8.0 min
11) NB Train Departs	3900	4	10.0 min	5.0 min	
12) SB Train Arrives	4149	1			9.1 min
13) NB Train Departs	4500	1	10.0 min	5.9 min	
14) SB Train Arrives	4872	2			12.1 min
15) NB Train Departs	5100	2	10.0 min	3.8 min	

VISSIM Modelling

AM Peak Hour Intersection Delay Comparison					
AM Results		Base Model		Optimized TSP Model	
Int. Name	Approach	Delay	LOS	Delay	LOS
Apache and Dorsey	EB	8.9	A	17.5	B
	WB	14.1	B	13.9	B
	NB	22.3	C	22.5	C
	SB	20.3	C	19.4	B
	Total	13.6	B	15.7	B
Apache and Terrace	EB	17.1	B	22.5	C
	WB	13.4	B	13.1	B
	NB	46	D	47.7	D
	SB	27.6	C	29.2	C
	Total	16.5	B	18.7	B
Apache Pedestrian Crossing	EB	0.2	A	0.2	A
	WB	1.2	A	0.9	A
	Total	0.8	A	0.7	A
Apache and Rural	EB	37.6	D	28.2	C
	WB	35.1	D	46.6	D
	NB	78.6	E	48.1	D
	SB	32.3	C	34.6	C
	Total	56.5	E	43.0	D
Paseo del Saber Pedestrian Crossing	EB	9.5	A	10.6	B
	WB	6.3	A	12.4	B
	Total	7.3	A	11.8	B
Apache and McAllister	EB	7.9	A	7.5	A
	WB	8.0	A	10.9	B
	NB	32.0	C	33.4	C
	SB	22.1	C	22.9	C
	Total	9.3	A	11.1	B

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

David Lucas, ITS Network Engineer

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