

BUS RAPID TRANSIT IN CONSTRAINED URBAN ENVIRONMENTS



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CH2M HILL

Bus Rapid Transit (BRT) Topics

- **Definition and Elements of BRT**
- **Flexibility in constrained urban environments**
- **Case example BRT applications**
- **Conclusions**

Definition of Bus Rapid Transit (BRT)

National Bus Rapid Transit Institute

“Bus Rapid Transit (BRT) is an innovative, high-capacity, lower-cost public transit solution that can achieve the performance and benefits of more expensive rail modes. This integrated system uses buses or specialized vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet a variety of local conditions. BRT system elements can easily be customized to community needs and incorporate state-of-the-art, low-cost technologies that attract more passengers and ultimately help reduce overall traffic congestion.”

Definition of Bus Rapid Transit (BRT)

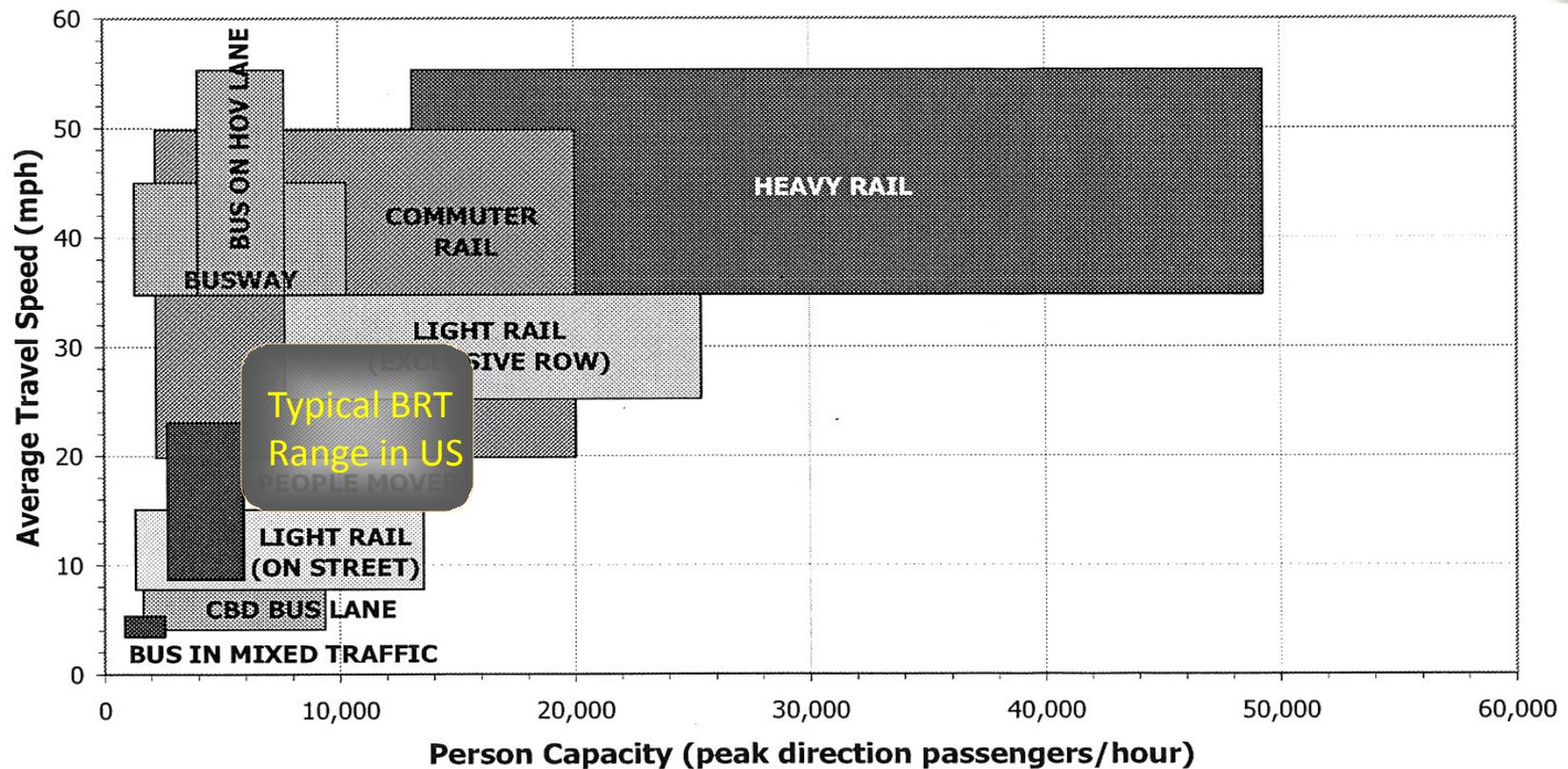
- **Unique attributes and advantages**

- Speed and reliability
- Identity and image
- Flexible and stageable
- Adaptable to fit context
- “Rail-like” service and quality
- Permanence



D-Line RapidRide, Seattle, WA

Relative Speeds and Capacities for Transit Modes



SOURCES: TCQSM speed and capacity estimation procedures, *TCRP Report 13 (R5), Transportation Planning Handbook (R2)*. *Characteristics of Urban Transportation Systems (R1)*

BRT flexibility enables context sensitivity

- **Address the transportation need**
 - Improve ridership, speed & reliability, comfort, convenience, safe, financially feasible
- **Be an asset to the community**
 - Accepted by stakeholders; meets broad community objectives
- **Be compatible with the natural and built environments**
 - Implemented with minimal impacts, aesthetically appropriate

Elements of Bus Rapid Transit



1 Running Ways



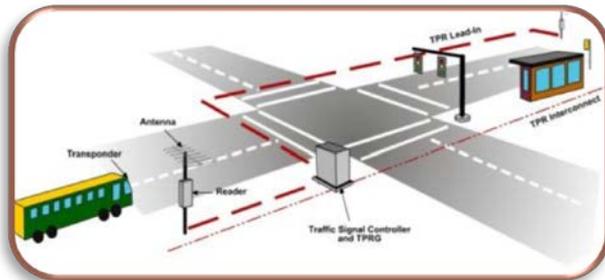
2 Stations and Stops



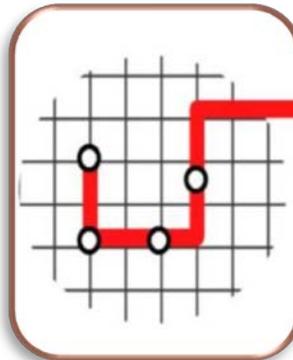
3 Vehicles



4 Fare Collection



5 ITS/Technologies



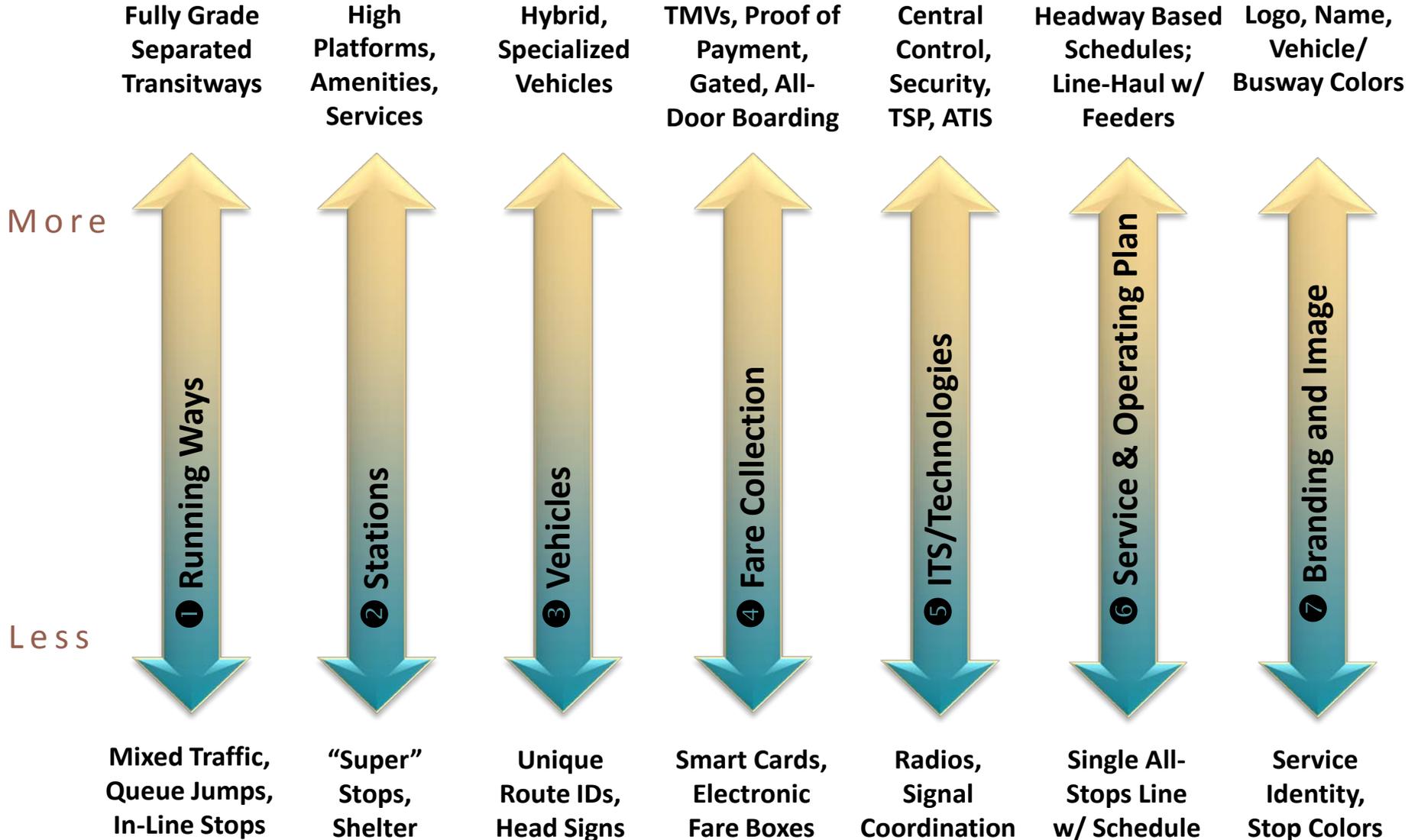
6 Service and Operating Plan



7 Branding and Image



Elements of Bus Rapid Transit Spectrum of Choices

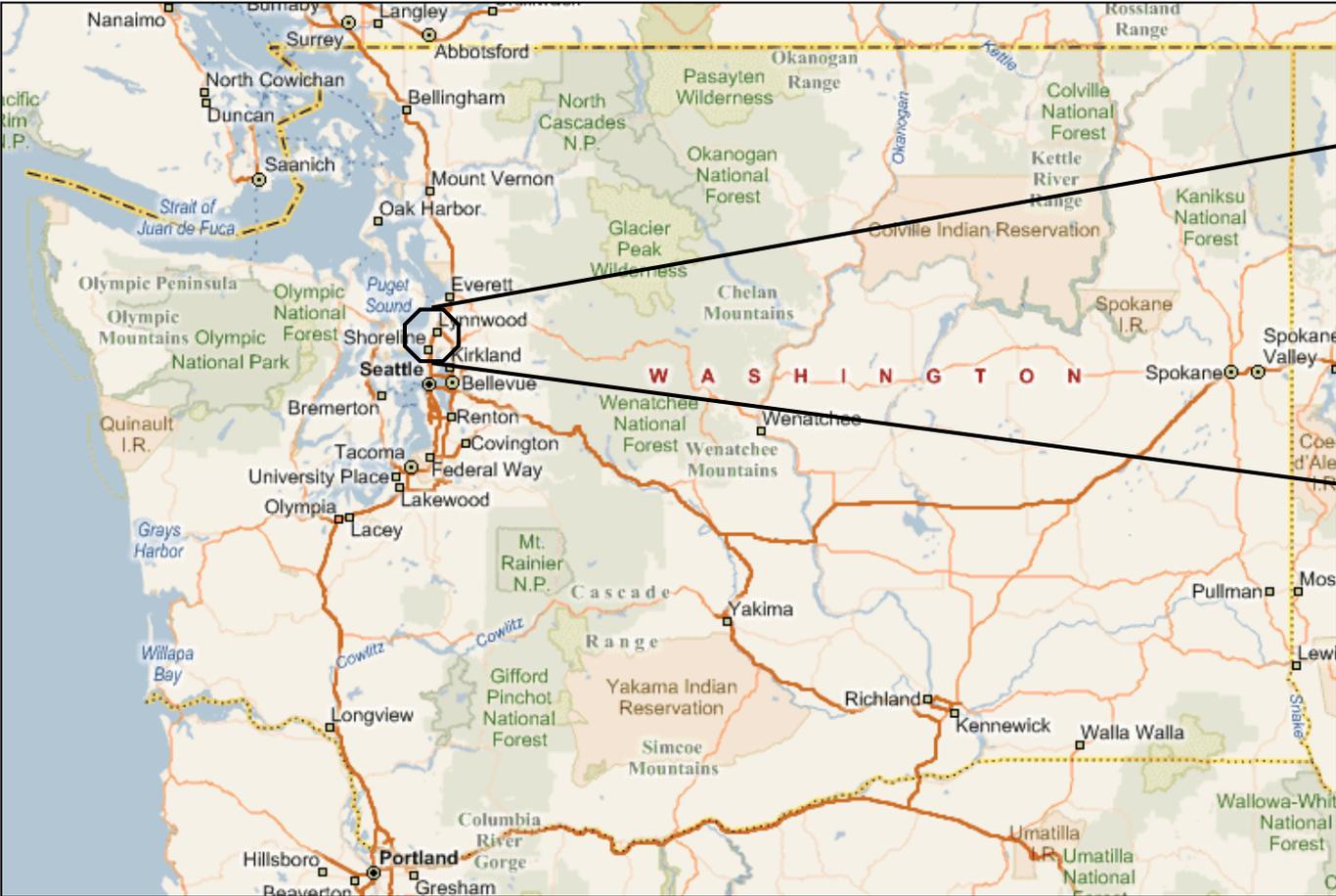


Case Examples of BRT Applications in Constrained Urban Environments

1. Bridging the Gap Transit, Ballard Corridor, Seattle, WA
2. Aurora Corridor RapidRide E-Line, Seattle/Shoreline, WA
3. RapidRide D-Line, Seattle, WA
4. Santa Clara-Alum Rock Bus Rapid Transit, San Jose, CA
5. Swift, Snohomish County, WA
6. SR710 North Study BRT Alternative, Los Angeles, CA

Case Example Applications: Aurora Corridor (future RapidRide E-Line)

Project Location – Cities of Shoreline & Seattle, WA



	PROJECT LOCATION
	REMAINING STUDY LOCATION

Case Example Applications: Aurora Corridor (future RapidRide E-Line)

● Project Context

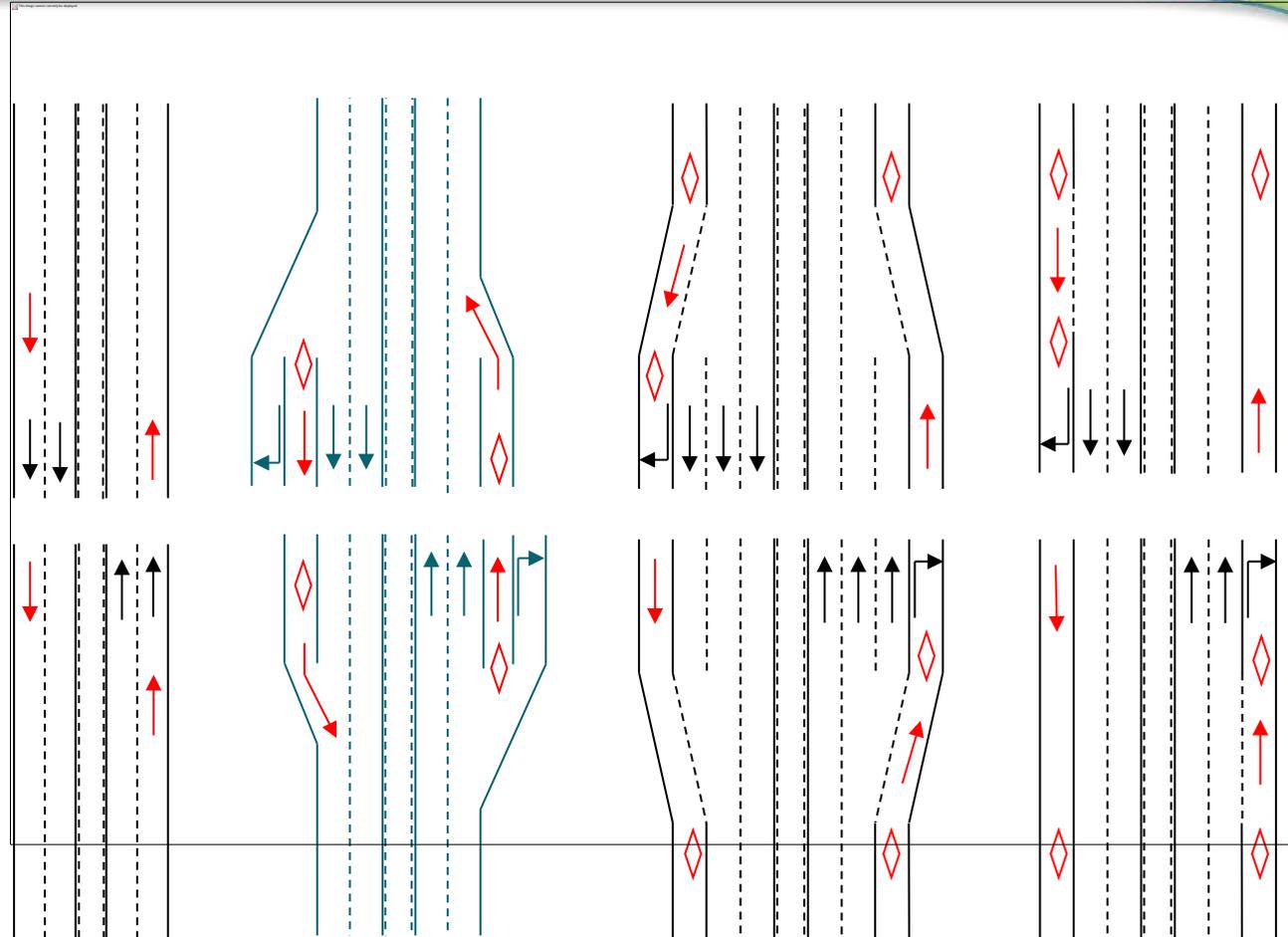
- Three miles; five lanes with TWLTL
- Traffic congestion
- High accident rates
- Limited sidewalks
- Poor aesthetics
- Activist community
- Non-supportive conditions for transit



Seattle Times Photo

Case Example Applications: Aurora Corridor (future RapidRide E-Line)

*Four Transit
Design
Options
Were
Evaluated*



No Build

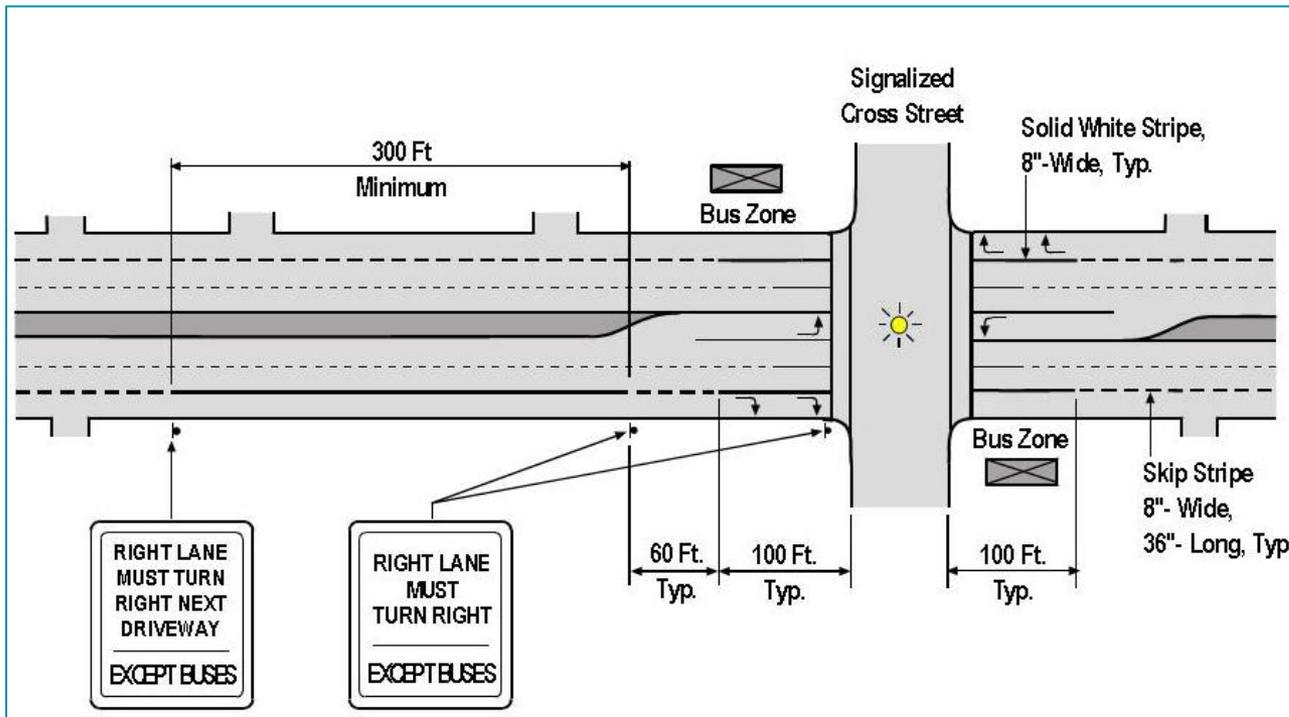
Queue Bypass

Transit Lane

Transit Lane-Mod.

Case Example Applications: Aurora Corridor Dedicated, Identifiable Running Way

Business Access and Transit Lane Concept

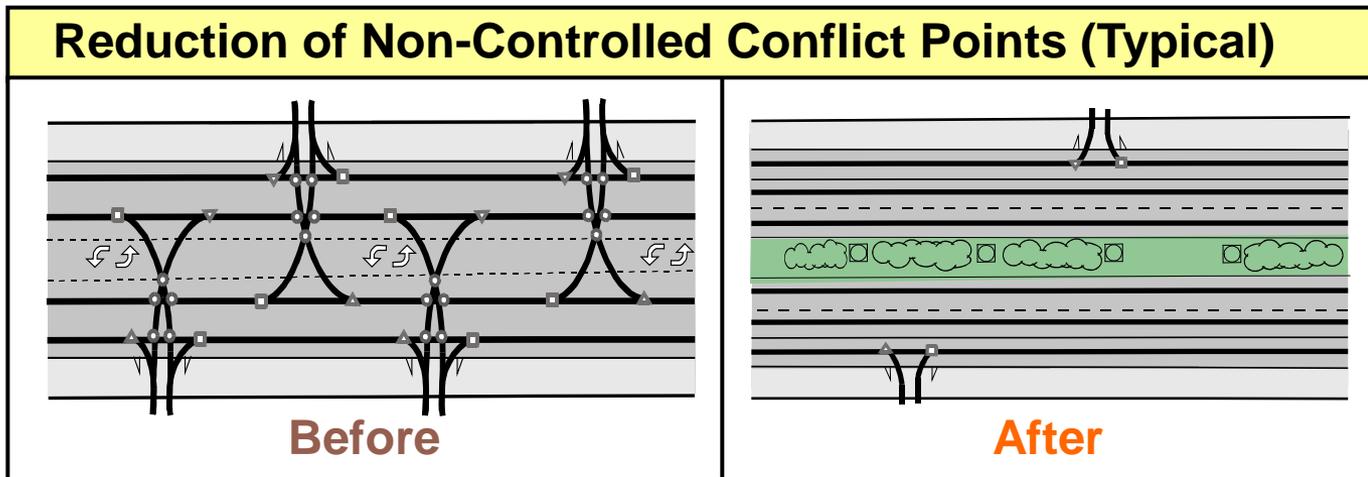


Case Example Applications: Aurora Corridor Factors Considered for BAT Lane Concept

- **Reduction of driveway-related accidents**
- **Enhancement of transit speed and reliability**
- **Business concerns regarding ease of customer access**
- **In-lane transit boarding/de-boarding at far side stops**
- **Need to expand traffic capacity & reduce side friction**
- **Accommodation of traffic volumes at intersections**
- **Driveway densities (average of 60 per mile)**

Case Example Applications: Aurora Corridor Safety Benefits

- Business concerns regarding ease of customer access
- Driveway densities very high (average of 60 per mile)
- Reduction of driveway-related accidents

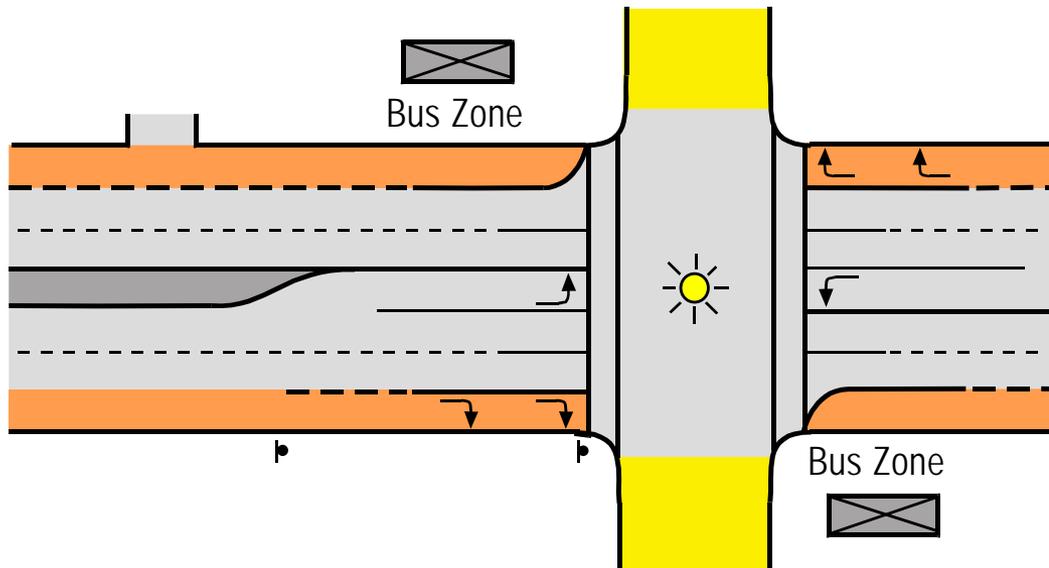


Total Corridor Non-Controlled Conflict Points

<u>Cross</u>	<u>Mrg/Div</u>
	Before
800	1,000
	After
60	400

Case Example Applications: Aurora Corridor Traffic Operations Benefits

- Improved traffic flow due to reduced side friction
- Accommodation of right turn traffic volumes at intersections
- Increased corridor traffic capacity and reduced average delay time



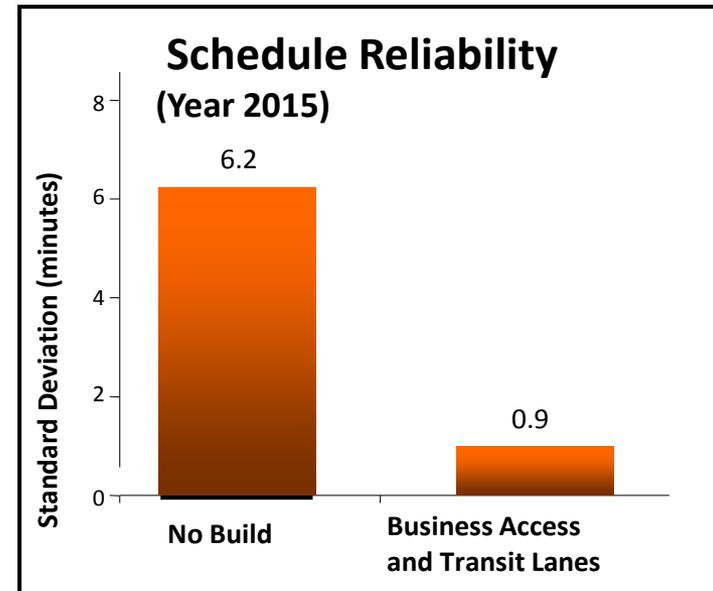
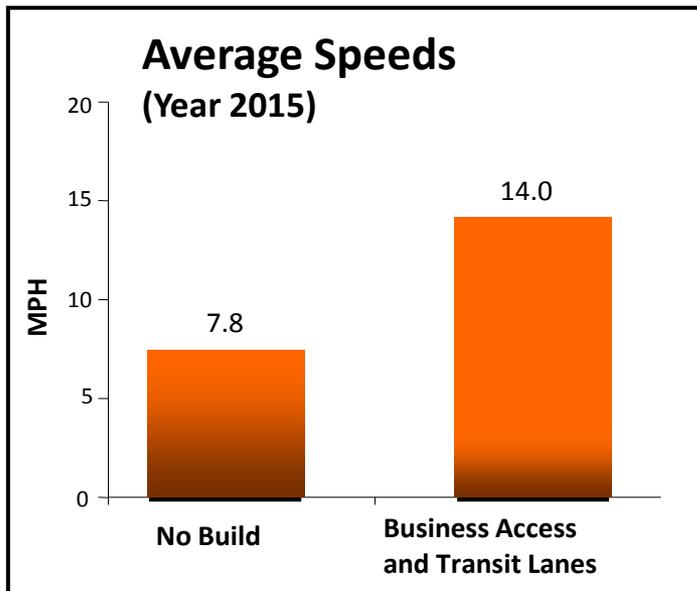
Corridor Capacity Increases

 Business Access and Transit Lanes	15%
 Side Street Capacity	10%

Case Example Applications: Aurora Corridor Transit Benefits

● Transit Benefits

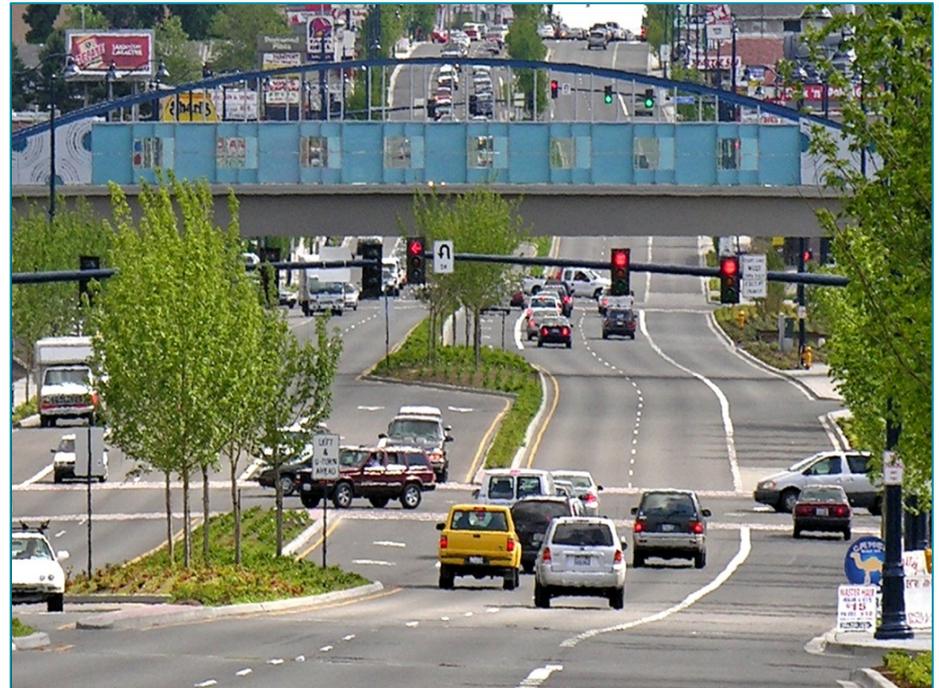
- In-lane transit boarding/deboarding at far side stops
- Enhancement of transit speed and reliability
- Increasing corridor person-movement capacity



Case Example Applications: Aurora Corridor (future RapidRide E-Line)

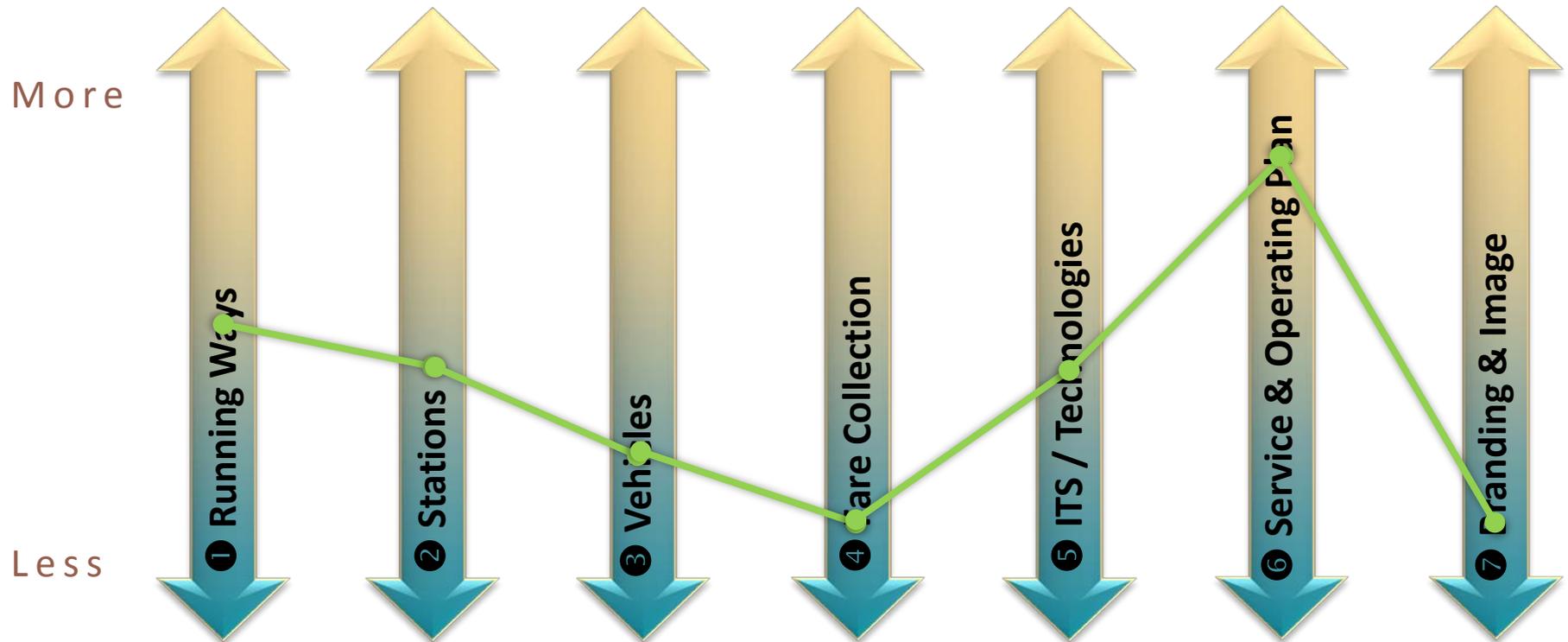


Before



After

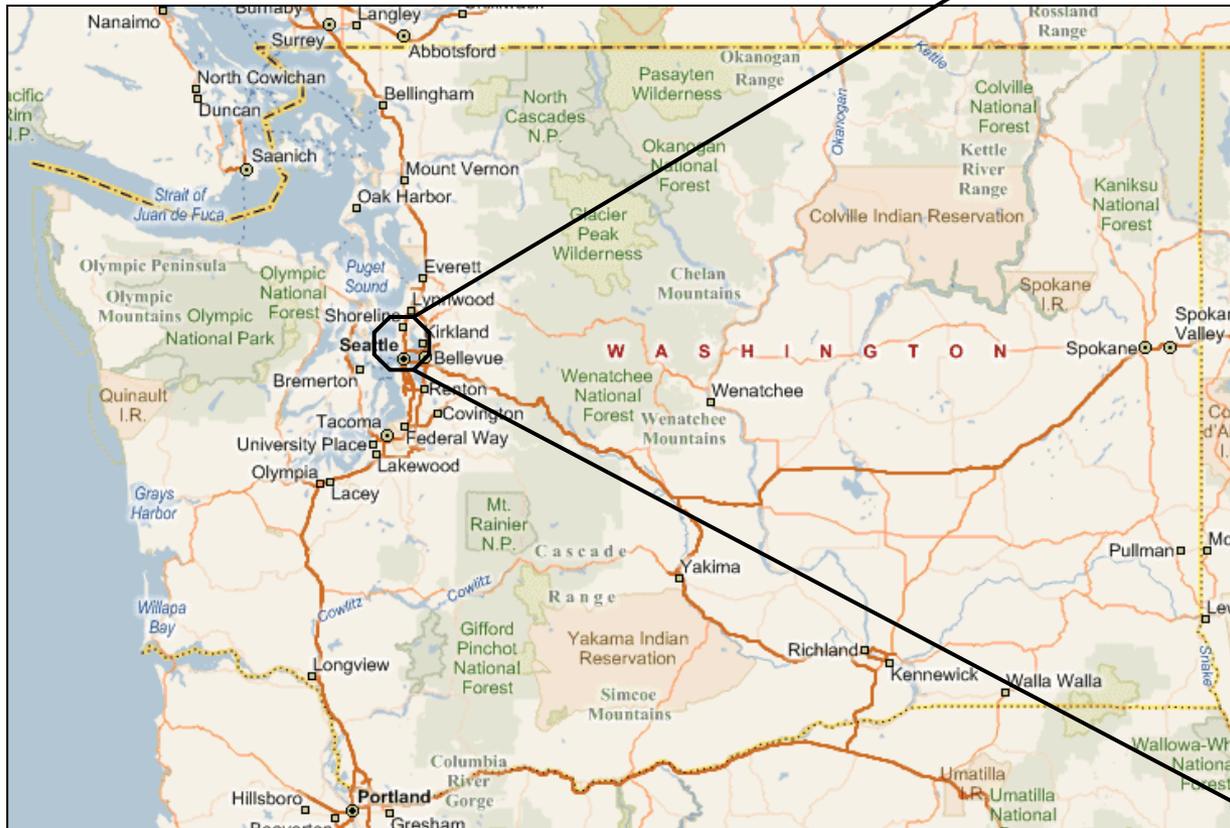
Case Example Applications: Aurora Corridor (future RapidRide E-Line)



Business Access and Transit Lanes	Enhanced Special Shelters	60-ft Hybrid Low-floor Buses	Smart Cards	TSP , AVL	Consolidated Frequent Services/ 6 Minute Peak Headways	Marketing, Name Brand, Colors
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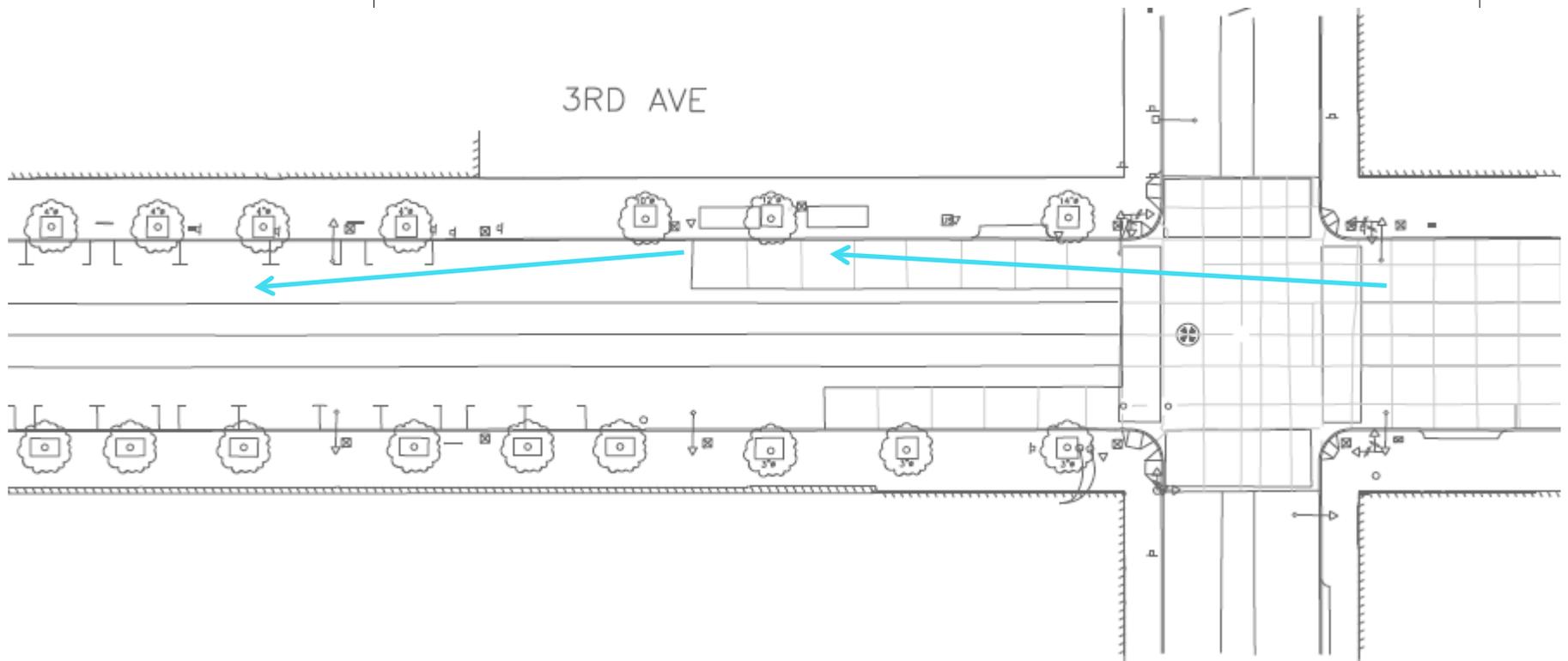
Case Example Applications: RapidRide D-Line – King County Metro

Project Location – Uptown, Interbay, Lower Queen Anne, Ballard - City of Seattle, WA



Case Example Applications: RapidRide D-Line – King County Metro

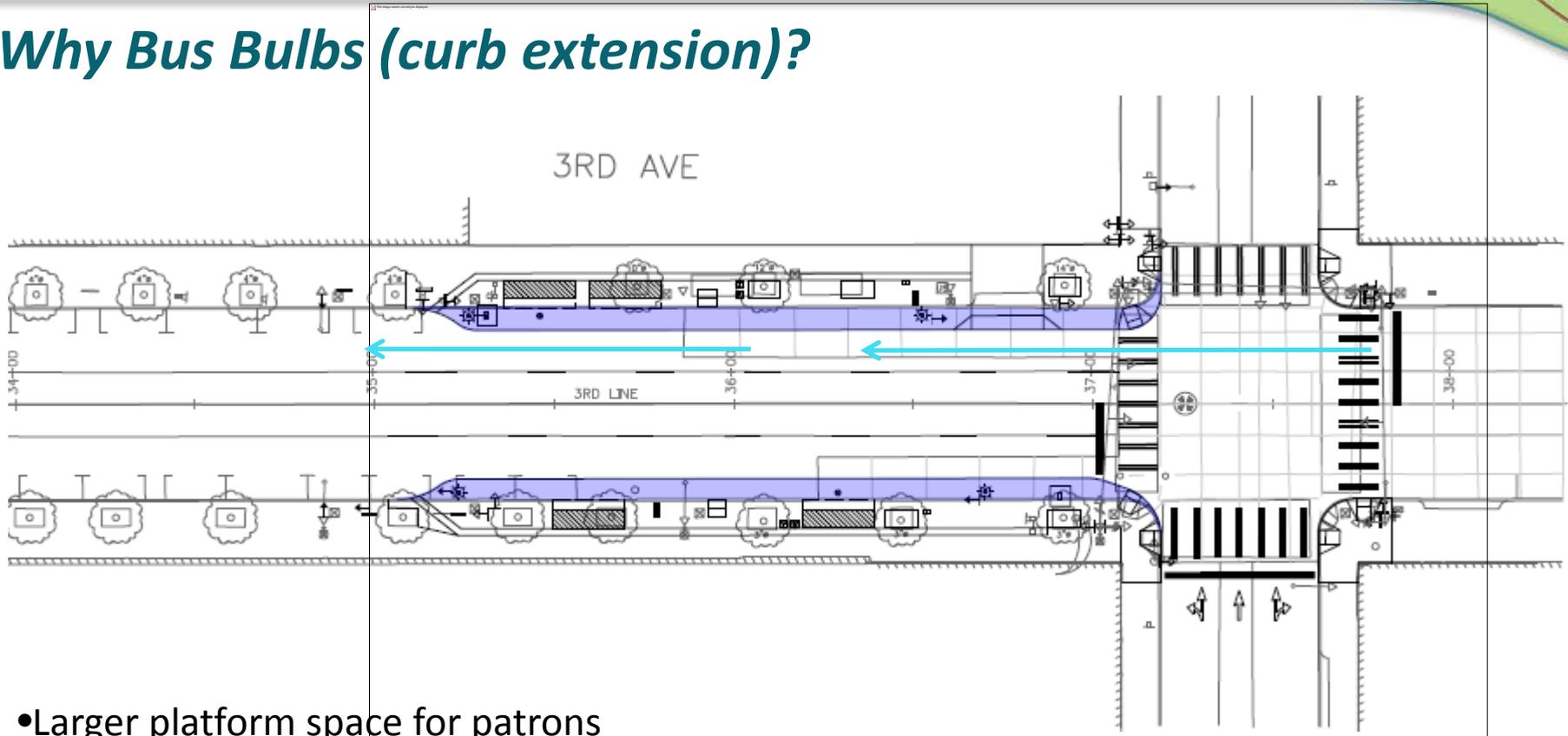
Why Bus Bulbs (curb extensions)?



- If buses must pull out of traffic, then transit speed & reliability is impacted.

Case Example Applications: RapidRide D-Line – King County Metro

Why Bus Bulbs (curb extension)?



- Larger platform space for patrons
- Shorter pedestrian crossing and better visibility for pedestrians
- Avoids delays of “pull-in” and “pull-out” for transit vehicles

Case Example Applications: RapidRide D-Line – King County Metro

Transit Design – Bus Bulbs (curb extensions)



Before
Without bus bulbs



After
With bus bulbs

Case Example Applications: RapidRide D-Line – King County Metro

Station Amenities

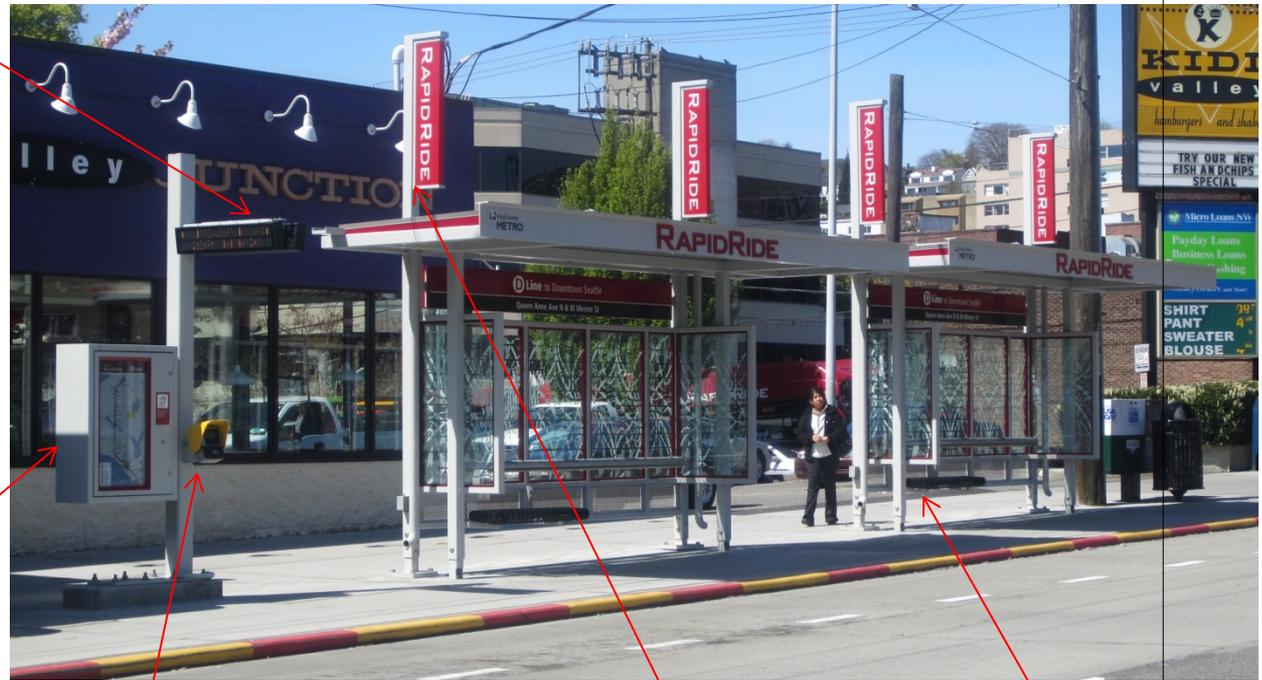
Tech Pylon with real time arrival information



Route map



Smart Card Reader



Branded blade marker (light up at night)

Branded shelter

Case Example Applications: RapidRide D-Line – King County Metro

Transit Design – Sidewalk stop enhancement with sustainability feature



Before



After



Solar panel

Solar powered internal shelter lighting

Case Example Applications: RapidRide D-Line – King County Metro

Transit Design – Sidewalk stop enhancement in urban dense environment



Before



After

Case Example Applications: RapidRide D-Line – King County Metro

Transit Design – Minimal stop enhancement for low boarding bus zone

BRT service shared stop with local bus service

Bus call button/signal & bus stop sign



Bench

Blade Marker

04/24/2013

Case Example Applications: RapidRide D-Line – King County Metro

Vehicle Amenities



60' low-floor articulated hybrid electric bus, with bike rack at front of bus (can accommodate three bicycles)

Wheel Chair area

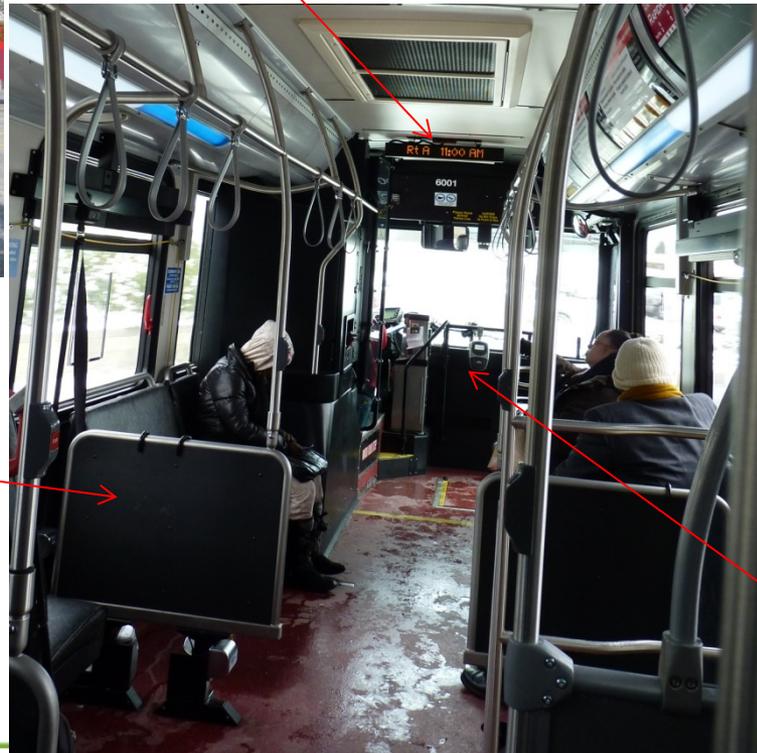
All door boarding for stations equipped with smart card reader.

Front door boarding for on-board fare collection

Route information display with next stop display and announcement



On-board CCTV



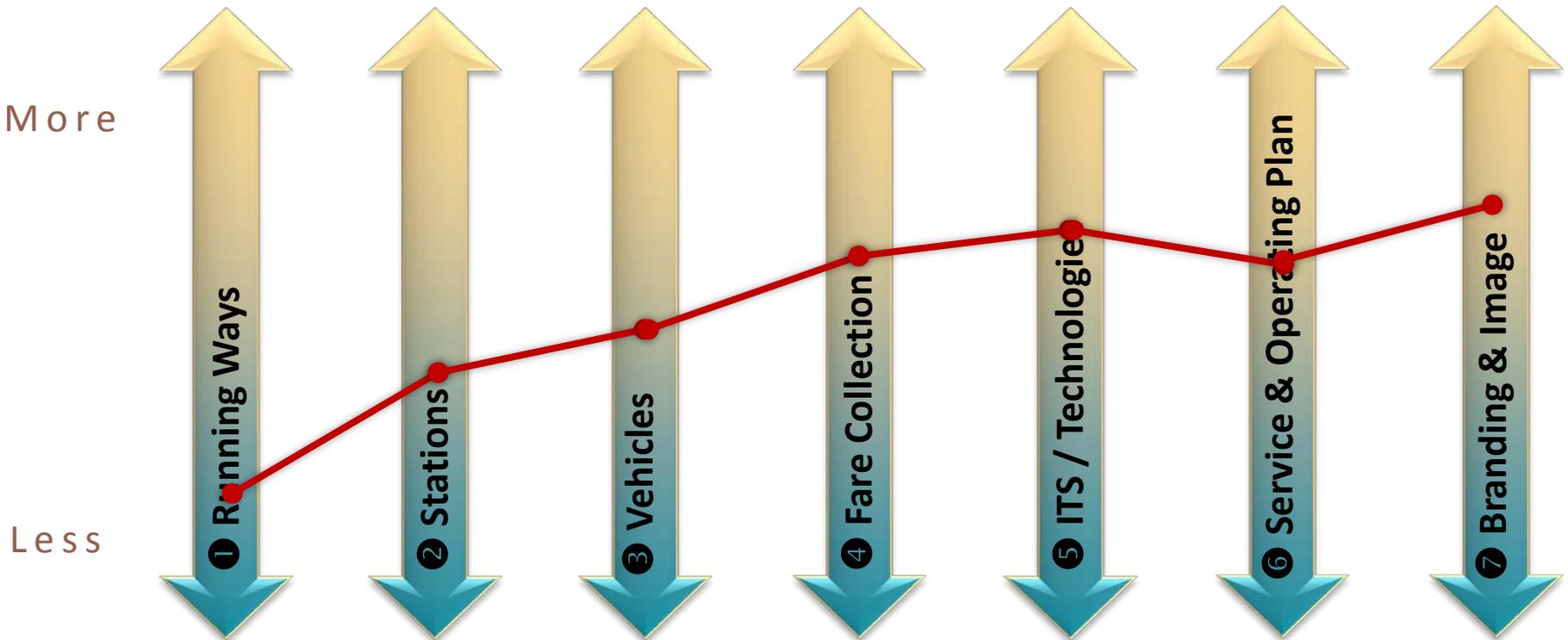
On-board free Wi-Fi

On-board fare collection and smart card reader

CH2MHILL.

Case Example Applications

RapidRide D-Line – King County Metro Transit



Some bus bulbs in SB direction, BAT lane segment	Enhanced Special Shelters, some without Shelters	60-ft Hybrid Low-floor Buses	Smart Cards/ Mixed of On-Board and Off-Board Payment	TSP/AVL/ Passenger Information	Consolidated Frequent Services/ 8 Minute Peak Headways	Marketing, Name Brand, Colors
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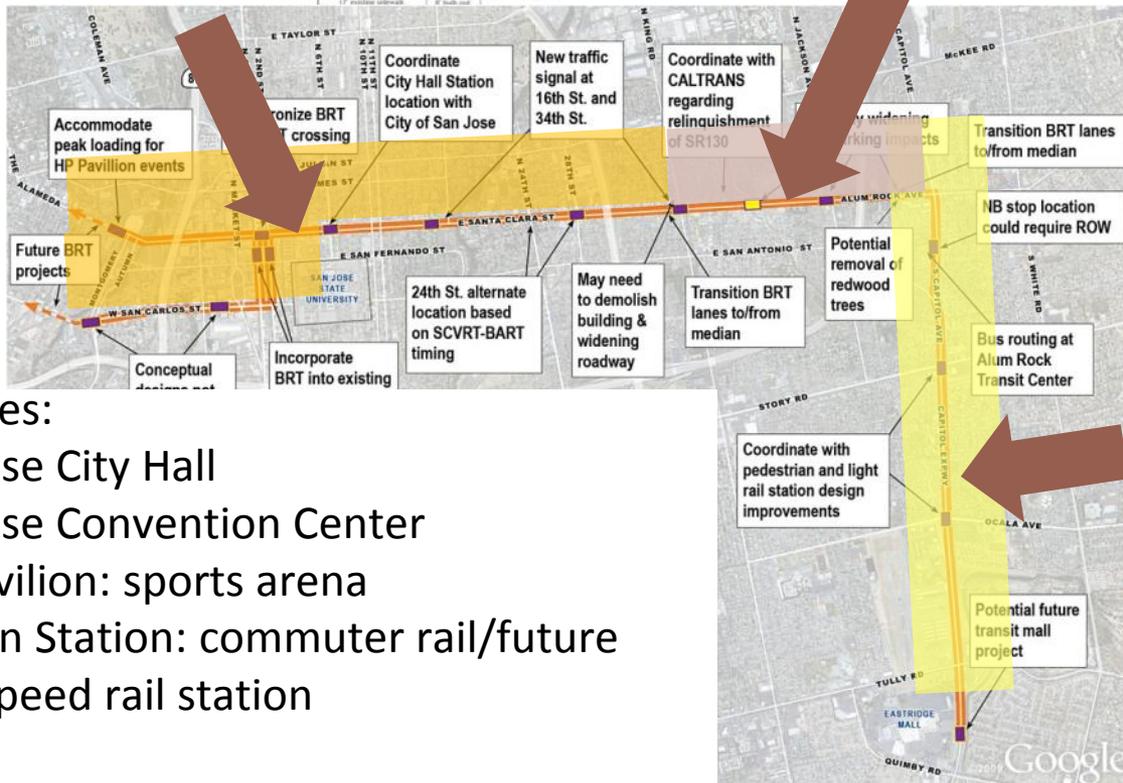
Case Example Applications: Santa Clara-Alum Rock BRT

Context:

- Operating in curb lane



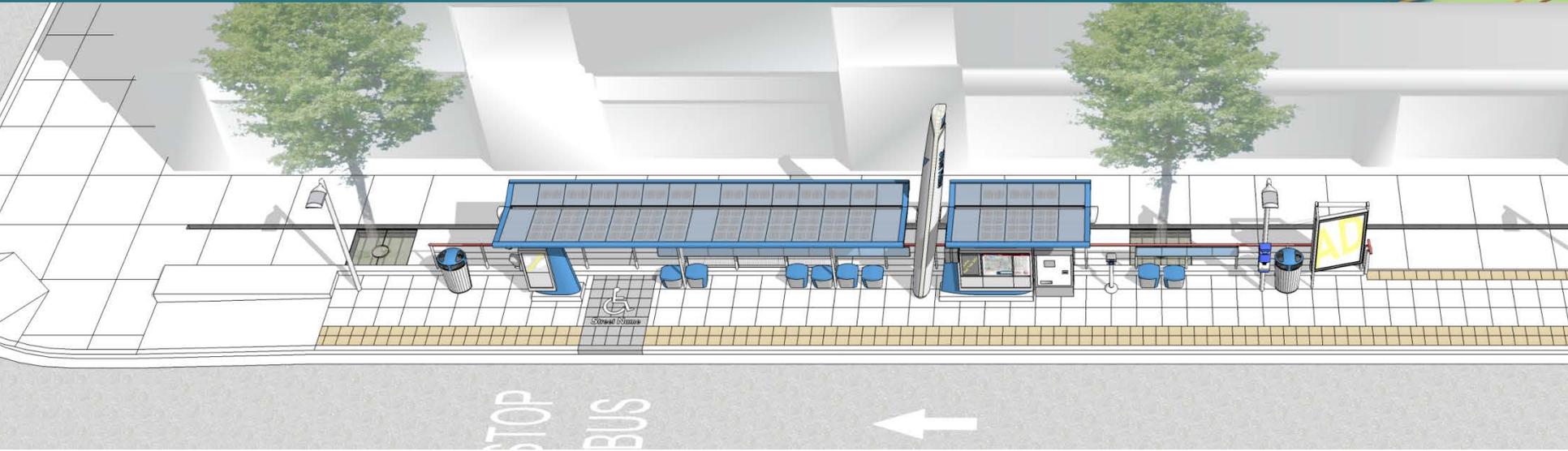
- Will run in exclusive median busway
- Historical and cultural neighborhoods



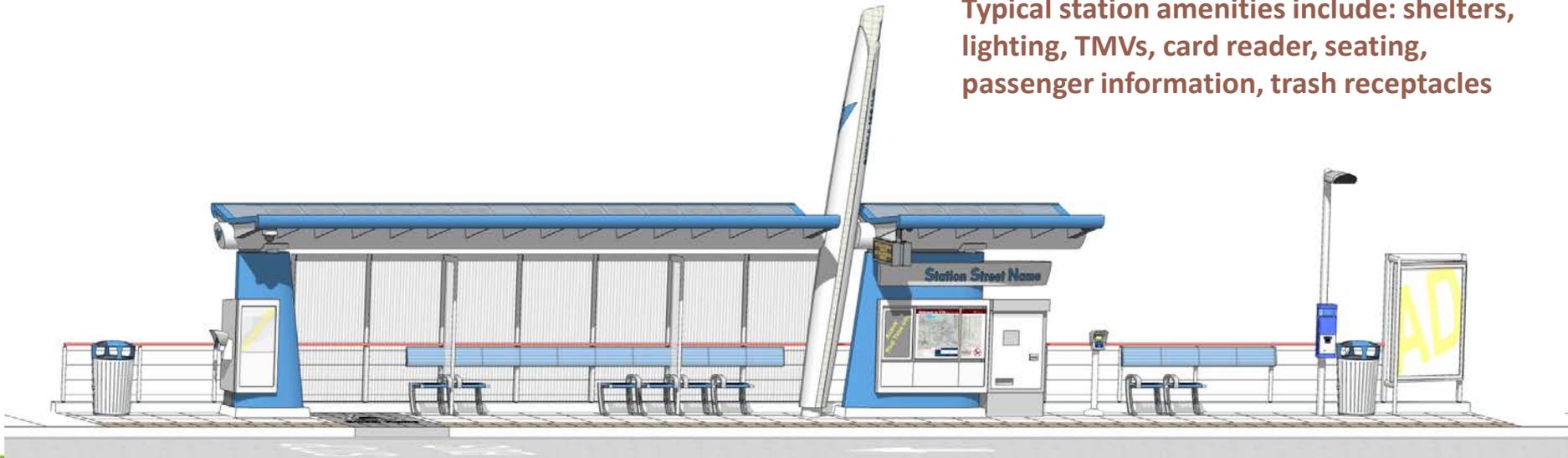
- Route passes:
 - San Jose City Hall
 - San Jose Convention Center
 - HP Pavilion: sports arena
 - Diridon Station: commuter rail/future high speed rail station

- Will run in HOV lane along existing expressway
- Limited pedestrian access

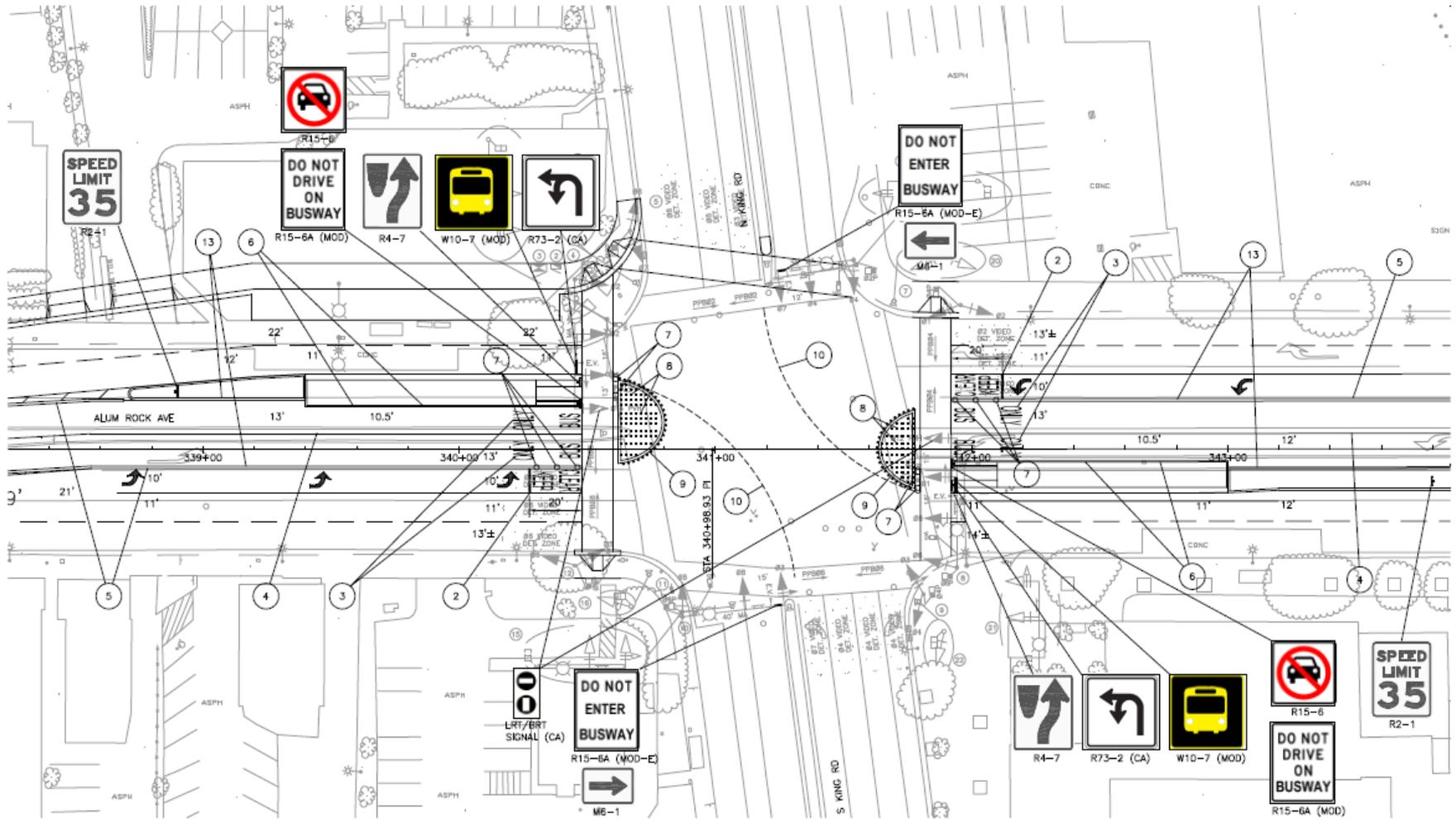
Case Example: Santa Clara-Alum Rock BRT Typical High Volume Right Side Station



Typical station amenities include: shelters, lighting, TMVs, card reader, seating, passenger information, trash receptacles



Typical Access & Safety Design Example

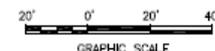


GENERAL NOTES:

- ① ALL EXISTING STRIPING AND PAVEMENT MARKINGS SHALL BE COMPLETELY REMOVED FROM AREAS TO BE RE-STRIPED/MARKED.
- ② SEE SHEET 5 FOR SIGNING AND STRIPING DETAILS.
- ③ INSTALL PER CALTRANS STANDARD PLAN A24E.
- ④ INSTALL PER CALTRANS STANDARD PLAN A20A-DETAIL 22.
- ⑤ MOUNTABLE TRAFFIC CURB.
- ⑥ MARK DOOR LOCATIONS ON PLATFORM.
- ⑦ CALTRANS TYPE Q OBJECT MARKER.
- ⑧ INSTALL CALTRANS TYPE D TWO WAY RETROREFLECTIVE MARKERS (2' SPACING O.C.), WHILE EXCLUDING WHEEL PATH AREA.
- ⑨ INSTALL PER CALTRANS STANDARD PLAN A20A, DETAIL 22 (MODIFIED).
- ⑩ INSTALL PER CALTRANS STANDARD PLAN A20D, DETAIL 41.
- ⑬ INSTALL PER CALTRANS STANDARD PLAN A20B.

CONSTRUCTION NOTES:

- ①
- ②

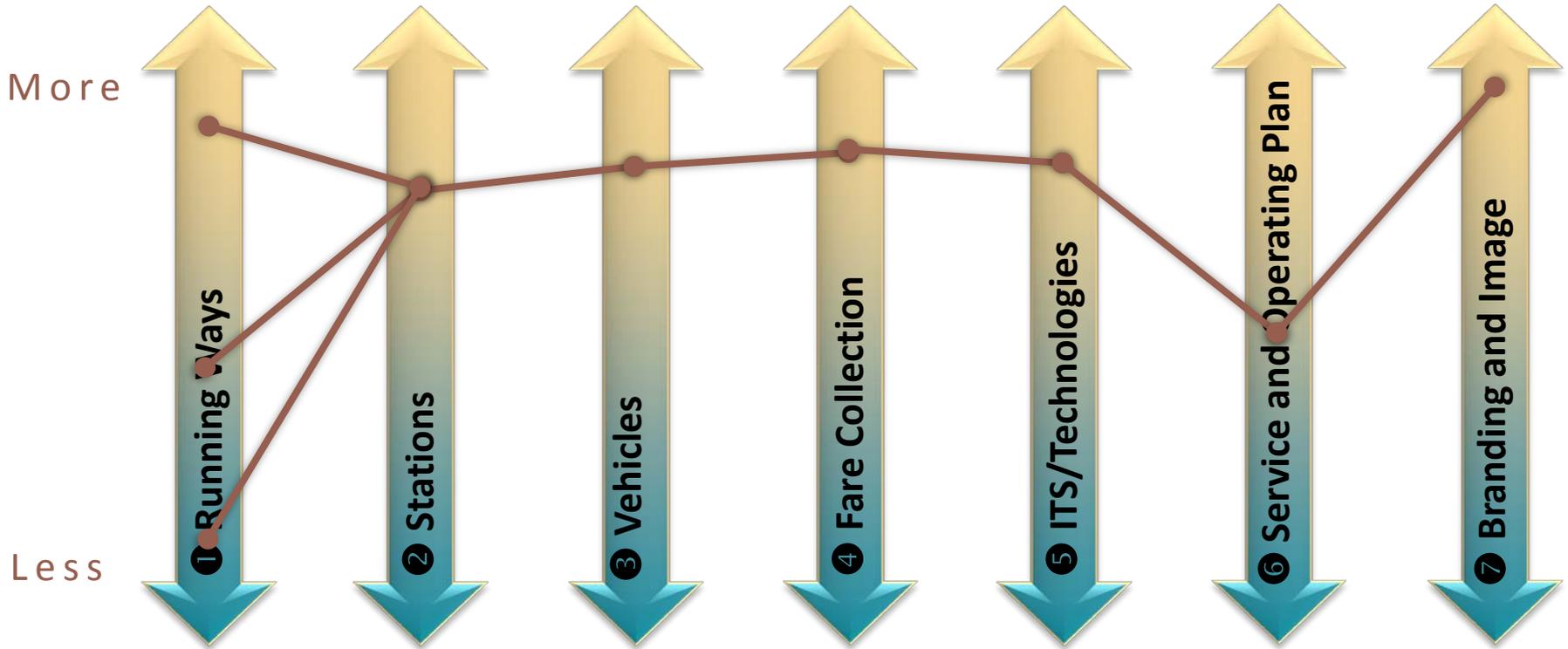


**PRELIMINARY
NOT FOR CONSTRUCTION**

Case Example: Santa Clara-Alum Rock BRT Median Busway Station with Safety Features



Case Example Applications Santa Clara-Alum Rock BRT



Exclusive median busway, curb lane, and HOV lane

New lighting, landscaping, information kiosks and street furniture

60-ft Low-floor Hybrid Vehicles

Smart Cards & TVMs; Validate On-board

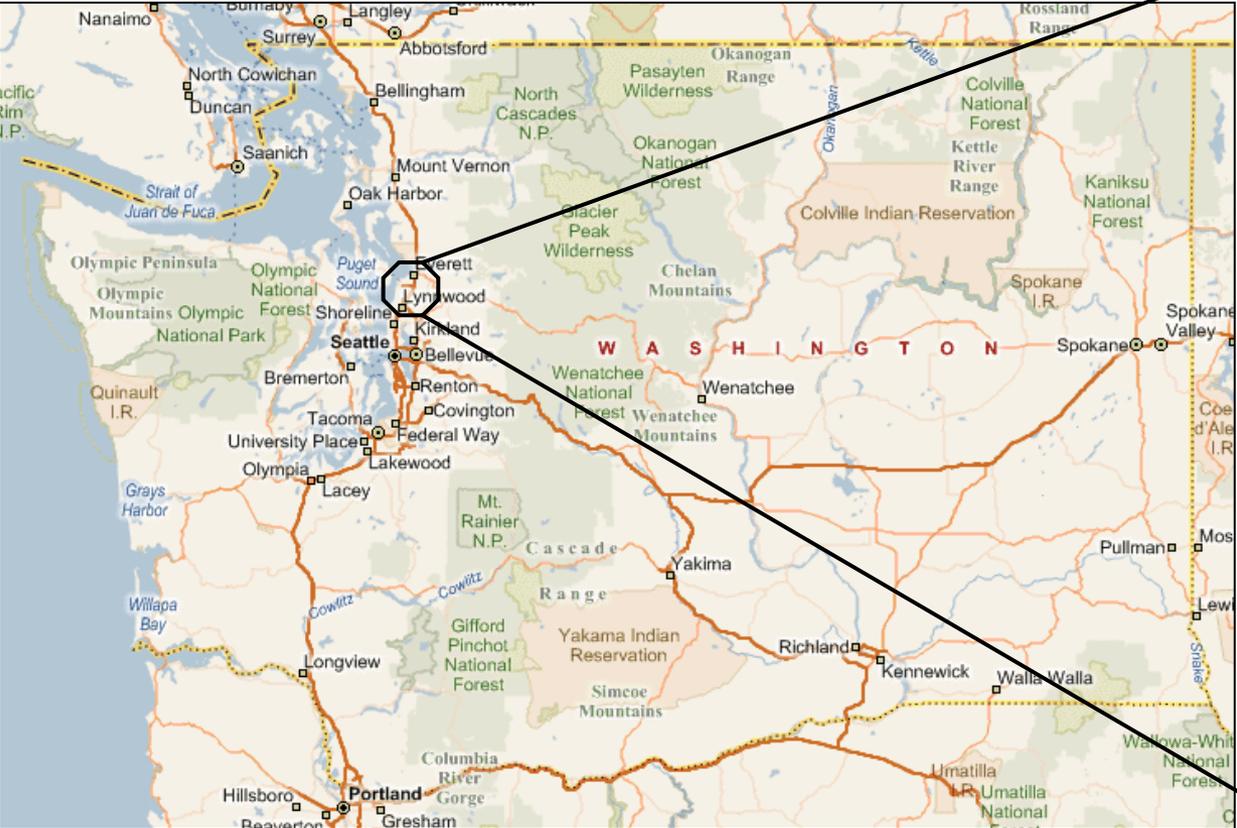
TSP/AVL/ CAD/ Passenger Information

10 minute Peak Headways, 13 Stops

Vehicle and Station Colors, Marketing

Case Example Applications: Swift – Community Transit

Project Location – Cities of Shoreline, Edmonds, Lynwood, Mukilteo & Everett, WA



Case Example Applications: Swift – Community Transit

“Right Turns Except Transit” Lane Treatment



Right turn only lane
except transit

Far Side Station

Case Example Applications: Swift – Community Transit

Signing for “Right Turns Except Transit” lanes at intersections



Case Example Applications: Swift – Community Transit

Transit Design – Station pull out



Buses to merge back to main line traffic

Far Side Station

Stripped shoulder for buses to pull out

Right turn only lane except transit

Case Example Applications: Swift – Community Transit

Station Amenities



Yellow curb for bus docking

Branded column and shelter

Ticket Vending Machine

Smart Card Reader

Curb height transition for near level boarding

Case Example Applications: Swift – Community Transit

Vehicle Amenities



Bumper extension



Wheel Chair area

Route information display



No on-board fare collection



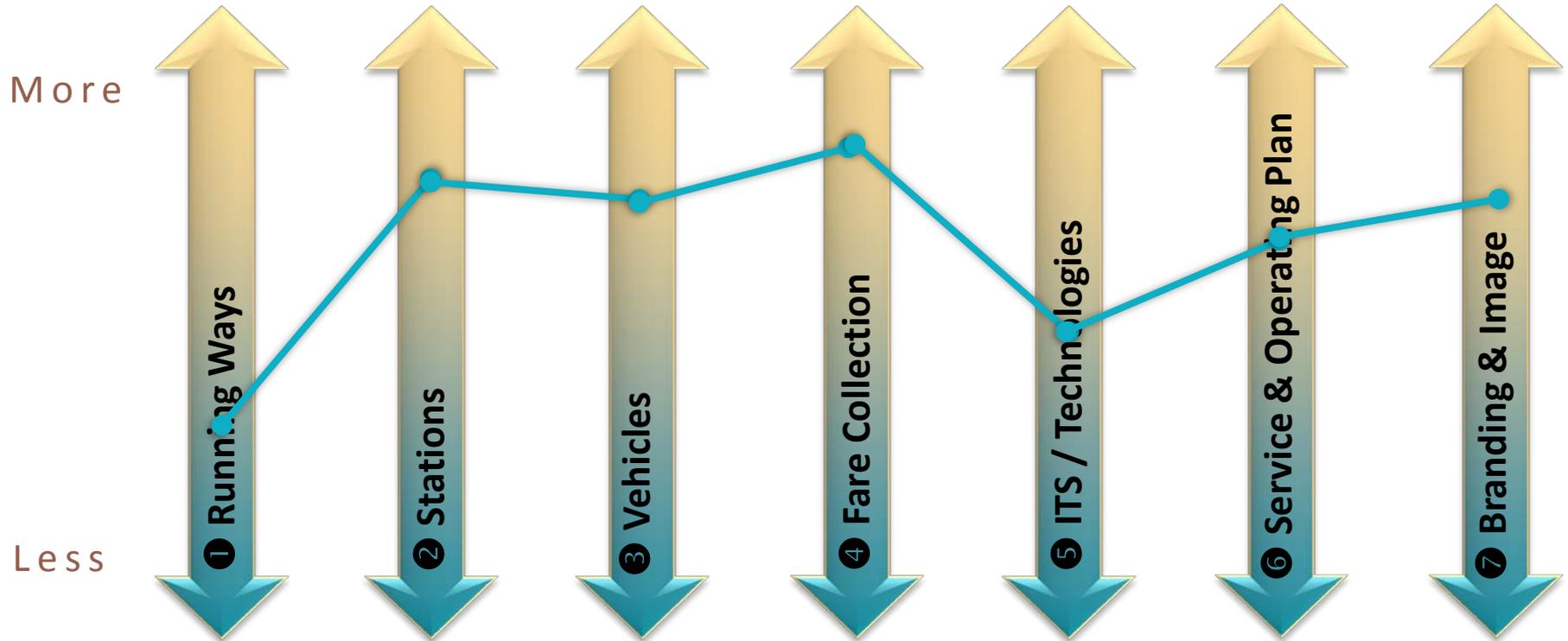
On-board bike storage area



Rear door boarding for bicycles

Case Example Applications

Swift – Community Transit



Mixed Traffic , Bus & Right-Turn Only Lanes at Intersections, In- Lane Stops	Enhanced Special Shelters, Amenities	62-ft Hybrid Low-floor Buses, 3-Doors	Smart Cards/ All Off-Board Payment	TSP/AVL/ Passenger Information on buses	Consolidated Frequent Services/ 12 Minute Peak Headways	Marketing, Name Brand, Colors
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Case Example Applications: Los Angeles SR 710 North Study



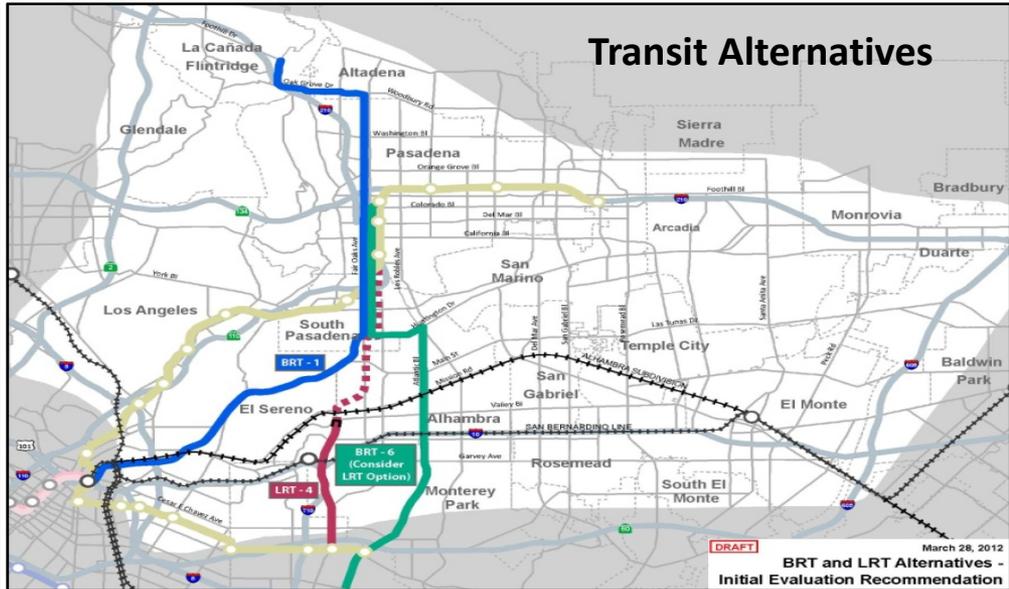
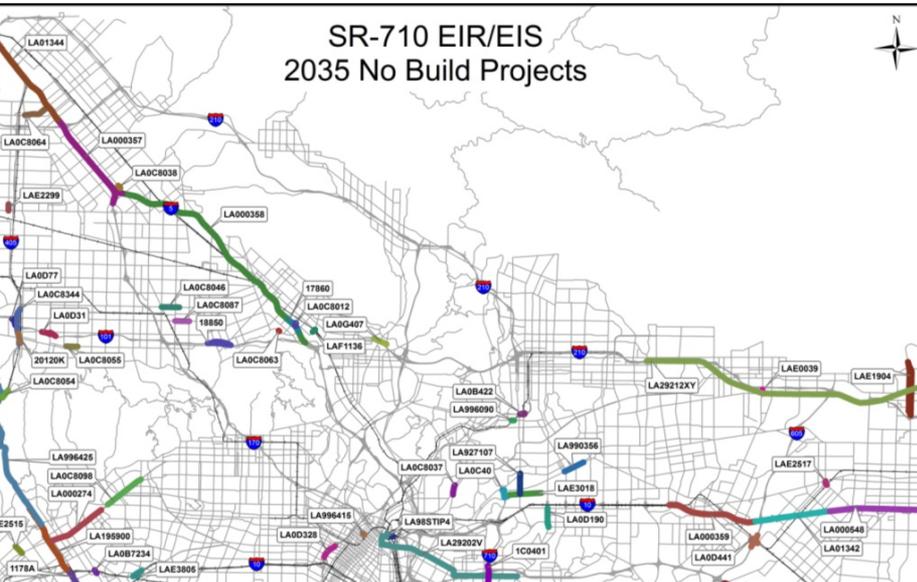
SR710P_114_4_BDS

Case Example: L.A. SR710

Study Needs, Objectives & Criteria

Element of Need	Objectives	Evaluation Criteria
1) Regional transportation system	1) Minimize travel time	Trip travel time; total travel time; travel time reliability
	2) Improve connectivity and mobility	Access to: regional freeway system; employment, health care, and education; access to regional transit system; north-south throughput
2) Freeway system in study area	3) Reduce congestion on freeway system	Level of congestion on study area freeways
3) Local street system	4) Reduce congestion on local street system	Local arterials traffic operations; traffic diversion to local arterials; Use of local arterials for long trips
4) Transit system in study area	5) Increase transit ridership	New transit ridership; transit accessibility; transit mode split

L.A. SR 710 Alternatives

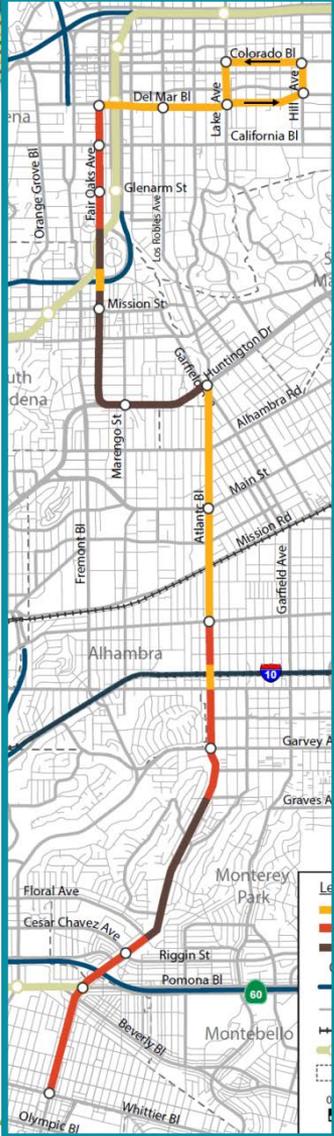


Case Example Applications: L.A. SR710

Developing Improved Speed & Reliability for BRT

- **Exclusive surface route is not available in study area without substantial costs & impacts**
- **Fully elevated route would have visual impacts and high costs**
- **Tunnel route would have high costs & would require electric or hybrid buses**
- **Atlantic/Fair Oaks route has the more right-of-way width than other north-south arterials**
- **Developing exclusive BRT lanes full length would have impacts & right-of-way needs**
- **Cumulative speed & reliability improvements provided using more than 30 incremental actions**

Case Example Applications: L.A. SR710 Highlights of BRT Alternative Design



- Peak-period dedicated bus lanes over most of route (brown 2-way; red 1-way; yellow mixed traffic)
- Intersection improvements for transit queue bypass & stops
- Include TSM/TDM improvements as baseline services
- Bus feeder services to/from BRT line
- Enhanced station amenities along BRT line, 12 stops on trunk
- All-door boarding for BRT line
- Combine/consolidate BRT line with Route 762 for 10 minute headways, local 260 overlay w/ 22 stops
- Includes Metro's Transit Signal Priority (TSP) project along route

Case Example Applications: L.A. SR710 BRT Peak-Period Bus Lanes and Intersections

● Peak-Period Bus Lanes

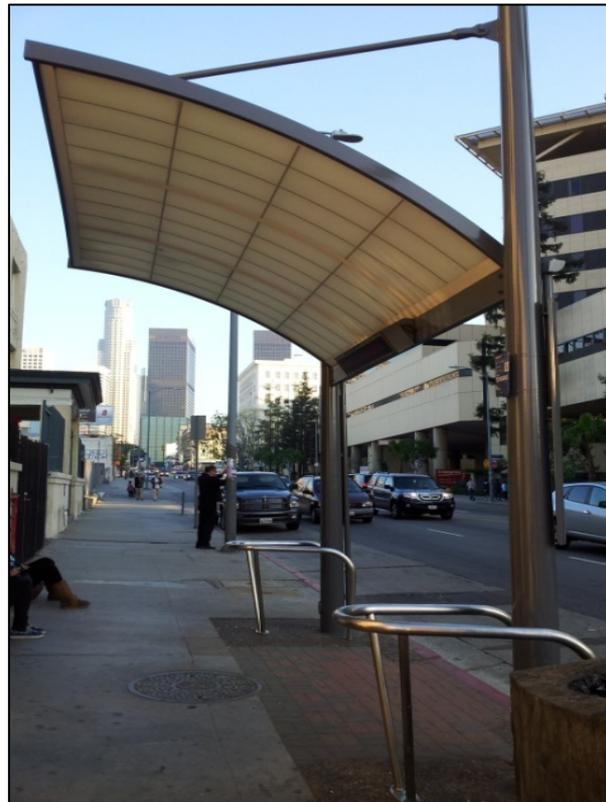
- Parking would be allowed in bus lanes outside of peak periods
- Potential effect to approximately 1000 on-street parking spaces in peak hours (95% available for use outside of peak hours)

● Intersection Improvements

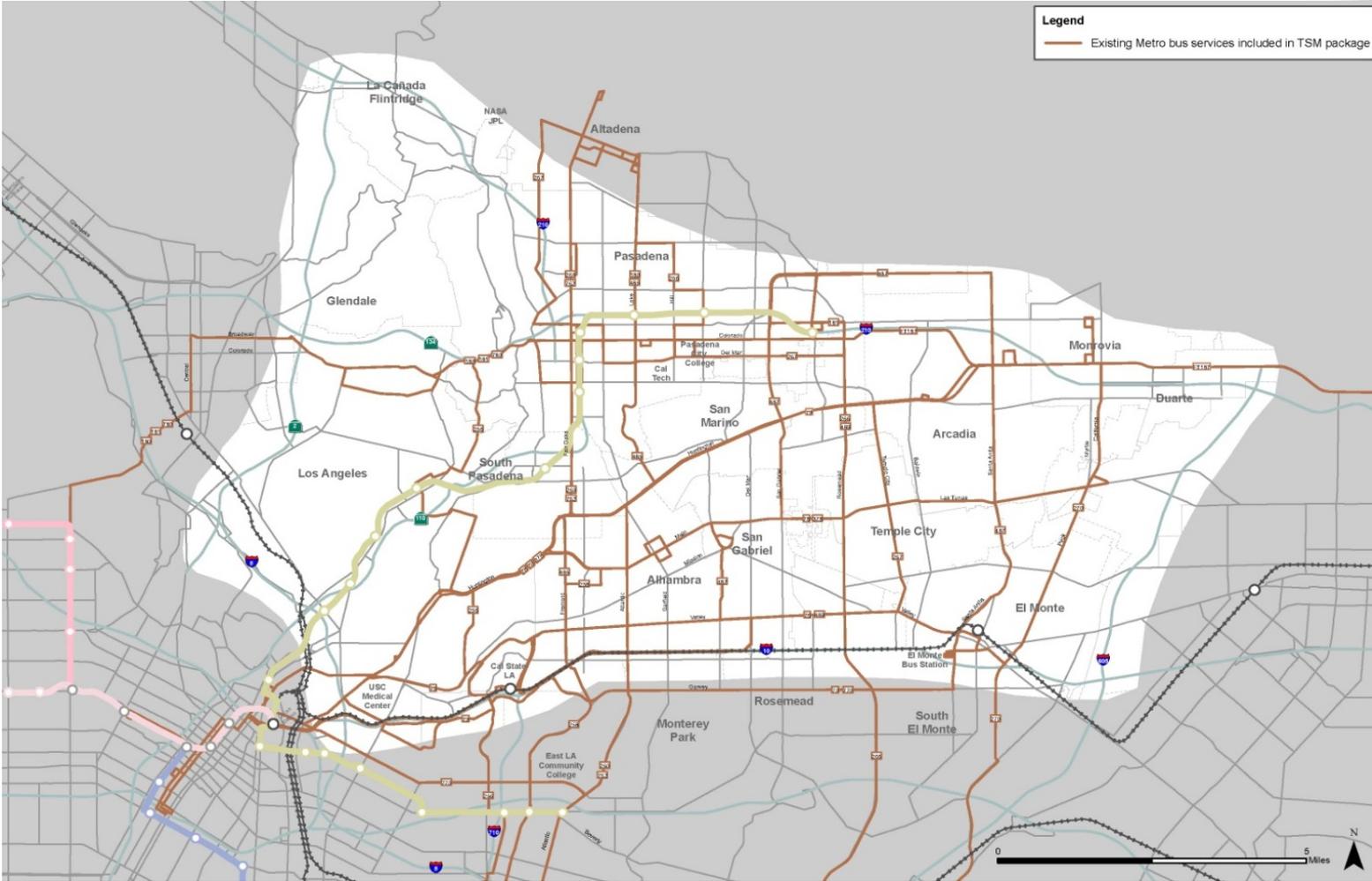
- Improve congested intersections by adding turn lanes and bus queue jump lanes (in addition to TSM intersections improvements)
- Minor right of way acquisitions required (no buildings affected)

Case Example Applications: L.A. SR710 BRT Station Improvements

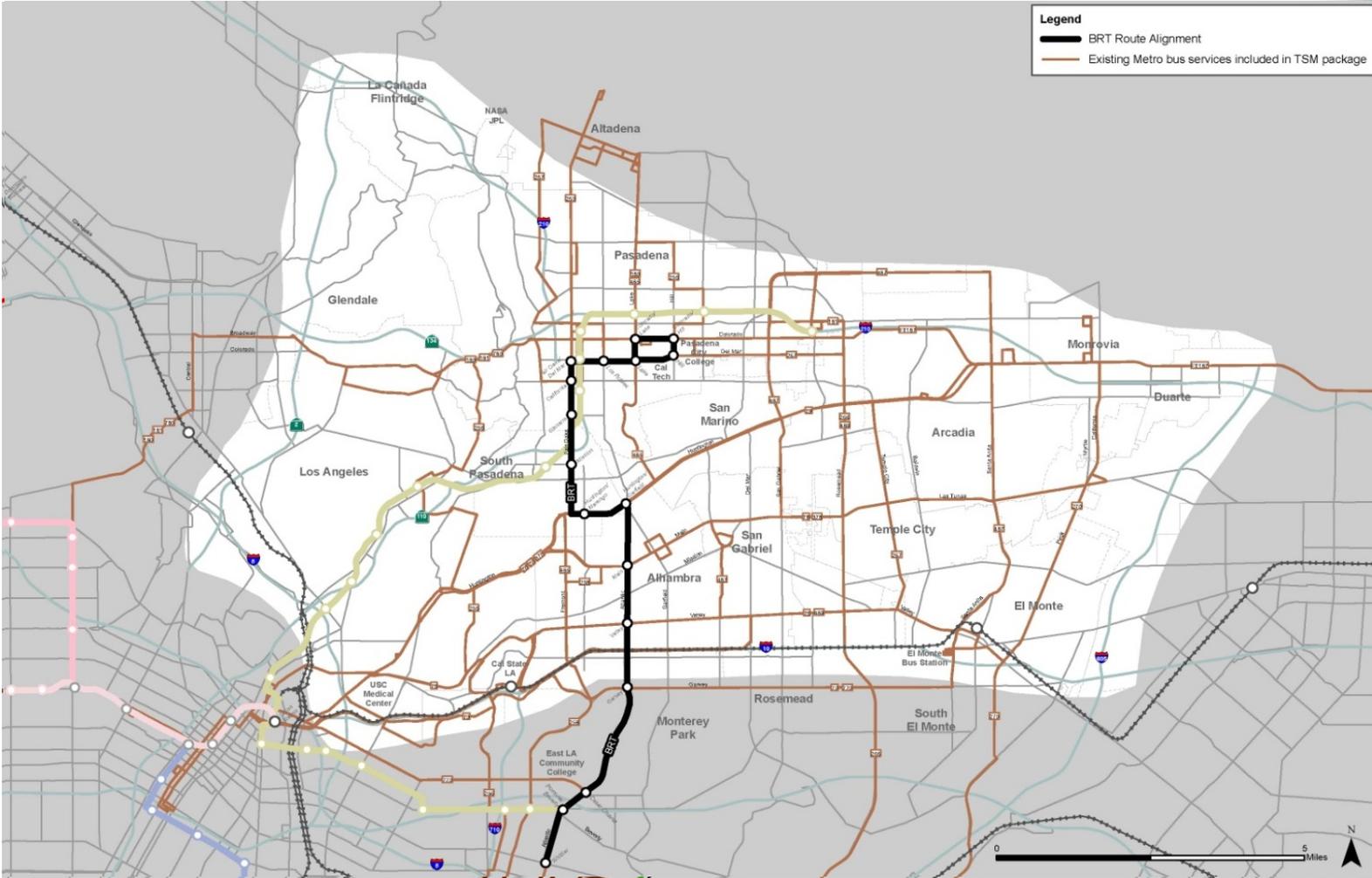
- **Amenities:**
 - Shelters
 - Lighting
 - On-Board validation
 - Next Bus displays
- **Separate BRT stations at high volume stops**
- **Mostly located at far side of intersections**
- **Accelerations lanes downstream of stations**



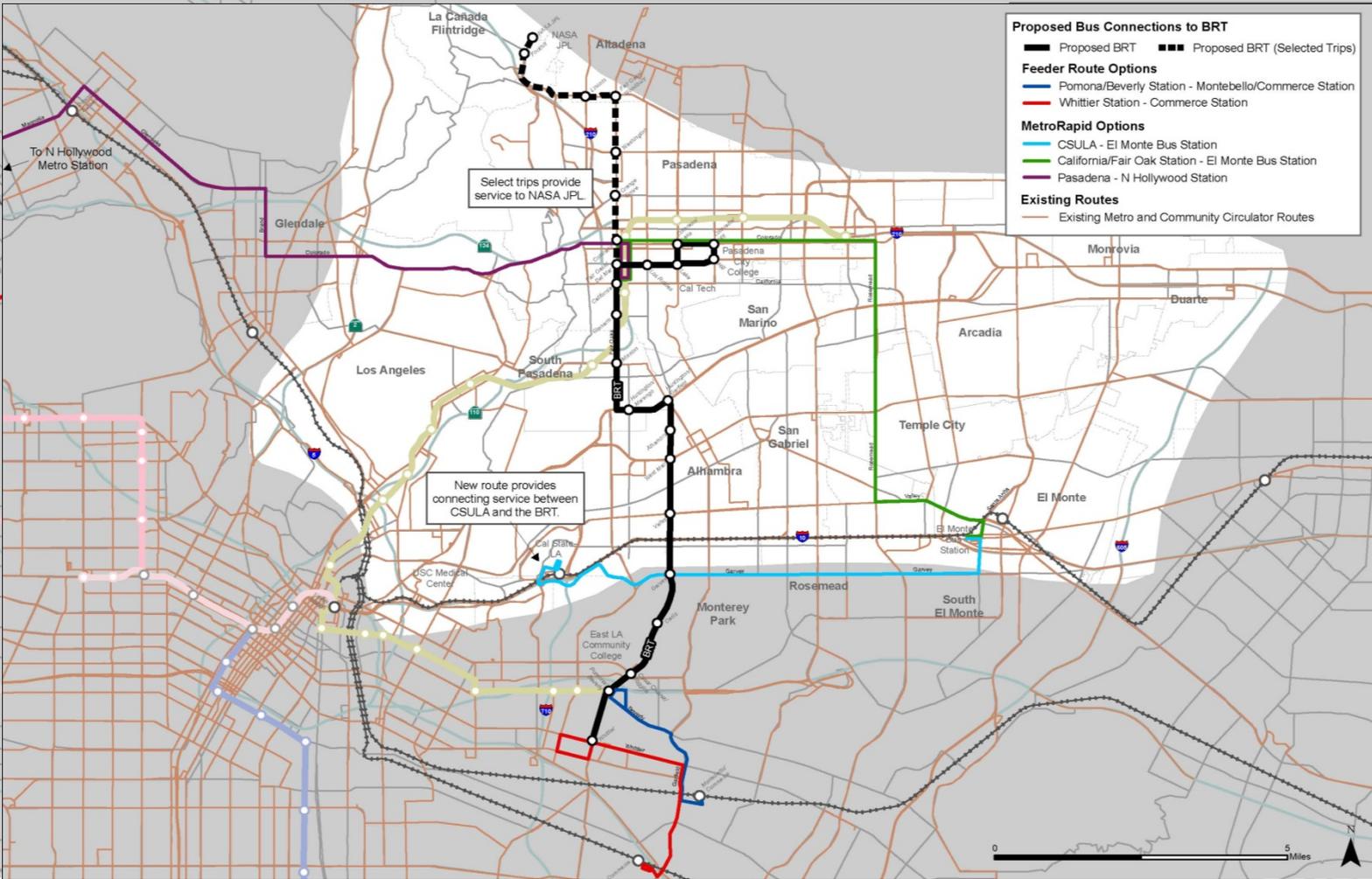
Case Example Applications: L.A. SR710 BRT Baseline Transit Service



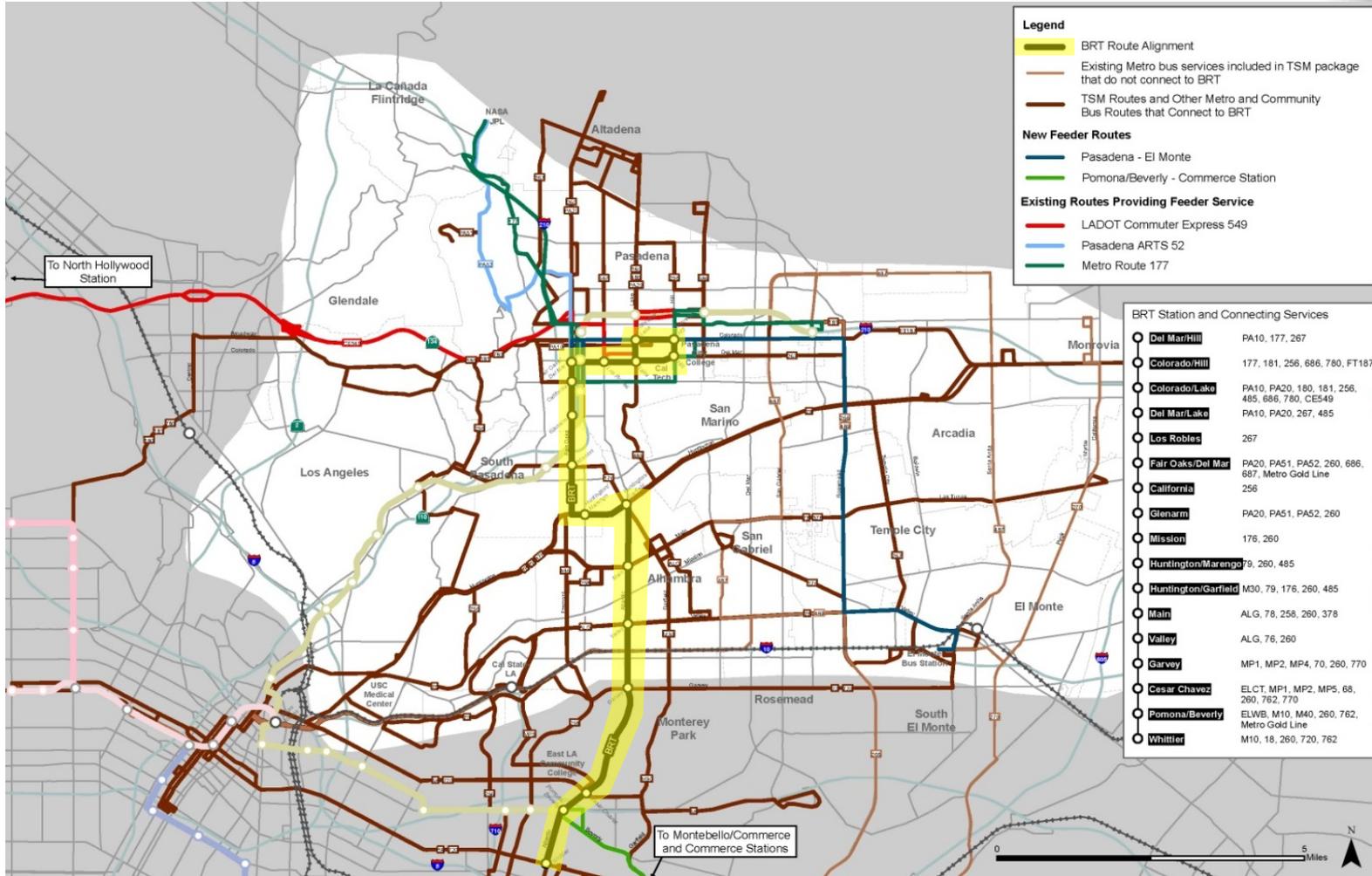
Case Example Applications: L.A. SR710 BRT Baseline Transit Service plus BRT Trunk Line



Case Example Applications: L.A. SR710 BRT Trunk Line with Feeders & Connectors

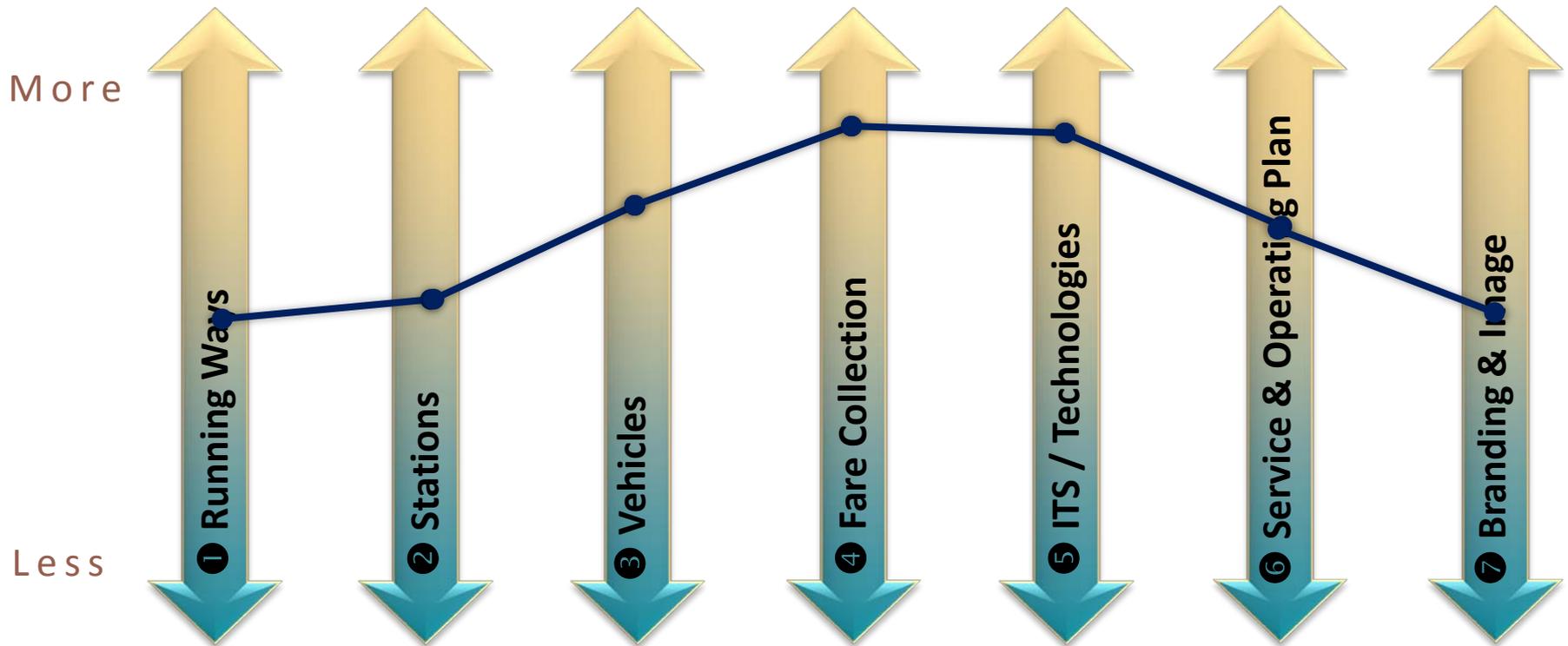


Case Example Applications: L.A. SR710 BRT Overall Transit Service



Case Example Applications

L.A. SR 710 North Study BRT Alternative



Business Access and Transit Lanes & Mixed Traffic	Enhanced Special Shelters, Amenities	60-ft CNG Low-floor Buses, 3-Doors	Smart Cards/ On-Board Validation, All-door Boarding	TSP/AVL/ Passenger Information, Headway Management	Consolidated Service/ 10 Minute Peak Headways	Marketing, Name Brand, Colors
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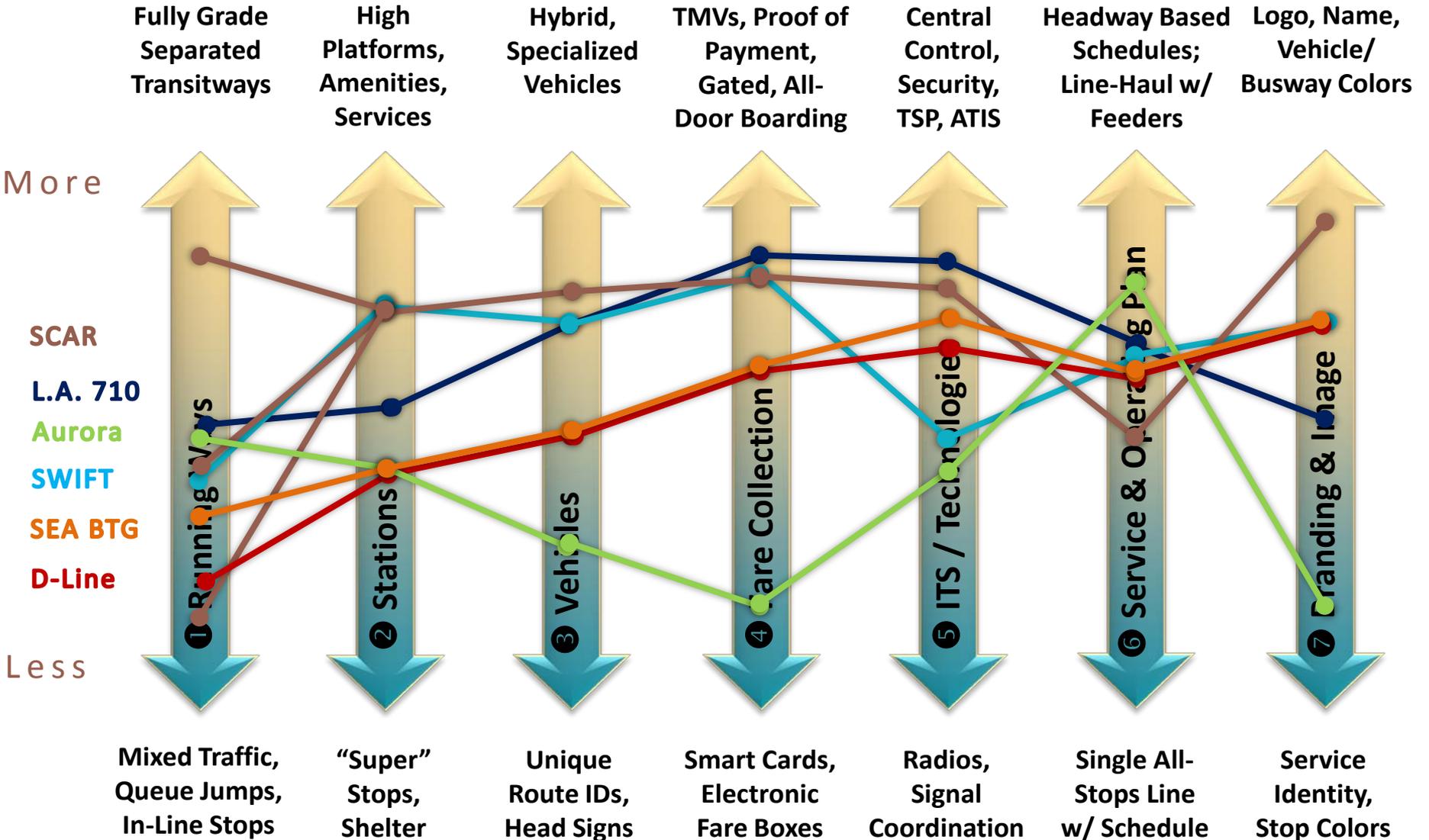
Conclusions – BRT for Constrained Urban Environments

- **Take Advantage of Unique Attributes and Advantages of BRT**
 - Speed and reliability
 - Identity and image
 - Flexible and stageable
 - Adaptable to fit context
 - “Rail-like” service and quality
 - Permanence



D-Line RapidRide, Seattle, WA

BRT Provides a Spectrum of Choices to Satisfy Needs, Objectives & Context



Questions – BRT in Constrained Urban Environments



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