BUS RAPID TRANSIT IN CONSTRAINED URBAN ENVIRONMENTS

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Bus Rapid Transit (BRT) Topics

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

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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."

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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

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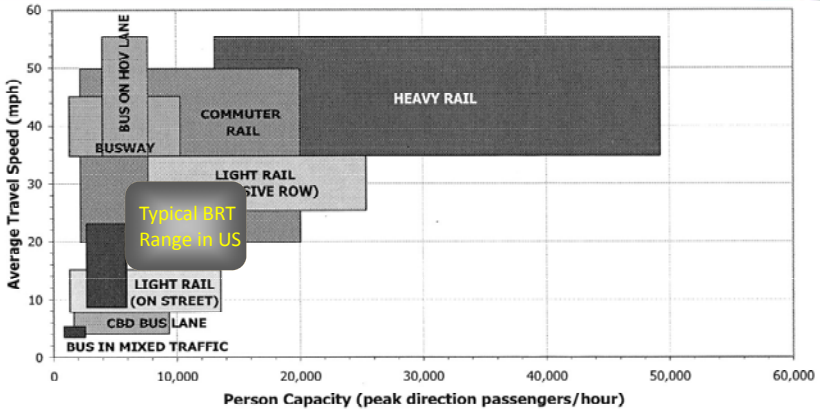
Relative Speeds and Capacities for Transit Modes



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

Transit Capacity and Quality of Service Manual – 2nd Edition

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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

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Elements of Bus Rapid Transit

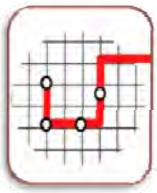
❶ Running Ways

❷ Stations and Stops

❸ Vehicles

❹ Fare Collection

❺ ITS/Technologies



❻ Service and Operating Plan

❼ Branding and Image

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Elements of Bus Rapid Transit Spectrum of Choices

	❶ Running Ways	❷ Stations	❸ Vehicles	❹ Fare Collection	❺ ITS/Technologies	❻ Service & Operating Plan	❼ Branding and Image
More	Fully Grade Separated Transitways	High Platforms, Amenities, Services	Hybrid, Specialized Vehicles	TMVs, Proof of Payment, Gated, All-Door Boarding	Central Control, Security, TSP, ATIS	Headway Based Schedules; Line-Haul w/ Feeders	Logo, Name, Vehicle/ Busway Colors
Less	Mixed Traffic, Queue Jumps, In-Line Stops	"Super" Stops, Shelter	Unique Route IDs, Head Signs	Smart Cards, Electronic Fare Boxes	Radios, Signal Coordination	Single All-Stops Line w/ Schedule	Service Identity, Stop Colors

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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

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Case Example Applications: Seattle Bridging-the-Gap Transit

- 7 linear corridors 4-11 miles each
- Focus on Congested Corridors Serving Transit
- Funded through Seattle "Bridging the Gap"
- Partnership with King County Metro Speed & Reliability Group

Case Example Applications: Seattle Bridging-the-Gap Transit

- Consideration of variety of solutions – Toolbox
- Agency Stakeholders Workshop
- Focus on Improving Transit Speed & Reliability
- Simplified Tools (Synchro)
- Key MOE – % Transit Travel Time Reduction (goal:10% or greater)

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Case Example Applications – Ballard Corridor Seattle Bridging-the-Gap Transit

- 6-Mile Corridor
- Serves Ballard to Downtown
- Focus on transit speed and reliability
- 2 to 7 bus routes
- Up to 38 buses per hour
- Route 15 – rapid ride
- Congested corridor

Bus Bulb Concept for BRT

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Case Example Applications - Ballard Corridor Seattle Bridging-the-Gap Transit

BRT Components - Uptown

- 5 Bus Bulbs
- 5 TSPs
- 2 Queue Jumps
- 2 Bus Stop Consolidations
- Parking Removal
- BAT Lane

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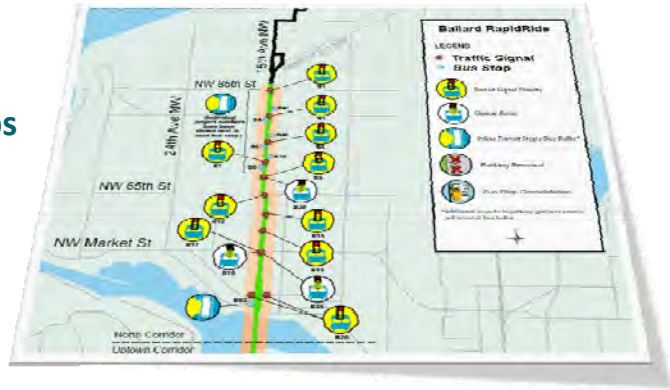
Case Example Applications - Ballard Corridor Seattle Bridging-the-Gap Transit

BRT Components - North

- 7 Bus Bulbs
- 10 TSPs
- 3 Queue Jumps



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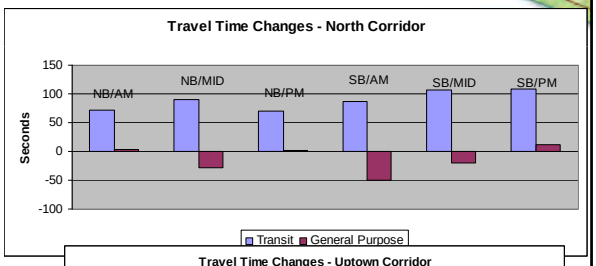
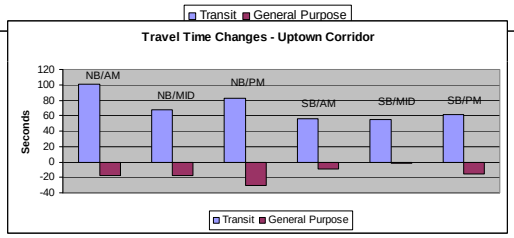
Case Example Applications - Ballard Corridor Seattle Bridging-the-Gap Transit

Project Benefits

- Improved intersection operations
- North Corridor – 50% of directional peaks experience better transit AND general purpose travel times
- Both Corridors – 100% of directional peaks experience better transit travel times





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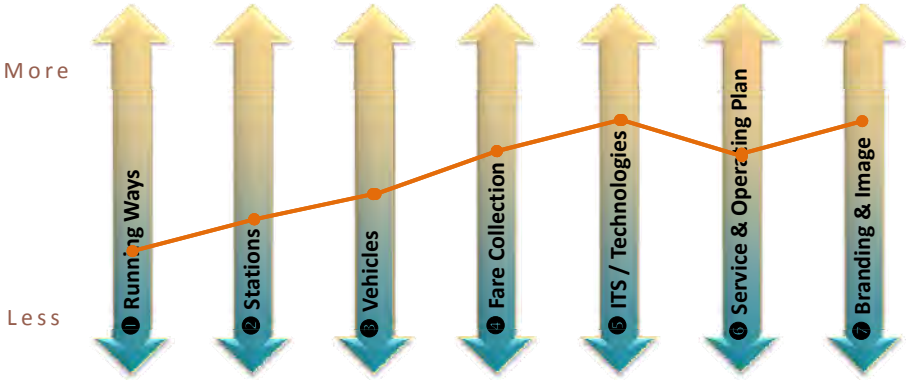
Case Example Applications Seattle BTG Transit – Ballard Corridor



Bus bulbs, queue jumps both directions, 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/ 10 Minute Peak Headways	Marketing, Name Brand, Colors

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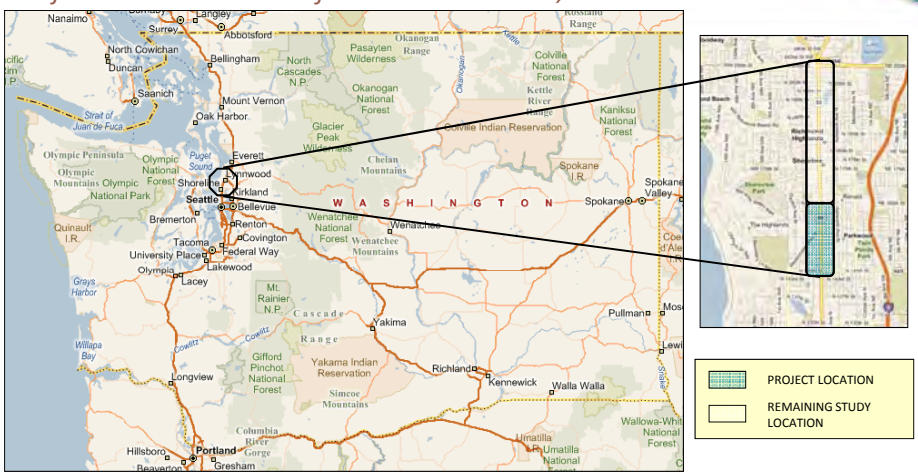
Case Example Applications: Aurora Corridor (future RapidRide E-Line)

Project Location – Cities of Shoreline & Seattle, WA



PROJECT LOCATION

REMAINING STUDY LOCATION

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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

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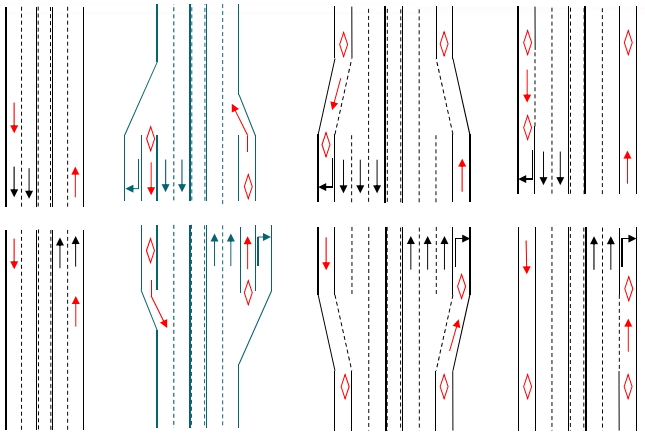
Case Example Applications: Aurora Corridor (future RapidRide E-Line)

Four Transit Design Options Were Evaluated



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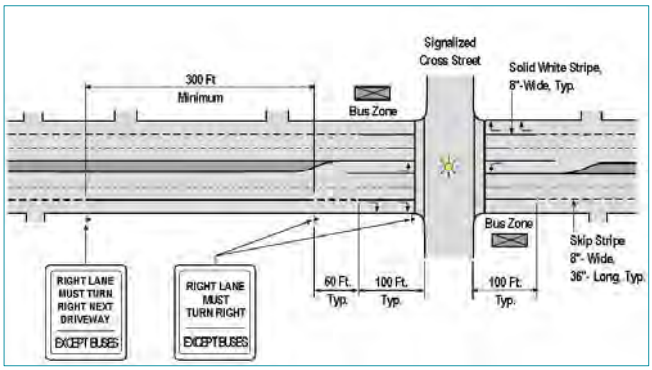
Case Example Applications: Aurora Corridor Dedicated, Identifiable Running Way

Business Access and Transit Lane Concept



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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)

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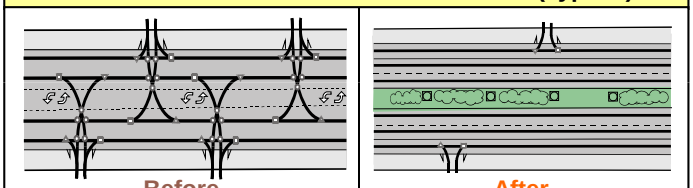
Case Example Applications: Aurora Corridor Safety Benefits

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

Reduction of Non-Controlled Conflict Points (Typical)



Total Corridor Non-Controlled Conflict Points

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

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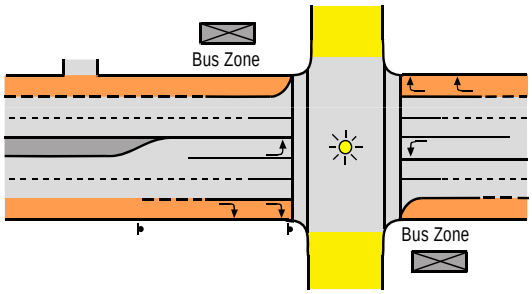
Case Example Applications: Aurora Corridor Traffic Operations Benefits

- 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%

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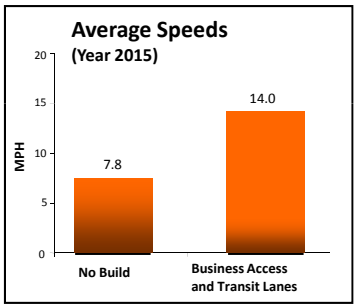
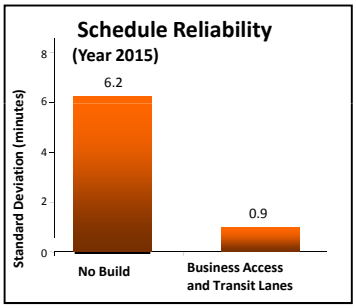
Case Example Applications: Aurora Corridor Transit Benefits

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





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

Before

After

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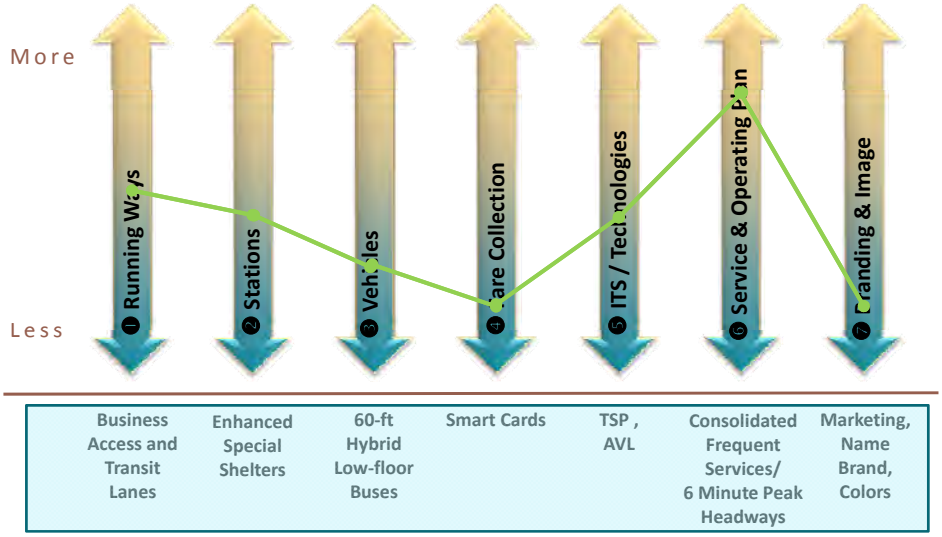
Case Example Applications: Aurora Corridor (future RapidRide E-Line)



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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

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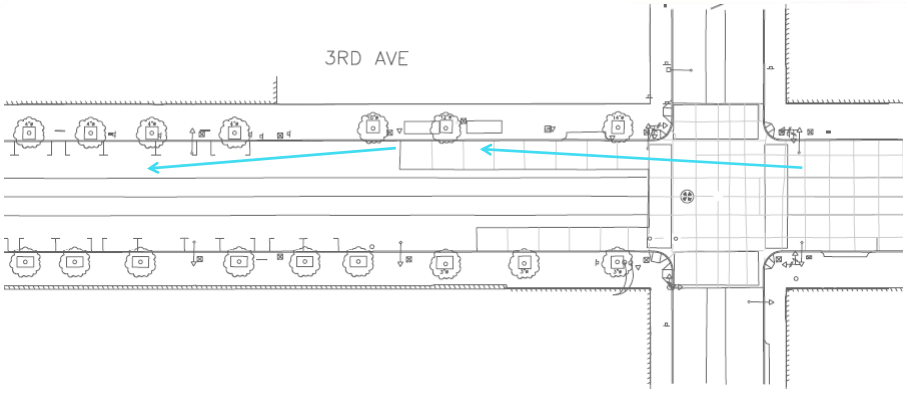
Case Example Applications: RapidRide D-Line – King County Metro

Why Bus Bulbs (curb extensions)?



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

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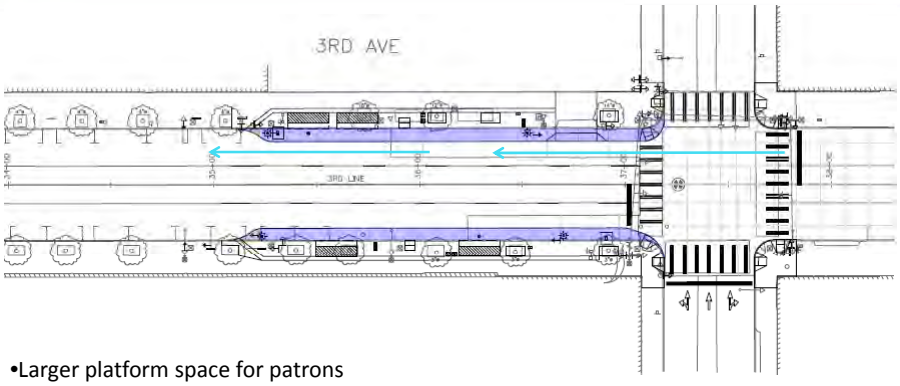
Case Example Applications: RapidRide D-Line – King County Metro

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

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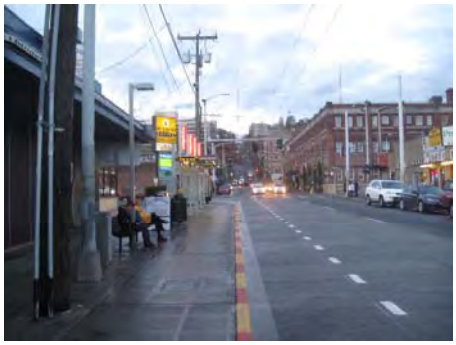
Case Example Applications: RapidRide D-Line – King County Metro

Transit Design – Bus Bulbs (curb extensions)

Before
Without bus bulbs



After
With bus bulbs

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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

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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

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

Transit Design – Sidewalk stop enhancement in urban dense environment

Before

After

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

Transit Design – Minimal stop enhancement for low boarding bus zone

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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)

Route information display with next stop display and announcement

On-board CCTV

Wheel Chair area

All door boarding for stations equipped with smart card reader.

Front door boarding for on-board fare collection

On-board free Wi-Fi

On-board fare collection and smart card reader

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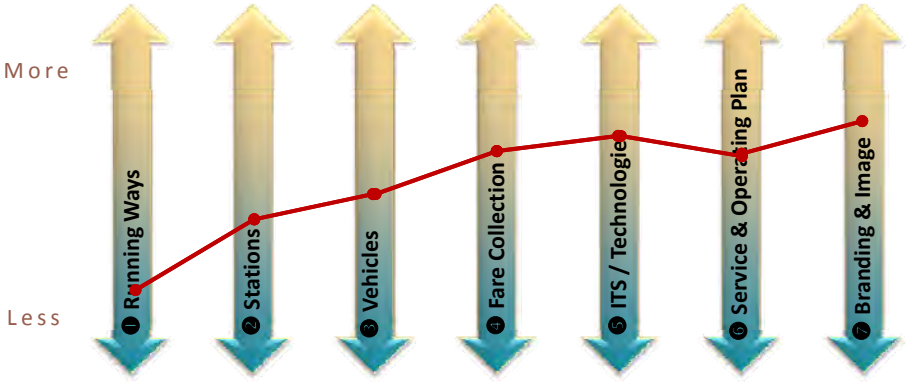
Case Example Applications RapidRide D-Line – King County Metro Transit



Running Ways	Stations	Vehicles	Fare Collection	ITS / Technologie	Service & Operating Plan	Branding & Image
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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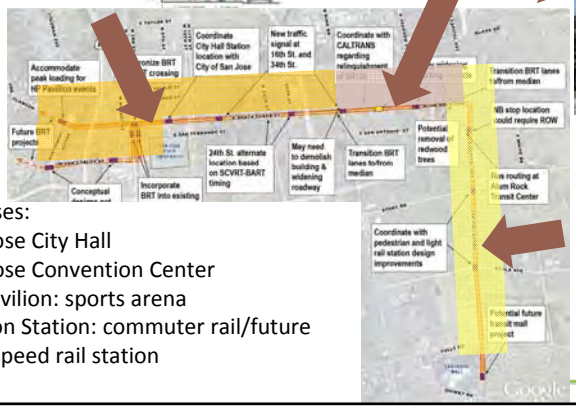
Case Example Applications: Santa Clara-Alum Rock BRT

Context:

- Operating in curb lane



- 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 exclusive median busway
- Historical and cultural neighborhoods

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

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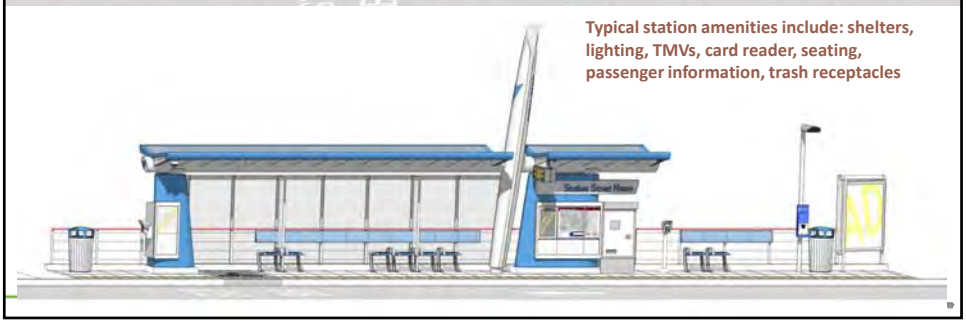
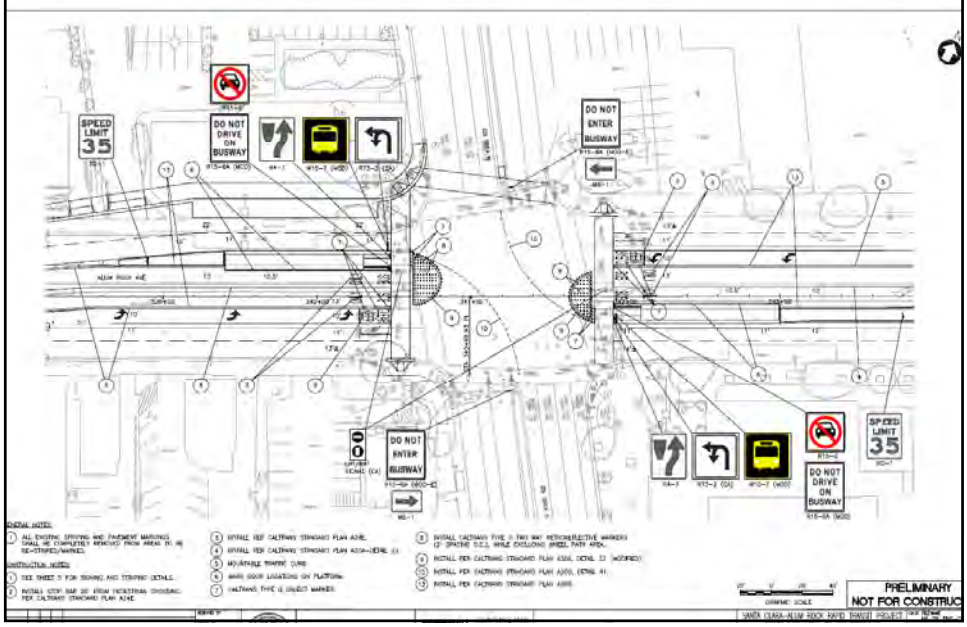
Case Example: Santa Clara-Alum Rock BRT Typical High Volume Right Side Station



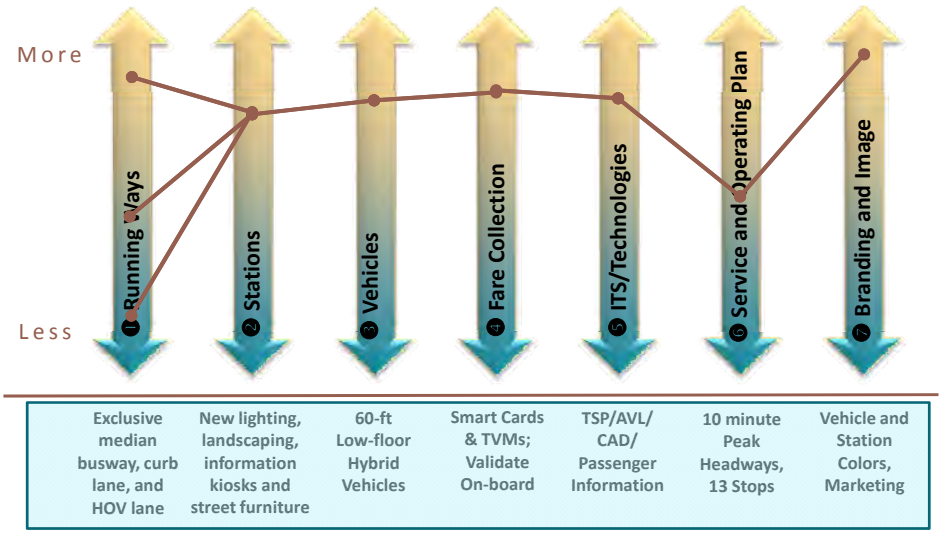
Typical station amenities include: shelters, lighting, TMVs, card reader, seating, passenger information, trash receptacles

Typical Access & Safety Design Example



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

Case Example Applications
Santa Clara-Alum Rock BRT



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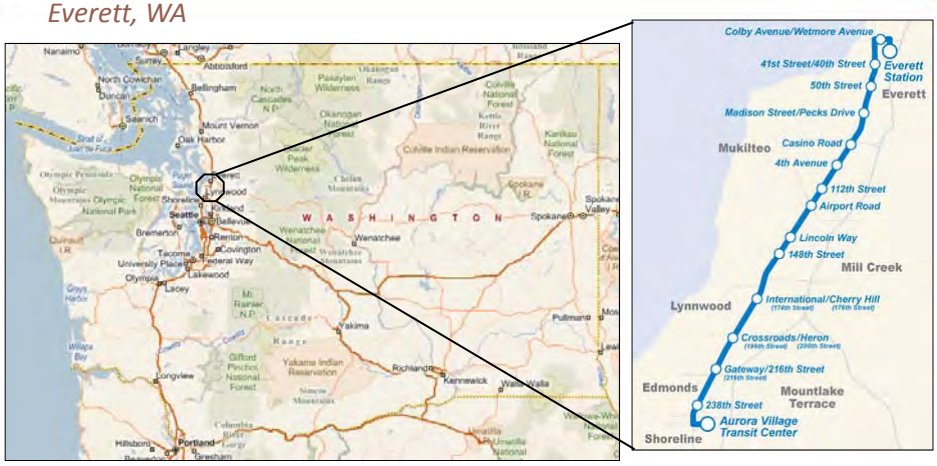
Case Example Applications:
Swift – Community Transit

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



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Case Example Applications: Swift – Community Transit

"Right Turns Except Transit" Lane Treatment

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Case Example Applications: Swift – Community Transit

Signing for "Right Turns Except Transit" lanes at intersections

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Case Example Applications: Swift – Community Transit

Transit Design – Station pull out

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Case Example Applications: Swift – Community Transit

Station Amenities

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Case Example Applications: Swift – Community Transit

On-board bike storage area

Vehicle Amenities

Bumper extension

Route information display

No on-board fare collection

Wheel Chair area

Rear door boarding for bicycles

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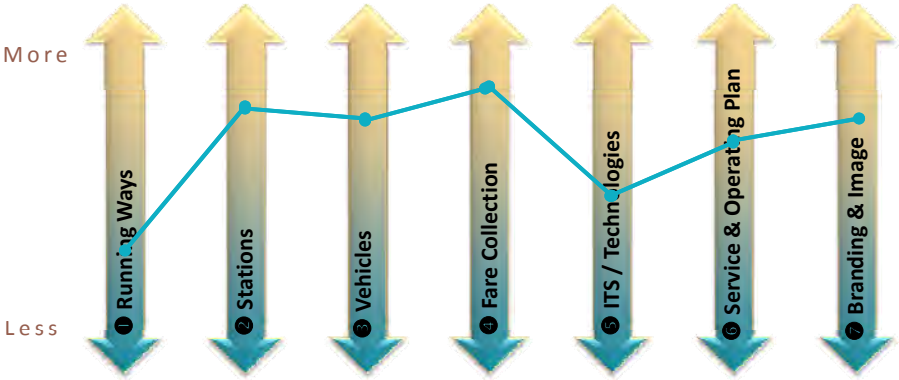
Case Example Applications Swift – Community Transit



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

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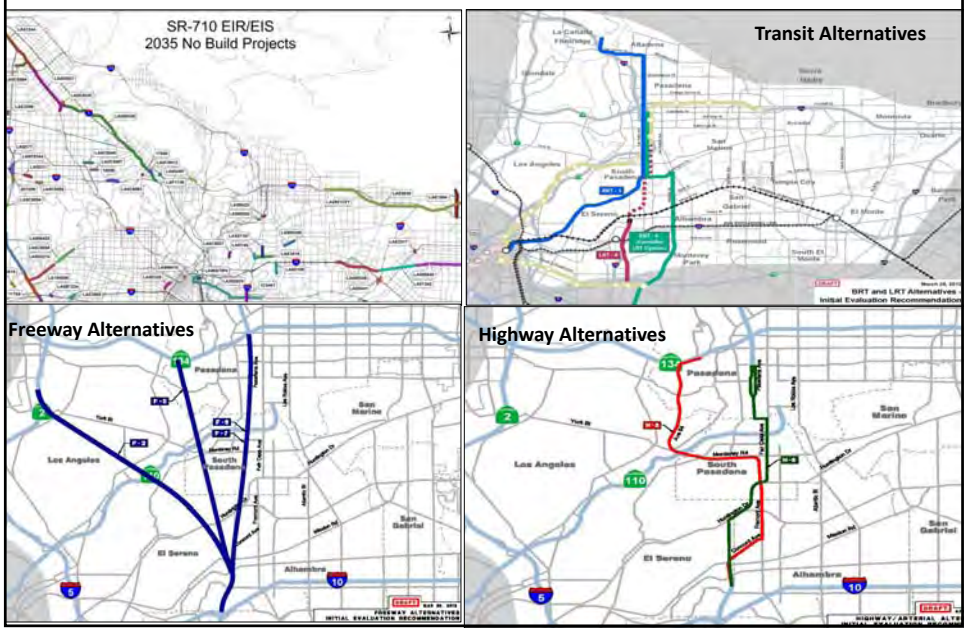
Case Example: L.A. SR710 Study Needs, Objectives & Criteria

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

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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

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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)

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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**

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

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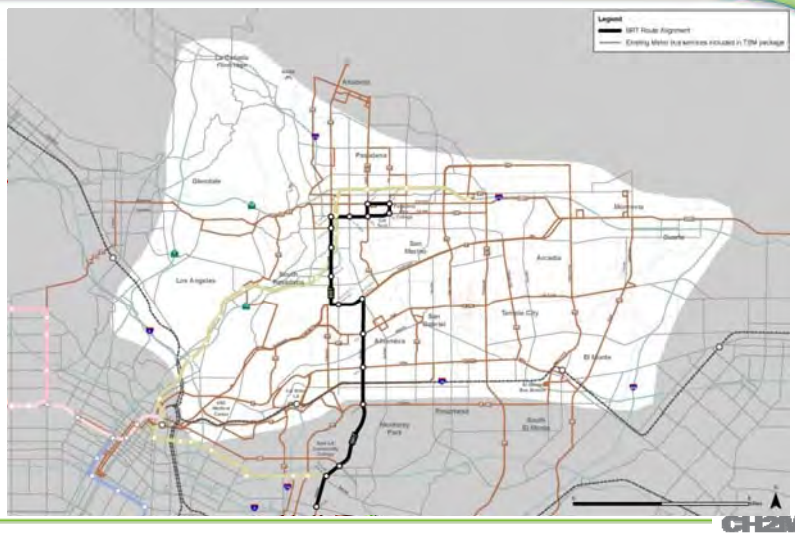
Case Example Applications: L.A. SR710 BRT Baseline Transit Service plus BRT Trunk Line



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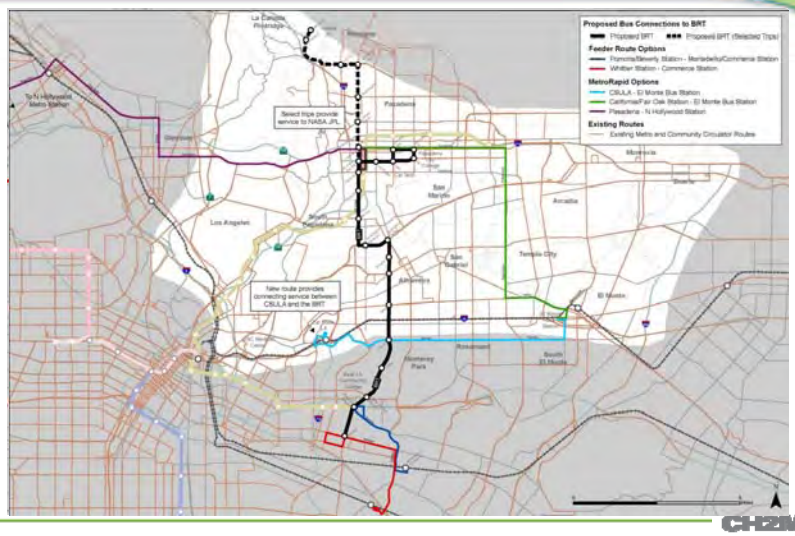
Case Example Applications: L.A. SR710 BRT Trunk Line with Feeders & Connectors



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

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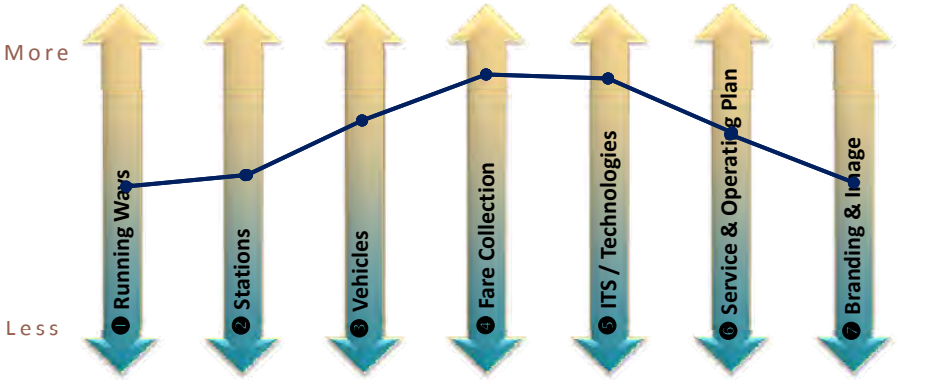
Case Example Applications L.A. SR 710 North Study BRT Alternative



Running Ways	Stations	Vehicles	Fare Collection	ITS / Technologies	Service & Operating Plan	Branding & Image
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

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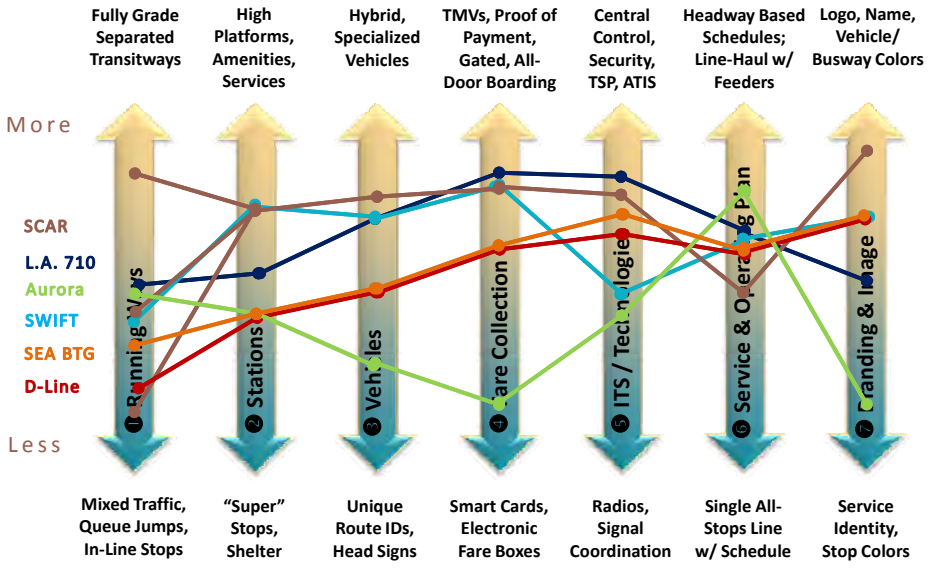
BRT Provides a Spectrum of Choices to Satisfy Needs, Objectives & Context



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Questions – BRT in Constrained Urban Environments

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