



DENVERMOVES
Federal
A Transit Alternatives Analysis

Transit Alternatives Analysis

Summary Report

Denver Moves: Federal

Final – May 2022

City and County of Denver



DENVER
THE MILE HIGH CITY

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1 Executive Summary

Introduction

The Denver Moves: Federal project is focused on improving transit service and access along the Federal Boulevard (Federal) corridor within the City and County of Denver (the City). This project aims to create a complete street for Federal, integrating transit and other modes to move more people in safety, comfort, and with efficiency. To create a true complete street, multiple considerations must be advanced or achieved. Several of these elements are expressed through the purpose statement created with stakeholders, including:

Provide greater transit access.

Improve local and regional connectivity.

Support the creation of a frequent transit network.

Support the stability of local neighborhoods and businesses.

Integrate multimodal options.

Bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility.

Enhance safety.

A major goal of this effort was to advance the transit vision collectively defined in the City's 2017 Federal Boulevard Corridor Study, the Regional Transportation District's (RTD) 2019 BRT Feasibility Study, and the City's overall transit plan – Denver Moves: Transit (2018). Led by the City in partnership with RTD and the Colorado Department of Transportation (CDOT), the Denver Moves: Federal project identifies transit improvement options along the corridor and examines how enhanced transit can better serve the communities that make this corridor such a vibrant and multi-faceted place.

Report

Denver Moves: Federal is an alternatives analysis, providing a comparative analysis of a reasonable range of transit improvement options. The options were analyzed for their performance and ability to meet the overall transit and mobility goals for the Federal corridor. This alternatives analysis forms the next step to define transit improvements and advance towards the funding needed for future implementation.

The purpose of this alternatives analysis report is to present the research and findings of the Denver Moves: Federal transit evaluation process. This report details the development of the alternatives, evaluation criteria, evaluation process, agency and stakeholder engagement, and the resulting transit improvement recommendations.

Alternatives Analysis

The alternatives evaluation for Denver Moves: Federal was structured as a series of sequential evaluation levels, where increasingly detailed and comprehensive evaluation measures were applied to a decreasing number of alternatives at each level. The process was designed to identify the alternatives that best support the Draft Purpose and Need for project. The evaluation process became increasingly rigorous at each evaluation level either by adding new measures, progressively refined definitions of the same measures, or removing measures no longer useful in differentiating performance.

Technology and Level 1 Analysis

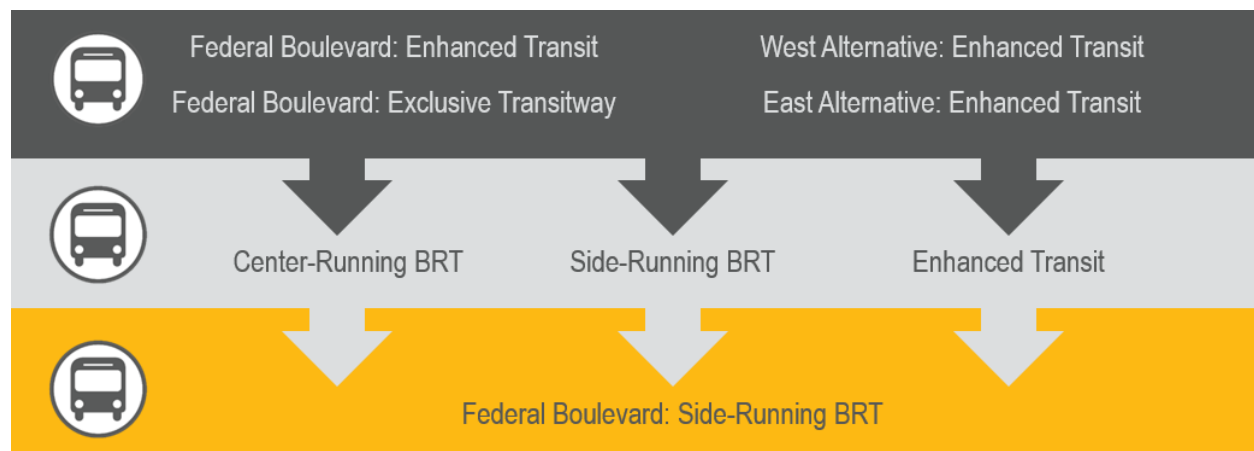
The analysis began with an examination of various transit technologies. This included consideration of a wide range of technologies, from enhanced bus and bus rapid transit (BRT) to rail options like light rail transit (LRT) and streetcar. After careful consideration and stakeholder feedback, bus based technologies were ultimately advanced for further analysis.

The bus technologies were then aligned with physical corridor and transit operational options. Each alternative was evaluated and screened based on unique criteria for each level of evaluation. The initial alternatives included options on Federal Boulevard both with and without exclusive transit lanes; as well as options that traveled through the neighborhoods to the east and west of Federal Boulevard. The options physically located on Federal were advanced for further analysis.

Level 2 Recommendations and Next Steps

At the second level of screening, the alternatives were further refined to define their specific characteristics for operations and transit exclusivity. Center-Running BRT, Side-Running BRT, and Enhanced Transit (operating in mixed traffic) along Federal were all evaluated. Figure 1-1 provide a simple graphic depiction of the process.

Figure 1-1: Alternatives Advanced



Through the final evaluation, the Side-Running BRT option yielded the highest performance when compared across the majority of criteria and when balancing cost, impacts, and benefits.

Based on the quantitative and qualitative analysis conducted through Level 2, Side Running BRT is recommended as the ultimate high capacity transit vision for the Federal corridor.

Advancing Side-Running BRT:

- Attracts approximately 30% more riders than Enhanced Transit in the horizon year (2040) and the same number of riders as Center-Running.
- Results in fewer property acquisition needs than Center-Running BRT, but more physical infrastructure and property acquisition needs than Enhanced Transit.
- Can be phased more simply and allows for re-use of any improvements completed before implementation of Side-Running is complete.
- Creates new transit demand and integration with regional service, with the most increased ridership between Alameda and Colfax, and the Decatur-Federal Station.
- Provides the lower cost option of the two BRT alternatives; while resulting in similar ridership and less potential impact than Center-Running BRT.
- Is the stronger potential alternative for funding because of its lower cost versus benefits (considering FTA Small Starts criteria).
- Provides better integration of transit into the existing urban realm (sidewalk) with simple access on the curbside between transit and local neighborhoods, businesses, and services.

2 Introduction

The Denver Moves: Federal project is focused on improving transit service and access along the Federal Boulevard (Federal) corridor within the City. This project aims to advance the transit vision collectively defined in the City's 2017 Federal Boulevard Corridor Study, the RTD 2019 BRT Feasibility Study, and the City's overall transit plan – Denver Moves: Transit (2018). Led by the City in partnership with the RTD and the CDOT, the Denver Moves: Federal project identifies transit improvement options along the corridor and examines how enhanced transit can better serve the communities that make this corridor such a vibrant and multi-faceted place. Denver Moves: Federal is an alternatives analysis, providing a comparative analysis of a reasonable range of transit improvement options. The options were analyzed for their performance and ability to meet the overall transit and mobility goals for the Federal corridor. This alternatives analysis forms the next step to define transit improvements and advance towards the funding needed for future implementation.

2.1 Report Purpose and Context

The purpose of this alternatives analysis report is to present the research and findings of the Denver Moves: Federal transit evaluation process. This report details the development of the alternatives, evaluation criteria, evaluation process, agency and stakeholder engagement, and the resulting transit improvement recommendations.

2.1.1 Organization and Appendixes

This report is organized into ten chapters that provide that provide the necessary background and details to support the final recommendations. Additional technical details and relevant research are included as appendices to this report. The sections of this report include:

Executive Summary – Provides succinct synopsis of the entire process, analysis and resulting recommendations.

Introduction – Details the overall purpose and structure of the report including the project goals and study area.

Purpose and Need – Includes the summary statement of what transit improvements are aiming to accomplish and why these improvements are needed.

Evaluation Methodology and Process – Describes the approach to the development of transit alternatives and the comparative evaluation.

Public and Agency Engagement – Summarizes the overall engagement program, stakeholder input, and how this input influenced the recommendations.

Initial Screening and Results (Level 1) – Details the fatal flaw screening of the initial set of transit corridor improvements and transit technologies (bus, rail, etc.).

Final Screening and Results (Level 2) – Presents the more rigorous evaluation of the remaining transit alignments.

Conclusions and Recommendations – Provides the final recommendations resulting from the Level 2 analysis; as well as next steps required to advance the recommendations.

Bibliography – Recognizes the stakeholders, agency partners, and project team that contributed to this effort. Provides sources for citations in the document.

Appendixes – Additional information as necessary to support the report.

2.2 Study Area and Termini

The study area defines the overall geographic area of analysis and is generally coincident with the transit market around Federal Boulevard. The termini are specific locations that form the end points of this project's potential alternatives. The termini are the locations the alternatives are seeking to connect to and from. Termini are typically characterized by significant transit connection points, multimodal hubs, and/or major origin/destination points (activity centers) that are supportive of transit.

The primary focus of this study is Federal Boulevard within the City and County of Denver. However, because mobility needs are not confined by jurisdictional boundaries, the analysis of transit alternatives includes both a capital study area (physical improvements) and an operational study area (transit service changes). The capital study area, which stops at City boundaries, focuses on physical improvements such as stop infrastructure, changes to the street to provide more priority for transit, etc. The operational study area extends into adjacent jurisdictions, where improved transit

operations and connections may be appropriate to benefit the overall network; however, any physical improvements in this area would be under the purview of the adjacent jurisdictions (not the City). Therefore, this study only considered operational changes (not infrastructure improvements) for areas outside of the City. Further advancement of any operational changes outside of the City limits would also require additional consultation with the adjacent jurisdictions.

Capital Study Area and Termini

The capital termini set the boundaries for infrastructure and stop area improvement investments within the City. The preliminary southern terminus is the Loretto Heights campus (South Federal Boulevard and West Floyd Avenue) and the preliminary north boundary is the Regis University campus (North Federal Boulevard and West 52nd Avenue). The Loretto Heights campus holds a rich history as a religious and educational facility. Since the site's recent sale to private owners, the City and the surrounding communities completed a small area plan. This plan defines the vision for redevelopment of the campus, while integrating and respecting the historic aspects and the context of the surrounding neighborhood. Loretto Heights is envisioned as an important activity center and a multimodal hub seamlessly linking to the transit, bike, and pedestrian networks. Regis University is the northern terminus and this project would provide a significant opportunity to better serve this established and iconic destination on Federal. Additionally, the new campus master plan identifies the expansion of the campus with university facilities serving as a catalyst for revitalization along Federal. Adjacent to the university, the ongoing Aria development and infill opportunities create a destination with transit as a key component to serve existing and new residents and businesses. The corresponding capital study area includes a zone within one-half mile of the roadway alignment for most data analysis (exceptions are noted as needed).

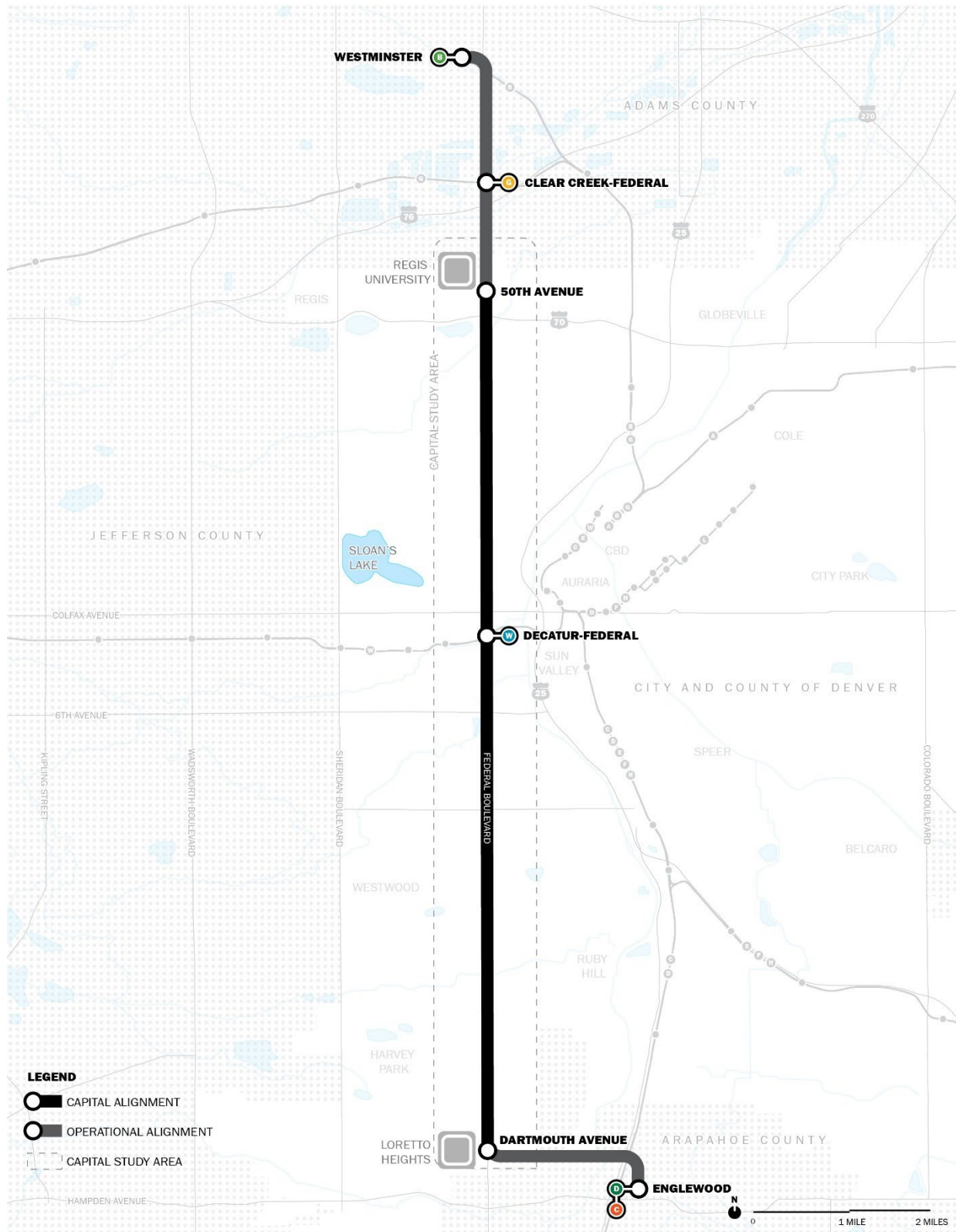
Operational Study Area and Termini

The operational study area sets the boundaries for any proposed changes to transit service related to the Federal corridor. The operational southern terminus is located at RTD's Englewood Station (C and D light rail lines) in the City of Englewood. This area is an evolving destination, associated with the Englewood CityCenter district, Englewood municipal facilities, and connections to RTD's light rail (C and D lines). The northern terminus is the Westminster Station (B-Line commuter rail) in the City of Westminster. The station is adjacent to significant park and recreational facilities. The area is planned for transit oriented development (TOD) along the Clear Creek valley in Adams County and the City of Westminster. The operational study area encompasses a zone within one-half mile of the roadway alignment for most data analysis (exceptions are noted as needed).

Jurisdictions other than the City and County of Denver within the operational study area include the cities of Sheridan, Englewood, Westminster, as well as Arapahoe and Adams counties. Additional capital improvements sponsored by neighboring jurisdictions or RTD may be completed within the operational study area, but will not be the subject of specific recommendations emerging from the Denver Moves: Federal project. Any physical changes outside of the Denver limits would be at the discretion of the respective local

jurisdictions. RTD's 2019 Regional BRT Feasibility Study set the groundwork for the operational study area and termini. RTD's study examined the potential for BRT service along Federal from Englewood Station (Santa Fe Drive south of Dartmouth Avenue) in the City of Englewood, extending all the way to 120th Avenue (Wagon Road Park-n-Ride) in the City of Westminster. Further coordination and potential partnerships with the adjacent jurisdictions are possible and encouraged to realize the full vision for transit improvements along Federal identified in the Regional BRT Feasibility Study. Figure 2-1 provides a graphic representation of the study area and termini.

Figure 2-1: Study Area and Termini



3 Draft Purpose and Need

Developing a draft purpose and need statement is considered best practice for an alternatives analysis project. The purpose and need statement attempts to clarify the desired outcome of the project. The purpose and need also creates an overarching framework that guides the creation of transportation alternatives and the evaluation criteria. A quality purpose and need statement is typically concise, clear, non-technical, and easy to understand. Overall, the purpose and need provides the rationale and justification for the project and is the basis for the consideration of alternatives.

Purpose – What are we trying to accomplish?

The function of a purpose is to broadly define the problem to be solved and the desired transportation outcome of the project.

Need – Why is it necessary?

The need supports the purpose with a quantifiable explanation of the mobility deficiencies.

Should the recommendations included in this report be advanced for funding from the federal government, clearance will be required under the National Environmental Policy Act (NEPA). A draft purpose and need statement is required prior to entering into NEPA (Executive Office of the President, 2017). The purpose and need must be defined well enough for stakeholders to understand the proposal and provide meaningful input.

In the case of Denver Moves: Federal, the purpose and need focuses on defining the desired future state for high quality transit within the Federal Boulevard transit market. It defines 'what success looks like, but does not define the specific methods or transportation improvements to achieve this. Defining the options is the role of the analysis process; while the purpose and need helps to frame the potential alternatives. The purpose and need provides parameters for the potential alternatives that are broad enough to create a range of options, but specific enough to address the problem at hand. In general terms, the purpose and need:

- Provides a succinct justification for the project.
- Outlines the existing and future mobility deficiencies and issues.
- Is supported by facts and data.
- Guides the development of evaluation criteria and alternatives.
- Helps make the case for action and funding.

The purpose and need is considered draft and is a living document, potentially evolving as new information is available and stakeholder input is collected. A formal purpose and need statement may be created using the draft as a base, as the project advances into future stages (project development and environmental).

3.1 Draft Purpose and Need Statement

Draft Purpose

The purpose of the Denver Moves: Federal transit corridor project is to support current and future transit users with more frequent, reliable, high capacity, and high quality transit service along the Federal Boulevard corridor. The corridor includes the transit market served by Federal Boulevard from approximately the Denver city limits (north and south). While capital improvements for this project will remain within city limits, the analysis of alternatives includes considerations of possible operations beyond these boundaries.

Consistent with the City's Denver Moves: Transit Plan, the Federal Boulevard Corridor Study, and the Regional Transportation District's (RTD) Regional Bus Rapid Transit Feasibility Study, the project's infrastructure and operational improvements seek to:

Provide greater transit access.

Improve local and regional connectivity.

Support the creation of a frequent transit network.

Support the stability of local neighborhoods and businesses.

Integrate multimodal options.

Bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility.

Enhance safety.

Draft Need

The need for transit improvements in the Federal Boulevard corridor is indicated by the following:

Meet the mobility needs of underserved communities.

Historically, transit usage has been highest among households with less income and those with no access to a vehicle. There are approximately 4,000 affordable housing units, both renter and owner occupied, within ½ mile of the corridor which represents 25% of all such units in the City (City and County of Denver, Accessed 2020). Additionally, 12% of households within ½ mile of the corridor do not own a vehicle (US Census Bureau, 2017).

Meet the mobility needs of existing and future local/regional residents and businesses.

Sustained population and employment growth along the corridor is expected to continue through 2040. In 2020, approximately 150,000 people, or 4% of the region's population, live within ½ mile of the likely operational limits of the project corridor (79% of those live

within Denver's city limits)¹. Regional forecasts project a growth of 22,000 new residents (64% of which will be within Denver's city limits) between 2020 and 2040. Population growth is expected to be concentrated near Regis University (56% growth from 2020 to 2040), and the Valverde neighborhood (47% growth from 2020 to 2040).

Approximately 3.5% of the region's jobs (67,000) are located within ½ mile of the likely operational limits of the project corridor as of 2020 (three-quarters of which are within Denver city limits). Employment along the corridor is expected to grow by 17,000 jobs during the same period. This growth is expected to be concentrated in the Stadium District north of Colfax Avenue (82% growth from 2020-2040) and in the vicinity of the Loretto Heights Campus (40% growth from 2020-2040) (DRCOG, 2020).

Address the limited north/south transit connectivity in the western metropolitan area.

Interstate 25 (I-25) and the South Platte River create barriers to movement, limiting transit trips to desired destinations. The six stops with the most daily bus boardings within the corridor all serve major transfers to east-west transit services (RTD, 2020), and the bus stop facilities along the corridor frequently lack amenities and consistent connectivity to the surrounding neighborhoods.

Improve unpredictable travel times due to increased congestion.

Despite high overall ridership, existing transit service along the corridor does not offer competitive service for most users. Routes serving the corridor can be unreliable, with buses reaching their stops approximately two minutes behind schedule on average during peak commuting hours (RTD, 2018)². When there is little or no traffic congestion, transit riders can expect to spend almost 50% more time traveling along the corridor as compared with people in cars (RTD, 2020) (Google, Accessed 2020)³. Anticipated growth in the region will further impact transit reliability (and therefore viability) for vehicles operating in mixed traffic.

Align mobility improvements with land use plans and regeneration.

The Federal Boulevard corridor serves some of the City's most vibrant and engaged neighborhoods including Regis, Sun Valley, Westwood, Harvey Park, etc. Active and engaged citizens groups have expressed preliminary support for recent transit planning efforts that have identified Federal Boulevard as a high-priority transit corridor. These plans include RTD's Regional BRT Feasibility Study, which found that the corridor was among the top tier candidates for BRT service within the district based on likely ridership, available right-of-way, traffic congestion, community support, and other factors. Additionally, the City's Denver Moves: Transit includes Federal Boulevard as one of the City's High Capacity Transit investment corridors. Finally, transit improvements in the

¹ The region corresponds with DRCOG MPO boundaries.

² Includes routes 30, 30L, and 31. Schedule deviation for buses at the 50th percentile ranges from 0:51 to 5:22 at AM and PM peak hours (depending on direction and route).

³ Reflects the 6.4 miles from the Federal/Evans transfer station to 38th Avenue (approximately the alignment of Route 31). Includes in-vehicle time only.

corridor are included the regional Long Range Transportation Plan (LRTP), with near-term speed and reliability improvements included the 2020-2023 Transportation Improvement Program (TIP) compiled by the Denver Regional Council of Governments (DRCOG).

Provide transportation improvements without major acquisition of private properties.

Given the urban context of the Federal Boulevard corridor, there are limited opportunities to acquire more space for transit improvements from surrounding private properties. Therefore, this project must seek out transit options to move more people in the existing constrained corridor. Priority will be given to those options that remain within the existing right-of-way.

4 Alternatives Development and Evaluation Process

The alternatives evaluation for Denver Moves: Federal was structured as a series of sequential evaluation levels, where increasingly detailed and comprehensive evaluation measures are applied to a decreasing number of alternatives at each level. The process was designed to identify the alternatives that best support the Draft Purpose and Need for project. The evaluation process became increasingly rigorous at each evaluation level either by adding new measures, progressively refined definitions of the same measures, or removing measures no longer useful in differentiating performance.

Figure 4-1: Process



No single criterion drove the decision making. It was the cumulative examination of the evaluation, combined with City policy direction, proven transit system design, and stakeholder engagement that ultimately supports the final recommendations.

4.1 Evaluation Methods

Several methods were used to compare and evaluate alternatives at different screening levels. The evaluation process uses a combination of qualitative and quantitative evaluation methods to determine the feasibility and reasonableness of alternatives. The methods used in evaluating alternatives are defined as follows:

- Qualitative assessment compares each alternative against a set of evaluation criteria, and based on technical evaluation and considerations, alternatives are given a basic ranking for each evaluation criterion. The ranking given for each evaluation criterion can be as simple as applying consumer reports style 'harvey ball' graphics for the qualitative assessment, based on the level of ability to achieve each criterion.
- Quantitative analysis evaluates alternatives on data-driven metrics and measurements to identify major advantages and disadvantages of each alternative. This analysis method utilizes technologies such as Geographic Information System (GIS) analysis, travel demand model results, and cost-benefit valuation. For analyses that use a quantitative analysis approach, the numeric value reported for the criterion compares each alternative against one another.

4.2 Alternatives, Level 1, and Level 2 Process

On the ground conditions, past planning efforts, current mobility and demographic data, engagement with stakeholders, and input from our agency partners framed the development of the initial range of alternatives. Transit options and multimodal improvements were extracted from the City's 2017 Federal Boulevard Corridor Study, the Regional Transportation District's (RTD) 2019 BRT Feasibility Study, and the City's 2018 transit plan, Denver Moves: Transit. Each plan identified Federal Boulevard as a critical north/south transit corridor and most identified the need for high capacity transit to support future demand along Federal. With these plans, data, and stakeholder input as the foundation, the project team systematically created the initial reasonable range of alternatives.

As the analysis progressed through the two levels of evaluation, only the best performing alternatives were advanced for further examination. Those alternatives that did not meet the purpose, need, or vision of the project were documented and set aside. The following section details the actions taken at each subsequent step to further define the transit options and technologies.

4.2.1 Alternatives Development Process

Data collection and development of the existing context memorandum provided an understanding of transit and mobility needs and deficiencies within the study area. Overlapping areas of higher potential transit demand and mobility deficiencies helped highlight the potential locations of alternative. The State of the Corridor Memorandum – June 2020, includes the detailed mobility and demographic analysis of the study area. This document is a companion to this report and is included as Appendix 1.

4.2.2 Initial Screening Process (Level 1)

Level 1 – Technology Screening

Level 1 included two components, identifying physical 'corridors' that transit may travel along and examining various types of transit technologies to determine those technologies appropriate for the Federal transit market. Technologies included a range of

transit vehicles from bus based technologies, to rail options, and other urban transit options like gondolas. A wide range of technologies were first presented and amended through stakeholder engagement to verify a reasonable, yet visionary range of technologies were considered for the study area.

Level 1 – Corridor Screening

Level 1 corridors were defined following various routes that may support transit demand, communities of need, and connect to the termini within the Federal transit market (study area). At Level 1 the alternatives were referred to as corridors, because they represented initial, high level routes and did not assume specific transit designs. The goal at Level 1 was determine if the corridor was appropriate before considering specific transit designs.

4.2.3 Final Screening Process (Level 2)

Level 2 – Alignments Screening

The Level 1 analysis resulted in advancing the most promising transit corridors for further refinement and more rigorous analysis in Level 2. At Level 2, these alignment alternatives were paired with the technologies that advanced through Level 1 as well. Cross section designs were developed to present the configuration of transit within the street. The cross sections presented the basic space needed to achieve the various Level 2 alternatives, assuming their assigned transit technologies.

Level 2 – Recommendations

The final screening at Level 2 compared and contrasted the remaining alternatives and technologies, resulting in the final recommendations. Final refinements to the recommended transit alternatives were completed. This included mixing and matching various elements of the Level 2 alternatives needed to best function in different segments of Federal. The final recommended transit configuration was advanced for concept design.

5 Public and Agency Engagement

The alternatives analysis effort was conducted through an open and collaborative process. The outreach and involvement process was aimed at engaging diverse groups of stakeholders (community members, advocacy organizations, seniors groups, groups supporting persons with disabilities, elected officials, public agencies, etc.) to help guide the outcomes. The stakeholder engagement strategy supported the decision making process, including the scoping of technologies, corridors, and alignments.

In March of 2020, Colorado and the broader US, witnessed the start of the COVID-19 pandemic. At that point, the project team reassessed the public engagement process, tools, and techniques, to confirm our engagement efforts could continue in a safe and effective manner. The project team worked with the City and stakeholders to adjust the engagement strategy and focus on engagement through means other than face to face contact.

The following sections provide an overview of the stakeholder involvement strategy, process, and details on stakeholder input collected that helped to guide the alternatives analysis.

5.1 Stakeholder Engagement Strategy

The stakeholder engagement strategy included actions, information sharing techniques, and input opportunities to garner meaningful input. This input helped to shape the analysis and outcomes of the analysis.

Engagement Objectives

The engagement strategy was guided by the following objectives for stakeholder participation:

- Inform stakeholders and the public to create awareness about the purpose and process of the alternative analysis project.
- Partner with local jurisdictions, elected officials, and key stakeholders to promote project milestones.
- Engage the public and collect meaningful feedback to inform the technical team.
- Transform complex technical data into easy to understand comprehensive communication materials.

Target Audiences

The engagement strategy also targeted representative audiences from the communities adjacent to Federal, advocacy groups, and agency stakeholders, including:

- Local and regional governments.
- Persons with disabilities or limited mobility.
- Low-income communities.
- Racial and social diversity among stakeholders representing the local community.
- Local businesses.
- Local residents.
- Neighborhood organizations.
- Roadway users.
- Bicycle and pedestrian advocacy groups.
- Landowners.
- Developers.

5.2 Stakeholder Engagement Activities

Several outreach and participation strategies were utilized at key project milestones and on an ongoing basis to achieve the project’s goals for meaningful public participation.

5.2.1 Community Advisory Team

The project’s community advisory team (CAT) was comprised of local residents, registered neighborhood organizations (RNO), local decision makers; as well as other representatives from local governments, mobility advocacy groups, housing organizations, and other critical transit and specialized transportation stakeholders. Membership was based on geographic location, constituent groups, and issue areas to ensure the committee represented the Federal corridor. Table 5-1 provides a list of organizations invited to participate as part of the CAT.

Table 5-1: Community Advisory Team Invitees

CAT Invitees	
Athmar Park RNO	Loretto Heights RNO
Berkeley Regis United Neighbors RNO (BRUN)	Mental Health Center of Denver
Bicycle Colorado	Metropolitan Football Stadium District
CDOT	Mi Casa Resource Center
Chaffee Park Neighborhood Association	Namaste Solar
City Council District #1	One Federal Boulevard Task Force
City Council District #2	Regis University
City Council District #3	ReVision
City Council District #7	RTD
College-View Neighborhood Association	Ruby Hill Neighbors
Community Coalition of Barnum	Sloan's Lake Citizen's Group (SLCG)
Council Member District #7	Sloan's Lake Neighborhood Association
Denver Health	Sun Valley
Denver Housing Authority (DHA)	Sunnyside United Neighbors, Inc. (SUNI)
Denver Public Schools (DPS)	The Denver Broncos
Denver Regional Council of Governments (DRCOG)	Urban Land Conservancy
Denver Streets Partnership	Valverde Neighborhood Association
DRCOG	Vietnamese Senior Citizens Center
Federal Boulevard Partnership	Vietnamese-American Community of Colorado
Federal Business Improvement District	Villa Park Neighborhood Association
Fresh Start Denver	West Colfax Association of Neighbors – WeCAN

CAT Invitees	
Harvey Park Community Organization	West Colfax Business Improvement District
Highland United Neighbors, Inc. (HUNI)	West Denver Renaissance
Independence House	West Highland Neighborhood Association
Jefferson Park United Neighbors	Westwood Unidos

The CAT was convened at key milestones to guide the development and screening of transit alternatives. CAT members not only provided direct feedback from their perspective, they also served as a connection for feedback from their constituents (neighborhood groups, etc.). Each CAT member was tasked with sharing the project information with the constituents they represent for broader feedback from stakeholders to inform the decision making process. The CAT met at four critical milestone points in the process and focused on the following topics:

CAT meeting #1 (Dec 11, 2019 – Barnum Recreation Center) – This meeting provided an introduction for members. The purpose of the meeting was to introduce the project, explain the role of a CAT member, present background on previous studies along Federal Boulevard, and obtain input to guide development of the project’s Purpose and Need statement. The meeting was opened by Eulois Cleckley, Executive Director of City and County of Denver Department of Transportation and Infrastructure (DOTI).

CAT meeting #2 (Feb 25, 2020 – Namaste Solar) – The focus of this meeting was to understand community needs, review background research on the Federal corridor, define the project study area and termini, and provide final input on the revised purpose need statement. The group also participated in exercises aimed at evaluation criteria and scoping potential transit technologies and potential corridor alignments.

CAT meeting #3 (Jul 22, 2020 – Virtual Online Meeting) – This meeting provided critical feedback on the initial technology and corridor screening results. Generally, the group supported the analysis to date, but agreed to spend time following the meeting obtaining feedback from their organizations and collecting additional feedback on the technologies and corridors.

CAT meeting #4 (Jan 13, 2021 – Virtual Online Meeting) – The committee provided feedback on the final screening of transit alignment alternatives and the draft recommendations of the project. CAT members agreed to support the promotion of the final stakeholder engagement activities through social media and other outlets associated with their organizations. The committee also discussed the project next steps.

5.2.2 Technical Team

In addition to the CAT, a technical team was initiated to meet (as needed) to address and resolve specific technical issues associated the development and screening of alternatives. The technical team was comprised primarily of City staff from a range of

departments with responsibilities and interests along Federal. Additionally, agency partners (RTD, CDOT, and DRCOG) were included as key members of the technical team. These agencies participated in the CAT and technical team to better understand both the agency and stakeholder perspectives. The technical team met on four occasions generally around the milestone points of the alternatives analysis.

Technical team kickoff #1 (Sep 12, 2019 – Wellington Webb Building) – This meeting served as the kickoff for the project and coordination among the technical project team. Team exercises were conducted to identify issues and opportunities along Federal that could help identify transit improvements.

Technical team meeting #2 (Jan 16, 2020 – HDR Denver) – The technical team focused on the information collected at the December CAT meeting to craft the draft purpose and need statement for stakeholder review and begin discussion of logical project termini.

Technical team meeting #3 (May 19, 2020 – Virtual Online Meeting) – This meeting was the technical team’s introduction to the initial (Level 1) screening of transit technologies and corridors. The team provided important feedback to support the presentation of these results to the CAT and broader stakeholders.

Technical team meeting #4 (Jan 5, 2021 – Virtual Online Meeting) – This meeting focused on review of the final (Level 2) screening results, recommendations, and next steps. Additionally, the team further scrutinized the traffic and ridership analysis.

The Technical Team was essential to keeping the technical design, coordination, and policy considerations in plain sight throughout this effort. Critical team members, such as RTD and CDOT played an important role in guiding the team. CDOT currently owns the majority of the Federal Boulevard right-of-way (ROW) and is responsible for maintenance. As the owner, CDOT must consider their goals for regional movement along the corridor; along with the local needs. CDOT was an active partner in the Technical Team and was transparent with their thoughts on opportunities and challenges implementing high capacity transit. They recognized this study is just the beginning of planning, design, and coordination regarding BRT and are open to continued dialog. CDOT provided the following statement in response to the recommendations.

CDOT understands this to be an early stage alternatives analysis and planning study effort to identify, from the City of Denver's perspective, and key stakeholders engaged through the process, what they feel are the available and preferred options to progress their vision of transit on the corridor. CDOT expects an appropriate level of traffic analysis, as determined by CDOT, to be completed for the 6-lane section prior to any approval. Further, the 4-lane cross section is only appropriate for signal adjustments and bus-in-mixed-flow operations. – CDOT

5.2.3 Informational Tools

Given the current COVID-19 environment, the project team utilized a variety of electronic information distribution methods and social media postings. The primary tools are detailed below.

Website

The project team developed and regularly updated a project website in support of the project. The website was an important source of information for stakeholders and was presented on the City's website platform, under DOTI's project pages. Key project information (e.g., project overview, study area map, and opportunities for engagement and input) was made available on a project webpage. The project website also featured fact sheets, notices, and links to the online questionnaires.

Email Blasts and Social Media

The team researched and maintained a detailed contact list/email distribution for stakeholders across the corridor. Email blasts were utilized at key milestones to announce the availability of project information for stakeholder review. Additionally, email blasts were an important method to publicize the stakeholder questionnaires and online public meetings. Social media, including Facebook and Twitter, served an important function to share project information and feedback opportunities with stakeholders. DOTI utilizes its own Twitter and Facebook accounts to convey information on a range of projects associated with the department. The Denver Moves: Federal team developed focused social media language and graphics at key milestones for posting by DOTI communications staff. Social media content, graphics, and photos were also provided to stakeholders and CAT ambassadors for easy sharing on their own organizations' social media accounts, to enhance the reach of the project's communications. Social media postings were provided in English, Spanish, and Vietnamese.

Collateral Materials

A variety of easy-to-read materials were created to educate stakeholders and maintain consistent information. Collateral materials included a project fact sheet, press releases, multiple presentations, and informational boards (for online public meetings). All collateral materials were created in both English and Spanish in electronic format for posting on the website and distribution.

5.2.4 Engagement Events

Originally, community events and direct engagement was to be conducted to gain input on the screening and evaluation of transit alternatives. Due to COVID-19, new options were identified to provide similar feedback, without direct contact. The team flexed to use a combination of online events and the CAT members as project ambassadors.

Online Public Meetings and Questionnaires

Online public meetings and questionnaires were strategically used to provide opportunities for stakeholder education and feedback at key milestones and decision points in the project. Online questionnaires were developed and distributed electronically via Survey Monkey. The questionnaires were presented at the project scoping and recommendations milestones. The questionnaires were promoted via email blasts, social media, and through our CAT ambassadors.

A virtual format was also used to solicit stakeholder feedback via online public meetings. This format provided a more convenient alternative to traditional (in person) events and allowed stakeholders to participate on their desired schedule. The online public meeting format included a series of web based informational pages (similar to informational boards at a traditional meeting). The pages were sequenced to step the participant through the event, educating and answering key questions throughout. Opportunity to provide direct feedback was included throughout the online meeting. The meetings were made available at www.DenverMovesFederalMeeting.com (meeting currently closed). Each public meeting provided viewing options in English, Spanish, and Vietnamese. The meetings were posted and remained open for up to three weeks, allowing participants to access the information at any time and was not limited to a few hours (as in a traditional meeting). Online public meetings were promoted via email blasts, through CAT ambassadors, multiple social media outlets, the project website, and Spanish radio.

Questionnaire #1

The initial questionnaire kicked off the broad public engagement program and was aimed at building knowledge of the alternatives analysis project and providing opportunity for valuable input. The questionnaire was available from April 9 to 24, 2020. Questionnaire #1 presented questions to inform the draft purpose and need statement's development. Questions related to how and why stakeholders move along or across Federal; as well as the critical mobility needs for Federal. A total of 211 questionnaires were completed, including responses in English, Spanish, and Vietnamese.

Public Meeting #1

To gain input on the project's draft purpose and need; as well as Level 1 analysis of technology options, and initial corridor alignment options, the first online public meeting was held from August 3 to 14, 2020. The online format provided an opportunity for stakeholders to view project materials and provide critical feedback to guide this stage of the alternatives analysis. Stakeholders were asked to review and provide input on the proposed transit technologies and corridors based on their personal experiences and priorities. The meeting hosted 187 individual visitors, resulting in 54 feedback responses. Some visitors viewed the information but did not provide direct feedback. Stakeholders providing input via the online public meeting generally agreed that BRT on Federal Boulevard was a desirable solution.

Online Public Meeting and Questionnaire #2

The second community event was held from January 19, 2021 to February 12, 2021. This combined online public meeting questionnaire served as an opportunity for stakeholders to engage and provide feedback on the Level 2 analysis results and recommendations. The online public meeting included a video presentation of the project's progress completed since the last public event. The video included a voice-over presentation from the project team in English and Spanish, and a version with Vietnamese translation. The online event hosted over 550 individual visitors, including over 190 views of the video presentation, and 74 questionnaire responses. Some visitors

viewed the information but did not provide direct feedback via the questionnaire. Questionnaire responses were received in English, Spanish, and Vietnamese.

Through this online event, stakeholders were updated on the final alternatives analysis (Level 2 results) and presented with the draft project recommendations for feedback. The majority of respondents to the questionnaire were enthusiastic over the prospect of advancing BRT along Federal; however, this included some caveats. Concern was expressed about the recommendation to not include exclusive transit lanes north of 20th Avenue and that BRT could be less reliable when mixed with traffic. Details on the recommendations are provided in section 8 (Level 2 Conclusions and Recommendations). In general, those who responded to the questionnaire supported advancing the recommendations. The feedback received provides an important basis as additional planning and design work advances, beyond this study. The concerns expressed provide a focal point for future engagement discussions as the BRT design is refined.

CAT Community Ambassadors

Members of the CAT also served as community ambassadors for the project. Ambassadors represented the project publicly, disseminated project information, and encouraged public feedback to guide the analysis.

Ambassadors served an important role because of their existing relationships and trust with local stakeholders. Select ambassadors leveraged their connections with the local Vietnamese and Spanish language communities. Ambassadors were able to convey information directly in Vietnamese and Spanish, connecting at levels within the local communities that would not have been possible by the project team. At key milestones and decision points, ambassadors were provided with collateral materials and social media messages to support their conversations with stakeholders.

5.2.5 Feedback and Key Engagement Topics

The information in Table 5-2 provides a high level overview of a few of the key feedback topics noted by stakeholders through events, CAT meetings, questionnaires, etc. The associated feedback from these key stakeholder topics helped guide the project team in the development of alternatives analysis and recommendations.

Table 5-2: Feedback Topics

Feedback Topics	Details
Support for BRT	General support for implementation of BRT was expressed throughout the project. The desire for high capacity transit along the corridor helped advance the recommendation for BRT.
Traffic Congestion and Regional Connectivity	The importance of Federal as a regional connection balanced with the local needs was a regular topic of feedback. It was noted that BRT has the ability to move more people, more efficiently through the corridor; however, the space required may create less efficient travel for other drivers and freight along the corridor.

Feedback Topics	Details
Displacement and Property Impacts	Many stakeholders expressed concerns with any options that would require significant purchase of private property, potentially leading to displacement of long-term residents and small businesses. This feedback helped refine recommendations to minimize property impacts along the most constrained portions of the corridor.
Pedestrian and Bike Integration	The importance of integrating the recommendations with the existing (and future) pedestrian and bike networks was a common theme. These active mobility links are key to the success of BRT. People must be able to effectively get to and from their origin or destination (beyond the bus trip).

6 Initial Screening and Results (Level 1)






The Level 1 screening represents the initial review and narrowing of options. The goal of Level 1 is to take a reasonable range of potential transit options and ultimately identify a smaller subset of the best performing alternatives for additional scrutiny through Level 2.

Level 1 analysis was completed with two components, examination of technology and corridors.

Evaluation Ratings

To identify those Level 1 technologies and corridors that performed well versus those that may have fatal flaws or major deficiencies, summary ratings for each evaluation criterion specified were established. Ratings are based on each Level 1 technology or corridor's perceived performance to satisfy the evaluation criteria. Rating threshold levels were established at high, medium, and low (with variations). Table 6-1 displays the performance ratings and their corresponding rating icon.

Table 6-1: Level 1 – Evaluation Ratings

Criteria	Rating
Higher performance.	
Higher/medium performance	
Medium performance.	
Medium/lower performance.	
Lower performance.	

The performance ratings for each technology and corridor relative to the evaluation criteria are accompanied by an explanation (or rationale) for the rating given. While the Level 1 evaluation is designed as a qualitative screening, quantitative information and data were incorporated to measure potential benefits and/or potential impacts. Additional quantitative measures, information, and data are further expanded upon and included the Level 2 evaluation.

6.2 Level 1 Technologies

The Level 1 technology analysis applied four key criteria to identify those transit technologies (bus, BRT, rail, etc.) that are most appropriate for Federal and meet the project's draft purpose and need. The Level 1 technology criteria presented below attempt to address a range of critical questions regarding cost, community acceptance, physical attributes, and design feasibility of each technology.

6.2.1 Level 1 – Technology Criteria

Consistency with Local/Regional Plans

The unique operating characteristics and design features of each technology must generally fit with the urban context of Federal.

Community Support

The alternative is generally supported by stakeholders as expressed through past planning effort and ongoing engagement for this project.

Engineering/Operational Feasibility

The unique operating characteristics and design features of each technology must generally fit with the urban context of Federal.

Capital Costs

Benefits (in terms of ridership and expected economic development) are maximized in terms of typical up-front planning, design, and construction cost associated with each technology in contexts similar to Federal.

6.2.2 Level 1 – Technology Options

The Level 1 technologies evaluated included the range of urban options to support transit along Federal Boulevard. Bus, BRT, rail (streetcar, tram, light rail), and other non-traditional urban transit options (gondola, commuter rail, etc.) were considered. The technology options were identified and evaluated in consultation with agency partners and stakeholders.

Enhanced Bus



Enhanced bus service maintains, but improves upon the current bus service, including more frequency, improved stops, and transit signal priority. Electric, compressed natural gas (CNG), and diesel buses all could be considered for enhanced bus. The planned speed and reliability improvements will create a base level enhanced bus service along the Federal corridor.

Bus Rapid Transit (BRT)



BRT is designed to improve capacity and reliability using buses within exclusive right-of-way for transit. Electric, CNG, and diesel buses all could be considered. BRT may include repurposing lanes of travel for transit use. In general, BRT is defined by high capacity, high quality, branded, and low floor/level or near level boarding (similar to rail). Other key features include transit signal priority/specific BRT signals, all door boarding, off bus fare purchases, and enhanced transit stations.

Streetcar



Streetcar technology includes rail vehicles powered by electricity. Streetcars provide low floor/level or near level boarding and amenities similar to BRT. Streetcar shares travel lanes with traffic (similar to existing bus services). Streetcar vehicles are generally smaller than tram and LRT vehicles, providing similar space for passengers as an articulated bus.

Tram



Tram would require similar capital investment to streetcar (approximately \$80 to \$150 million per mile). However, tram could involve more intensive infrastructure changes and could require additional right-of-way. Because it would operate in exclusive transit space, higher ridership would be expected than for streetcar, potentially resulting in similar cost/benefit ratios.

Light Rail Transit (LRT)



Implementation of LRT along Federal would be the most infrastructure intensive alternative, likely requiring full street reconstruction. This does not match with the goals of City or other regional transit plans. Further, it would require the use of right-of-way space not available along the corridor without compromising existing and planned land uses.

Non-Traditional Urban Transit Modes



For purposes of this analysis, non-traditional urban street modes and technology include heavy rail (subway or elevated), commuter rail, magnetic levitation (Maglev), monorail, personal rapid transit (PRT), and gondola systems, etc. These systems vary significantly in their application and use in urban environments. Heavy rail, subway, and Maglev typically transport high numbers of passengers in dense, ultra-urban cities. Monorail, PRT, and gondola services are used in focused applications where the context requires a unique mobility solution.

6.2.3 Level 1 – Technology Screening and Results




Each technology was researched and evaluated against the four criteria. At Level 1, the primary goal is to identify fatal flaws and low performing options that can reasonably be set aside to focus on the most promising alternatives. A rating of high, medium, or low was determined based on the evaluation. Additional rationale is presented for each rating.

Enhanced Bus

The summary results of the enhanced bus evaluation in relation to the criteria is presented in Table 6-2. Additional details on the analysis are also presented in this section.

Table 6-2: Level 1 – Technology Screening Enhanced Bus

Criteria	Rating	Summary
Enhanced Bus		
Consistency with Local/ Regional Plans		Serves as a baseline alternative, given funded improvements for speed and

Criteria	Rating	Summary
Community Support		reliability implementation. Contributes to goals identified by previous plans, but fall short of fully realizing the broad goals for transit.
Engineering/ Operational Feasibility		
Capital Costs		
Recommended for Further Analysis?	ADVANCE	

Consistency with Local/Regional Plans

Enhanced bus reflects the stated need for improvements to address existing deficiencies in transit reliability and amenity conditions, though falls short of the true high-capacity transit envisioned by Denver Moves: Transit. The lack of access, including reliable, high frequency, and high quality transit along the corridor creates challenges for land use and housing goals. While this option serves as a baseline alternative, given funded improvements for speed and reliability improvements, it falls short of fully realizing goals outlined in previous plans.

Community Support

This technology addresses community concern related to transit operations along the corridor and improves the travel experience for existing riders, although it does not allow for the kind of change to the corridor desired by the community. Enhanced bus is supported by the community. This support is reflected in the current plans to implement the speed and reliability improvements along the corridor. However, respondents from Questionnaire 1 as part of Denver Moves: Federal, RTD’s Regional BRT Feasibility Study, and Denver Moves: Transit expressed greater support for more extensive improvements. Stakeholders generally would like to see improvements beyond enhanced bus, such as exclusive right-of-way, robust stops, and multimodal connectivity. Project cost and fare cost were concerns expressed by stakeholders. Enhanced bus is likely one of the lowest capital cost options.

Engineering/ Operational Feasibility

Enhanced bus is the only technology proven and currently in service on the Federal corridor. The operations of the existing bus service will be upgraded with the speed and reliability improvements being planned by the City and RTD. Engineering feasibility and operations are the least complicated and likely least costly. However, the return on that investment is capped by challenges to reliability. The lack of dedicated right-of-way, exclusive to transit continues to mix transit and other traffic in the same lanes. As congestion continues to grow, reliability will continue to decline.

Capital Costs

Enhanced bus does not require the introduction of a new transit technology to the corridor and has a comparatively low capital cost. Enhanced bus is the least costly of technologies under consideration. Transit improvements are consistent with \$4 million transit speed and reliability project funded as part of the 2020-2023 DRCOG TIP.

Bus Rapid Transit (BRT)

The summary results of the BRT evaluation in relation to the criteria is presented in Table 6-3. Additional details on the analysis are also presented in this section.

Table 6-3: Level 1 – Technology Screening BRT

Criteria	Rating	Screening Summary
BRT		
Consistency with Local/ Regional Plans		Consistent with previous plans and is supported by existing transit usage and future land use and housing plans.
Community Support		
Engineering/ Operational Feasibility		
Capital Costs		
Recommended for Further Analysis?	ADVANCE	

Consistency with Local/Regional Plans

BRT is recommended for consideration from multiple previous plans, including Denver Moves: Transit, RTD BRT Feasibility Study, and the Federal Corridor Wide Study. Future land use and housing plans also support BRT or similar high capacity services.

Community Support

BRT reflects the possibility for addressing both transit and placemaking goals stated by stakeholder and public groups. BRT generally has community support based on previous plans, public engagement and surveys, and local agency input. This transit technology gained significant traction from RTD’s Regional BRT Feasibility Study. BRT is potentially implementable within the corridor. BRT also has the possibility to provide level of service and passenger quality as rail options, at a much lower cost. The soon to be implemented speed and reliability improvements will improve the corridor’s readiness for BRT.

Engineering/Operational Feasibility

BRT is a technology with proven implementability as seen in many US and international cities. Implementation of BRT can vary depending on the environment and projected ridership. Existing transit usage along Federal indicates the potential for growth in ridership to level necessary to support the implementation of BRT. The key aspect of BRT is the dedication of right-of-way exclusively for the use of the BRT vehicles. BRT may have a mixture of exclusive right-of-way mixed traffic lanes which may be necessary since there are some right-of-way challenges identified in the center of the corridor. Both side running and center running BRT may be considered. Both present challenges with existing traffic and other infrastructure, but these challenges do not present fatal flaws.





Capital Costs

Costs associated with BRT guideway construction and station improvements would be higher than what is needed to simply enhance existing service, but are significantly lower than any non-bus alternative. Capital cost of BRT varies widely depending on exact amenities. Denver Moves: Transit estimates a range of costs from \$20 to \$50 million per mile for moderate/full BRT implementation. Given the limitations of existing transit service on Federal, significant ridership gains would be anticipated with BRT with increased revenue. Investment in BRT also represents the potential to realize several of the neighborhood planning efforts (specifically multimodal connectivity).

Streetcar

The summary results of the streetcar evaluation in relation to the criteria is presented in Table 6-4. Additional details on the analysis are also presented in this section.

Table 6-4: Level 1 – Technology Screening Streetcar

Criteria	Rating	Screening Summary
Streetcar		
Consistency with Local/ Regional Plans		Capacity/service is consistent with Denver Moves: Transit, but cost is not viable when compared to ridership/benefits. Mode is not supported as part of RTD's planned BRT network.
Community Support		
Engineering/ Operational Feasibility		
Capital Costs		
Recommended for Further Analysis?	NOT ADVANCED	

Consistency with Local/Regional Plans

Capacity and associated amenities are consistent with previous plans, including Denver Moves: Transit. Integration with land use planning is less aligned. Streetcar is not included as part of RTD’s planned BRT network.

Community Support

Streetcar has some level of community support. However, stakeholders also recognize streetcar’s limitation due to high capital costs and issues operating in mixed traffic. Speed and reliability were identified in multiple community engagement campaigns as being a main goal for transit improvement along Federal. While intersection improvements, multimodal access, and transit frequency may be part of the streetcar implementation, this technology’s high cost potentially contradicts the community’s desires for an equitable and low cost system for users.

Engineering/Operational Feasibility

Streetcar is a proven mobility technology in service in cities such as Kansas City, Seattle, Oklahoma City, Atlanta, etc. Construction of any rail technology along Federal would require subsurface work to implement. The scale of street reconstruction needed to implement streetcar can vary. This presents the potential for utility conflicts and the need for additional drainage improvements during reconstruction. Because streetcar operates in the same lanes as other traffic, it would likely provide limited travel time improvements, similar to enhanced bus. Streetcar reliability would be limited because of congestion and not address or improve reliability.



Capital Costs



Typical costs for streetcar are higher than for BRT. Denver Moves: Transit estimates streetcar capital costs of \$80 million per mile, although other systems (such as Detroit’s QLINE) cost closer to \$50 million per mile. While total cost depends on associated amenity improvements, there would be significantly more infrastructure needed for streetcar than BRT.

Tram

The summary results of the tram evaluation in relation to the criteria is presented in Table 6-5. Additional details on the analysis are also presented in this section.

Table 6-5: Level 1 – Technology Screening Tram

Criteria	Rating	Screening Summary
Tram		
Consistency with Local/ Regional Plans		Capacity/service is consistent with Denver Moves: Transit, but cost is not viable when compared to ridership/benefits. Mode is not supported as part of RTD’s planned BRT network.
Community Support		

Criteria	Rating	Screening Summary
Engineering/ Operational Feasibility		
Capital Costs		
Recommended for Further Analysis?	NOT ADVANCED	

Consistency with Local/Regional Plans

Tram is similar to streetcar in terms of alignment, meaning this technology meets transit service goals, but does not match land use or broader network goals. Capacity and associated amenities are consistent with previous plans, including Denver Moves: Transit. Integration with land use planning is less aligned. Tram is not included as part of RTD’s planned BRT network.

Community Support

Tram technology has similar community support as streetcar, but attains the speed and reliability goals set out by the community. However, similar to any electrified technology, there is a much higher cost associated with implementation, including the unknown impacts associated with intensive construction. Stakeholder feedback has generally indicated that rail options (like Tram) generally provide similar mobility benefits and amenities as less expensive options like BRT.

Engineering/Operational Feasibility

Tram systems are prevalent throughout the world, but have only begun to be implemented recently in North America. Ottawa, Edmonton, Calgary, and the greater Toronto area in Canada are all planning or have recently implemented tram services. Construction of any rail technology along Federal would require subsurface work to implement. The scale of street reconstruction needed to implement tram can vary. This presents the potential for utility conflicts and the need for additional drainage improvements during reconstruction. Operationally, tram is superior to enhanced bus and streetcar, because it operates in its own right-of-way (as much as feasible) to improve speed and reliability.





Capital Costs

Tram would likely require more capital investment than streetcar (somewhere between \$80 and \$150 million per mile). The additional utility work, along with significant guideway improvements, right-of-way needs, and vehicle costs associated with other non-bus technology contribute to high capital costs. Because it would operate in exclusive transit space, higher ridership would be expected than for streetcar.

Light Rail Transit (LRT)

The summary results of the LRT evaluation in relation to the criteria is presented in Table 6-6. Additional details on the analysis are also presented in this section.

Table 6-6: Level 1 – Technology Screening LRT

Criteria	Rating	Screening Summary
LRT		
Consistency with Local/ Regional Plans		Prohibitive capital cost and right-of-way associated with light rail implementation.
Community Support		
Engineering/ Operational Feasibility		
Capital Costs		
Recommended for Further Analysis?	NOT ADVANCED	

Consistency with Local/Regional Plans

Implementation of LRT along Federal would be the most infrastructure intensive alternative, likely requiring full street reconstruction. The intensity of infrastructure and right-of-way needs contradict existing land use and mobility plans for the corridor. Further, it would require the use of right-of-way space not available along the corridor without compromising existing and planned land uses.

Community Support

LRT provides the kind of landmark, high-quality transit service desired by the public, but is disruptive of both the roadway and adjacent land uses to align completely with stakeholder and public directive. LRT is the most infrastructure intensive technology among the available options for the corridor. While LRT would provide the most separation from existing modes and highest speed and capacity, the cost and scale of improvements would require additional property and grade separations resulting in considerable impacts along the corridor. Stakeholders have expressed concerns with the potential impacts of construction, property needs, and local access (distance between stations).

Engineering/Operational Feasibility

LRT is a proven technology and, along with enhanced bus, is in operation in Denver. Construction of LRT is the most intensive of the technologies and would likely require multiple right-of-way purchases, full street construction, and considerable subsurface work. LRT construction would likely require a broad range of street, utility, drainage, and

urban realm changes to implement. The sequencing of construction, the length of the construction schedule, and disruption to local businesses and the community would present significant challenges.

Capital Costs

LRT, as it is typically implemented in Denver, would require significantly more infrastructure than other technologies. LRT costs in Denver were approximately \$46 million per mile nearly twenty years ago (according to FTA’s analysis of the New Starts program). Capital costs today would average at \$100 to \$200 million (plus) per mile.

Non-Traditional Urban Transit Modes

The summary results of the non-traditional urban transit modes evaluation in relation to the criteria is presented in Table 6-7. Additional details on the analysis are also presented in this section. For purposes of this analysis, non-traditional urban street modes and technology include heavy rail (subway or elevated), commuter rail, Maglev, monorail, PRT, and gondola systems, etc.

Table 6-7: Level 1 – Technology Screening Non-Traditional Urban Transit Modes

Criteria	Rating	Screening Summary
Non Traditional Urban Transit Modes		
Consistency with Local/ Regional Plans		Prohibitive capital cost and right-of-way associated with implementation. Additionally, does not support pedestrian-scale and land use connectivity requirements.
Community Support		
Engineering/ Operational Feasibility		
Capital Costs		
Recommended for Further Analysis?	NOT ADVANCED	

Consistency with Local/Regional Plans

These modes are also not consistent with the City’s planned high capacity transit network. Additionally, these modes and technologies likely fail to improve the pedestrian and urban realm environment along Federal, which is a primary goal of all local area plans.

Community Support

Most of modes and technologies described in the non-traditional urban mode category do not allow for street-level pedestrian improvements and placemaking opportunities, which are a significant part of the community’s goals for transit. While these technologies and modes are unique and may be viewed as an attraction to users, the practicality and cost of implementation is challenging. There has been little desire expressed by stakeholders or members of the public to implement these modes along Federal.

Engineering/Operational Feasibility

Only those proven technologies that are currently in operation in an urban context were considered. Technologies such as heavy rail, subway, and commuter rail exceed the planned mobility needs for the corridor and create implementation and access challenges, as compared to other options. Specialized mobility interventions like PRT and gondola present complicated infrastructure and operational solutions with similar or limited benefits to the other options under consideration. Given the right-of-way constraints and established land uses in many places along the corridor, these technologies are not feasible.

Capital Costs

Capital costs for alternative technologies vary. However, proven technologies such as heavy rail or subway present such intensive right-of-way needs for both construction and operation, they become cost prohibitive (specifically when compared to the ridership and other benefits). Unproven technologies such as autonomous shuttles carry significant risk, given the need for testing and the development of associated technological infrastructure. While some non-traditional modes might offer minor cost benefits, all operationally practical options represent the highest levels of capital investment.

6.2.4 Technology Summary

Table 6-8 presents the results of the technology screening. Because of their operational flexibility, cost, and overall compatibility with the existing corridor, bus based solutions were advanced over other options. Additional information on the screening of transit technologies is included in Appendix 2.

Table 6-8: Level 1 – Technology Screening Summary

Technology	Further Analysis	Rationale
Technology Summary		
Enhanced Bus	ADVANCE	Technology builds on funded improvements to transit operations through transit signal priority, stop design, and other comparatively minor changes to the roadway. This option therefore serves as a baseline, working toward goals identified in previous planning efforts.
BRT	ADVANCE	BRT offers enhancements to land use and mobility consistent with stated community goals as well as previous plans (including Denver Moves: Transit, RTD Regional BRT Feasibility, and Corridor-Wide Study).

Technology	Further Analysis	Rationale
Streetcar	NOT ADVANCED	Capital costs associated with streetcar do not align with expected benefits from a ridership or community development perspective. In addition, technology is not consistent with planned high-capacity transit
Tram	NOT ADVANCED	Capital costs associated with tram do not align with expected benefits from a ridership or community development perspective. In addition, technology is not consistent with planned high-capacity transit network.
LRT	NOT ADVANCED	Light rail does not fit within existing right-of-way along the corridor and would require a prohibitive level of capital investment and purchase of private property.
Non-Traditional Urban Transit Modes	NOT ADVANCED	Most technologies associated with this alternative do not fit within existing right-of-way or realistic budgetary constraints. In addition, these modes generally do not support a community vision for

6.3 Level 1 Corridors

Level 1 corridor analysis identified multiple transit routes (regardless of technology) that connected the project termini, served the Federal transit market, and met the draft purpose and need. Informed by stakeholder inputs, the Level 1 screening criteria were derived directly from the draft purpose and need statement.

6.3.1 Level 1 – Corridor Criteria

The Level 1 corridor screening criteria were chosen to facilitate early elimination of those alternative concepts that clearly cannot meet the project’s draft purpose and need and/or have potential impacts so significant that implementation is highly questionable from a cost, regulatory, or public-acceptance standpoint. The Level 1 screening criteria qualitatively considered major design or operational efficiencies, overall constructability, compatibility with local and regional plans, and a focus on potential benefits or impacts on the natural, built and social environments. Each criterion is described below.

Does it provide greater transit access?

The transit investment allows a greater number of people to access the service comfortably through stop/station amenity enhancements and improved reliability.

Does it improve local and regional connectivity?

The transit investment has the potential to connect efficiently with multiple local and regional services, supporting broader mobility across the transit network.

Does it support the creation of a frequent transit network?

The transit investment advances the high-frequency network identified in previous plans and maximizes the region’s existing rail and frequent bus service.

Does it support the stability of local neighborhoods and businesses?

The transit investment enhances the potential market for small businesses and benefits local residents through improved access to work, school, and services.

Does it integrate multimodal options?

The alternative promotes simple connectivity for people walking or rolling to and from the new transit service and supports the recommendations of multimodal plans including Blueprint Denver and Denver Moves: Pedestrians and Trails.

Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?

The transit investment not only improves access and mobility, but creates a community focal point, pride, and focus for further mobility enhancements.

Does it enhance safety?

The alternative helps to support the City's Vision Zero and other safety initiatives.

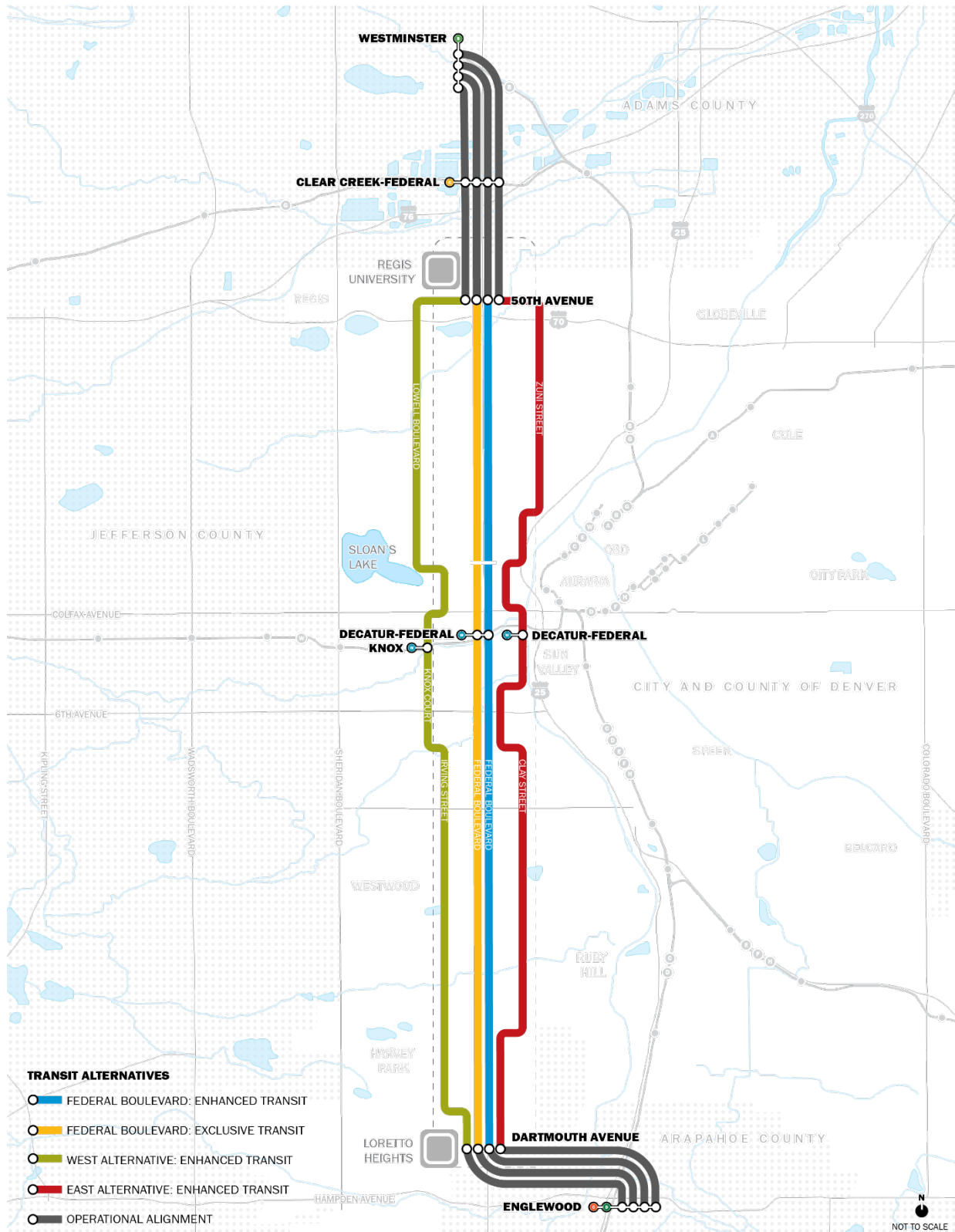
6.3.2 Level 1 – Corridor Alternatives

The initial alignments used in Level 1 analysis were based on analysis of the transportation needs of the corridor. The corridor alternatives focus on the alignment of the project based on stakeholder feedback reflected through the Purpose and Need, the characteristics and conditions of the urban and natural environments, and recommendations from previous planning studies. The development of initial alternatives for the project was based on the transportation planning context that includes:

- **Community engagement:** Input received from the public and project stakeholders, along with participation from cooperating public agencies such as RTD and CDOT.
- **System planning:** An assessment of existing transportation conditions, along with an understanding of existing travel markets.
- **Field review:** Extensive analysis of the study area to identify opportunities or constraints, account for physical features, future infrastructure projects, and community characteristics.
- **Land use assessment:** A comprehensive review of current land uses in the study area, regionally significant travel destinations, station area development opportunities, and constraints relative to candidate alignments.

Figure 6-1 presents the Level 1 corridors graphically.

Figure 6-1: Level 1 – Corridor Alternatives



Federal Boulevard: Enhanced Transit ●

Operating primarily in mixed traffic, this alternative directly connects transit along Federal Boulevard to the RTD B, G, W, and D rail lines via the Westminster, Clear Creek-Federal, Decatur-Federal and Englewood Stations. Building off of prior plans and studies, speed and reliability improvements will be targeted at key locations along the corridor within the City and County of Denver helping to reduce delay, improve on-time performance and enhanced the experience for customers at transit stops.

Federal Boulevard: Exclusive Transit ●

Operating primarily in an exclusive guideway, this alternative directly connects transit along Federal Boulevard to the RTD B, G, W, and D rail lines via the Westminster, Clear Creek-Federal, Decatur-Federal and Englewood Stations. Building off of prior plans and studies, speed and reliability improvements will be targeted along the corridor within the City and County of Denver helping to reduce delay, improve on-time performance and enhanced the experience for customers at transit stops.

West Alternative: Enhanced Transit ●

This alternative primarily travels along Lowell Boulevard, Knox Court, and Irving Street to provide access to west side neighborhoods. This alternative directly connects transit along this alignment west of Federal to the RTD B, G, W, and D rail lines via the Westminster, Clear Creek-Federal, Knox and Englewood Stations. Only select areas where sufficient right-of-way is available could be considered for exclusive guideway.

East Alternative: Enhanced Transit ●

This alternative primarily travels along Zuni Street, Clay Street, and maneuvers around Empower Field at Mile High. This alternative directly connects transit along these streets east of Federal to the RTD B, G, W, and D rail lines via the Westminster, Clear Creek-Federal, Decatur-Federal and Englewood Stations. Only select areas where sufficient right-of-way is available could be considered for exclusive guideway.

6.3.3 Level 1 – Corridor Screening and Results

Level 1 corridors were evaluated and retained if they provided an advantage on transit access and connectivity, constructability, access to activity centers, safety, or if they minimized harm to the built, social, and natural environments of the study area. A rating of high, medium, or low (with variations) was determined based on the evaluation. Additional rationale is presented for each rating.

Federal Boulevard: Enhanced Transit ●

The summary results of the Federal Boulevard: Enhanced Transit corridor in relation to the criteria is presented in Table 6-9.

Table 6-9: Level 1 – Corridor Screening Federal Boulevard: Enhanced Transit

Criteria	Rating	Screening Summary
Federal Boulevard: Enhanced Transit		
Does it provide greater transit access?		Serves as a baseline for future analysis – based on planned speed and reliability improvements.
Does it improve local and regional connectivity?		
Does it support the creation of a frequent transit network?		
Does it support the stability of local neighborhoods and businesses?		
Does it integrate multimodal options?		
Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?		
Does it enhance safety?		
Recommended for Further Analysis?	ADVANCE	

Does it provide greater transit access?

THE TRANSIT INVESTMENT ALLOWS A GREATER NUMBER OF PEOPLE TO ACCESS THE SERVICE COMFORTABLY THROUGH STOP/STATION AMENITY ENHANCEMENTS AND IMPROVED RELIABILITY.

Partially. Improvements such as transit signal priority, queue jumps, and bulb-outs could reduce peak hour delay approximately 15% (identified in the State of the Corridor memo). Boarding delay which causes up to a 15% delay is less likely to improve without significant changes to stop/station function such as level boarding and off-board payment which are not part of this alternative. This alternative would improve access to stops through specific intersection treatments but would not address overall feeling of vehicular primacy noted by many stakeholders through workshops and the questionnaire.

Does it improve local and regional connectivity?

THE TRANSIT INVESTMENT HAS THE POTENTIAL TO CONNECT EFFICIENTLY WITH MULTIPLE LOCAL AND REGIONAL SERVICES, SUPPORTING BROADER MOBILITY ACROSS THE TRANSIT NETWORK.

Partially. This alternative maintains the existing local connectivity, while improving the passenger experience. This alternative does not improve regional trips or significantly improve connections to regional facilities. This alternative continues to connect with existing regional transfer stations at Decatur-Federal Station and the Federal-Evans Transfer Station. The continuation of buses traveling with general traffic (and the resulting congestion) leads to speed and reliability concerns which also diminish connectivity.

Does it support the creation of a frequent transit network?

THE TRANSIT INVESTMENT ADVANCES THE HIGH-FREQUENCY NETWORK IDENTIFIED IN PREVIOUS PLANS AND MAXIMIZES THE REGION'S EXISTING RAIL AND FREQUENT BUS SERVICE.

Minimally. While this alternative would make it easier for people to access existing rail connections along Federal, these enhancements would not further enhance high-frequency transit service along Federal.

Does it support the stability of local neighborhoods and businesses?

THE TRANSIT INVESTMENT ENHANCES THE POTENTIAL MARKET FOR SMALL BUSINESSES AND BENEFITS LOCAL RESIDENTS THROUGH IMPROVED ACCESS TO WORK, SCHOOL, AND SERVICES.

Partially. All transit improvements along the corridor provide potential benefits to neighborhood residents and local businesses through improved access. The improvements to stop infrastructure, service timing, transfers, and transit signal priority included in this alternative are positive, but still lack the benefits of other options with exclusive space for transit. The enhanced transit assumes buses will continue to mix with traffic, maintaining the existing reliability issues resulting from congestion.

Does it integrate multimodal options?

THE ALTERNATIVE PROMOTES MULTIMODAL CONNECTIVITY WITH THE NEW TRANSIT SERVICE AND SUPPORTS THE RECOMMENDATIONS OF MULTIMODAL PLANS INCLUDING BLUEPRINT DENVER AND DENVER MOVES: PEDESTRIANS AND TRAILS.

Minimally. Enhanced transit does not imply the same level of station improvements that would meaningfully integrate other modes compared to exclusive right-of-way options. Federal Boulevard is defined as a pedestrian priority street by Blueprint Denver, but the breadth of improvements to the corridor would be less expansive as compared to the Exclusive Transit alternative. The enhanced transit alternative assumes areas with missing sidewalks, surrounding neighborhoods with narrow sidewalks, and crossing distances between signals greater than ¼ mile would remain. These gaps in the sidewalk network will continue to contribute to a lack of multimodal integration.

Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?

THE TRANSIT INVESTMENT NOT ONLY IMPROVES ACCESS AND MOBILITY, BUT CREATES A COMMUNITY FOCAL POINT, PRIDE, AND FOCUS FOR FURTHER MOBILITY ENHANCEMENTS.

Minimally. Enhanced Transit has the potential to provide improved service and access to local residents and businesses. This alternative continues to advance improvements to the corridor that have been expressed by stakeholders but does not go so far as to create a focus for a single, comprehensive vision for mobility. In general, this option does not advance transit convenience and connectivity sufficiently to create an enhanced sense of place or enhanced community focus.

Does it enhance safety?

THE ALTERNATIVE HELPS TO SUPPORT THE CITY’S VISION ZERO AND OTHER SAFETY INITIATIVES.


Partially. This alternative likely includes implementation of transit signal priority and improvements for pedestrians at intersections. While these improvements may provide some benefit to safety along the corridor, they do not take safety improvements to the extent identified in the Denver Vision Zero Action Plan, including reduction of traffic deaths, severe injuries, and speed. Federal Boulevard is part of Denver’s High Injury Network (HIN) and the majority of the corridor falls within DOTI’s Equity Index, both of which put people using Federal Boulevard at higher risk of injury and also effect a higher percent of vulnerable populations within the city.

Federal Boulevard: Exclusive Transit ●

The summary results of the Federal Boulevard: Exclusive Transit corridor in relation to the criteria is presented in Table 6-10.

Table 6-10: Level 1 – Corridor Screening Federal Boulevard: Exclusive Transit

Criteria	Rating	Screening Summary
Federal Boulevard: Exclusive Transit		
Does it provide greater transit access?		Supported by previous plans and community goals.
Does it improve local and regional connectivity?		
Does it support the creation of a frequent transit network?		
Does it support the stability of local neighborhoods and businesses?		

Criteria	Rating	Screening Summary
Does it integrate multimodal options?		
Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?		
Does it enhance safety?		
Recommended for Further Analysis?	ADVANCE	

Does it provide greater transit access?

THE TRANSIT INVESTMENT ALLOWS A GREATER NUMBER OF PEOPLE TO ACCESS THE SERVICE COMFORTABLY THROUGH STOP/STATION AMENITY ENHANCEMENTS AND IMPROVED RELIABILITY.

Yes. This alternative assumes the development of high-quality station areas to serve transit in dedicated right-of-way. These stations would include (at minimum) basic amenities such as shelter, lighting, traveler information, and clear wayfinding. In the current condition, the majority of stops along Federal Boulevard lack one or more of these amenities. These new stations would also create opportunities to design more inviting spaces for those accessing transit service, addressing a key impediment documented in a stop analysis conducted in collaboration with graduate students from the University of Colorado – Denver and Walk Denver (Walk Denver, Accessed 2020).

Exclusive Transit would also address the significant reliability issues within the corridor. Currently, buses traveling along Federal Boulevard experience up to 50% longer travel times during afternoon commuting hours (particularly for north-bound buses). This delay is attributable to a) navigating in mixed traffic and b) longer boarding times at stops. Both issues could be addressed in an exclusive Transit alternative, where buses would not compete with vehicles and station areas could be designed to expedite boarding.

Does it improve local and regional connectivity?

THE TRANSIT INVESTMENT HAS THE POTENTIAL TO CONNECT EFFICIENTLY WITH MULTIPLE LOCAL AND REGIONAL SERVICES, SUPPORTING BROADER MOBILITY ACROSS THE TRANSIT NETWORK.

Yes. This alternative improves local connectivity by creating a safer and more inviting pedestrian environment, particularly in station areas. It also allows for easier, more comfortable transfer to the approximately fifteen east-west local transit routes that intersect with Federal Boulevard within City limits.

This alternative also improves regional connection to existing rail service, as well as aligning with planned expansion of activity centers defined in Blueprint Denver. The increased speed and reliability of the service improves competitiveness of transit for trips

compared to auto-trips to key regional destinations, including downtown Denver in particular.

Does it support the creation of a frequent transit network?

THE TRANSIT INVESTMENT ADVANCES THE HIGH-FREQUENCY NETWORK IDENTIFIED IN PREVIOUS PLANS, AND MAXIMIZES THE REGION'S EXISTING RAIL AND FREQUENT BUS SERVICE.

Yes. This alternative's most significant contribution to a frequent transit network is in realizing a vision for high-frequency service on Federal Boulevard itself – identified as a top-tier candidate corridor in RTD's Regional BRT Study; as well as Denver Moves: Transit.

In addition to creating high-frequency service along Federal itself, this alternative allows for connections to other transit corridors. These include 26th, 38th, Mississippi, and Jewel/Evans/Iliff (all recommended for 'frequent' service, meaning 15-minute frequency), as well as Colfax and Alameda (recommended for 'very frequent' service, with headways between 5 and 10 minutes) (City and County of Denver, 2018).

Does it support the stability of local neighborhoods and businesses?

THE TRANSIT INVESTMENT ENHANCES THE POTENTIAL MARKET FOR SMALL BUSINESSES AND BENEFITS LOCAL RESIDENTS THROUGH IMPROVED ACCESS TO WORK, SCHOOL, AND SERVICES.

Partially. Developing a high quality, branded, and reliable transit service along Federal could provide improvements to both local access and access to businesses. Introduction of a reliable transit service could also improve access to/from homes and jobs along the corridor.

The creation of exclusive space for transit (regardless of technology) has been shown to increase property values near station areas, potentially increasing rent prices (FTA, 2012). Therefore, supportive policies and careful coordination with community development efforts would be critical to preventing displacement.

Analysis in Denver Moves: Transit shows an especially high transit propensity among the corridor's communities, which generally suggests the value of transit investments to these populations' communities (City and County of Denver, 2018). In addition, dedicating existing travel lanes and the overall prioritization of transit via exclusive lanes provides greater potential to spur additional investment in housing and business development.

Does it integrate multimodal options?

THE ALTERNATIVE PROMOTES MULTIMODAL CONNECTIVITY WITH THE NEW TRANSIT SERVICE AND SUPPORTS THE RECOMMENDATIONS OF MULTIMODAL PLANS INCLUDING BLUEPRINT DENVER AND DENVER MOVES: PEDESTRIANS AND TRAILS.

Yes. This alternative allows for significant improvements to pedestrian facilities through enhancements to sidewalks, crossings, and streetscape elements in station areas. These station areas would include opportunities to create connections to other modes.

These improvements would contribute to the vision of Federal Boulevard as a pedestrian priority corridor (as detailed in Blueprint Denver). Through the creation of high-quality pedestrian, bike, and other mobility connections at station areas, this alternative also allows for integration with parallel bike routes on the east and west of the corridor, as well as existing trail networks.

Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?

THE TRANSIT INVESTMENT NOT ONLY IMPROVES ACCESS AND MOBILITY, BUT CREATES A COMMUNITY FOCAL POINT, PRIDE, AND FOCUS FOR FURTHER MOBILITY ENHANCEMENTS.

Somewhat. Investment in the corridor can provide a more cohesive identity to the various activity centers along Federal through place-making opportunities. This could include creating station areas that make it easier for community members to access public and commercial destinations by orienting transit users through wayfinding. A comprehensive vision for mobility could be realized through a high quality/highly visible transit service. Minimizing or avoiding the negative aspects of such a high-profile infrastructure investment will require the incorporation of land-use, housing, and small business supportive policies. Housing vulnerabilities and inequities could be exacerbated by increasing property values and rental costs. While the risk of involuntary displacement should not minimize the investment in high quality transit, these issues must be addressed. Equitable housing and small business policies/support can be implemented in tandem with the transit development to mitigate this risk prior to implementation of the new infrastructure and likely increase in property values.

Does it enhance safety?

THE ALTERNATIVE HELPS TO SUPPORT THE CITY'S VISION ZERO AND OTHER SAFETY INITIATIVES.








Yes. Exclusive Transit could create a safer environment for pedestrians than Enhanced Transit in mixed traffic by reducing the number of conflict points between buses and vehicles. Maximizing these benefits relies on investments to increase access and connectivity for all modes. Reducing or narrowing travel lanes to provide adequate right-of-way for dedicated space for transit would help slow traffic and potentially decrease the amount of aggressive driving, which contribute to the fatal crashes along the corridor.

As part of the Vision Zero efforts, the City reduced the speed limit along Federal and installed ten traffic signals with pedestrian signal timing improvements. Following these changes, the corridor experienced a 17% reduction in crashes and zero fatalities recorded in 2018-2019 (City and County of Denver, Accessed 2020). This alternative has the opportunity to continue the safety enhancements begun by Vision Zero with additional capital improvements constructed along the corridor as part of the Exclusive Transit build-out.

West Alternative: Enhanced Transit ●

The summary results of the West Alternative: Enhanced Transit corridor in relation to the criteria is presented in Table 6-11.

Table 6-11: Level 1 – Corridor Screening West Alternative: Enhanced Transit

Criteria	Rating	Screening Summary
West Alternative: Enhanced Transit		
Does it provide greater transit access?		Does not meet core purpose and need of project – does not improve environment for pedestrians, businesses, or residents.
Does it improve local and regional connectivity?		
Does it support the creation of a frequent transit network?		
Does it support the stability of local neighborhoods and businesses?		
Does it integrate multimodal options?		
Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?		
Does it enhance safety?		
Recommended for Further Analysis?	NOT ADVANCED	

Does it provide greater transit access?

THE TRANSIT INVESTMENT ALLOWS A GREATER NUMBER OF PEOPLE TO ACCESS THE SERVICE COMFORTABLY THROUGH STOP/STATION AMENITY ENHANCEMENTS AND IMPROVED RELIABILITY.

Minimally. This alternative does not address access issues along Federal itself. In addition to focusing investment away from the existing stops, it could draw riders from current routes, making these services less pedestrian friendly. While it would create improved access to transit service for neighborhoods on the west side of the corridor, it has a neutral or negative impact on accessibility for eastern neighborhoods.

Does it improve local and regional connectivity?

THE TRANSIT INVESTMENT HAS THE POTENTIAL TO CONNECT EFFICIENTLY WITH MULTIPLE LOCAL AND REGIONAL SERVICES, SUPPORTING BROADER MOBILITY ACROSS THE TRANSIT NETWORK.

Minimally. This alternative provides some benefit to local access for areas west of Federal, because the service directly penetrates the neighborhoods. Overall regional connectivity improvement is degraded from the existing bus service along the corridor.

Connections to existing regional routes include the Knox Station along the W Line. While this service does penetrate the neighborhood and create shorter walk links to transit for some, the neighborhood street design and adjacent land uses likely create a slower and more unpredictable service than other alternatives.

Does it support the creation of a frequent transit network?

THE TRANSIT INVESTMENT ADVANCES THE HIGH-FREQUENCY NETWORK IDENTIFIED IN PREVIOUS PLANS, AND MAXIMIZES THE REGION'S EXISTING RAIL AND FREQUENT BUS SERVICE.

No. This alternative does not allow for level of transit service consistent with city and regional plans for high-frequency network. The kind of local service required for this alternative would not further enhance high-frequency connections, nor would it lay the groundwork for rethinking the city's transit network around high-frequency corridors.

Does it support the stability of local neighborhoods and businesses?

THE TRANSIT INVESTMENT ENHANCES THE POTENTIAL MARKET FOR SMALL BUSINESSES AND BENEFITS LOCAL RESIDENTS THROUGH IMPROVED ACCESS TO WORK, SCHOOL, AND SERVICES.

No. This alternative directly penetrates the established neighborhoods west of Federal. While providing simple walk links to transit is positive, transit improvements along lower speed or more residential streets have the potential to change the established land use patterns of these neighborhoods over time. Such changes could move the focus of commercial uses away from Federal, resulting in more dispersed land use patterns across the areas.

Does it integrate multimodal options?

THE ALTERNATIVE PROMOTES MULTIMODAL CONNECTIVITY WITH THE NEW TRANSIT SERVICE AND SUPPORTS THE RECOMMENDATIONS OF MULTIMODAL PLANS INCLUDING BLUEPRINT DENVER AND DENVER MOVES: PEDESTRIANS AND TRAILS.

Minimally. The West Alternative serves pedestrian priority routes but conflicts with bicycle routes throughout the alternative. This includes existing and planned facilities along Lowell Boulevard and Regis Boulevard in the northern segment, and along Knox Court and Irving Street in the central-southern segment. Additionally, adjacent streets to this alternative, predominantly in the southern segment, are identified in Denver Moves: Pedestrians and Trails as having sidewalks that are too narrow, which impedes pedestrian connectivity and limits Americans with Disabilities Act (ADA) accessibility.

Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?

THE TRANSIT INVESTMENT NOT ONLY IMPROVES ACCESS AND MOBILITY, BUT CREATES A COMMUNITY FOCAL POINT, PRIDE, AND FOCUS FOR FURTHER MOBILITY ENHANCEMENTS.

No. By its nature, this alternative focuses on the west side of Federal and does not cohesively bring together the range of neighborhoods along the corridor (east and west of Federal). While this option creates better transit access on the west side, its ability to

spur additional mobility links (multimodal or other links) may be limited. This is due to the size of the residential streets and established characteristics of the areas the West Alternative passes through.

Does it enhance safety?

THE ALTERNATIVE HELPS TO SUPPORT THE CITY’S VISION ZERO AND OTHER SAFETY INITIATIVES.

No. The West Alternative does not address the safety issues on Federal identified in multiple plans such as the Denver Vision Zero Action Plan and the Federal Boulevard Corridor Plan. Additionally, high-frequency buses on local streets with less right of way is likely to create increased congestion and conflicts with local traffic and existing bicycle and pedestrian routes.

East Alternative: Enhanced Transit ●

The summary results of the East Alternative: Enhanced Transit corridor in relation to the criteria is presented in Table 6-12.

Table 6-12: Level 1 – Corridor Screening East Alternative: Enhanced Transit

Criteria	Rating	Screening Summary
West Alternative: Enhanced Transit		
Does it provide greater transit access?		Does not meet core purpose and need of project – does not improve environment for pedestrians, businesses, or residents.
Does it improve local and regional connectivity?		
Does it support the creation of a frequent transit network?		
Does it support the stability of local neighborhoods and businesses?		
Does it integrate multimodal options?		
Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?		
Does it enhance safety?		
Recommended for Further Analysis?	NOT ADVANCED	

Does it provide greater transit access?

THE TRANSIT INVESTMENT ALLOWS A GREATER NUMBER OF PEOPLE TO ACCESS THE SERVICE COMFORTABLY THROUGH STOP/STATION AMENITY ENHANCEMENTS AND IMPROVED RELIABILITY.

Partially. This alternative does not address access issues along Federal itself. While it would create improved access to transit service for neighborhoods on the east side of the corridor, it has a neutral or negative impact on accessibility for western neighborhoods. In terms of reliability, this alternative is even less direct than the western alternative and therefore less likely to achieve schedule reliability.

Does it improve local and regional connectivity?

THE TRANSIT INVESTMENT HAS THE POTENTIAL TO CONNECT EFFICIENTLY WITH MULTIPLE LOCAL AND REGIONAL SERVICES, SUPPORTING BROADER MOBILITY ACROSS THE TRANSIT NETWORK.

Minimally. This alternative is a benefit to local access for areas east of Federal, because the service directly penetrates the neighborhoods. The alternative provides little to no benefit to regional connectivity though it does maintain connection to the existing Decatur-Federal Station. The service would likely suffer from speed deficiencies and unpredictable travel times due to the limitations presented by the neighborhood streets.

Does it support the creation of a frequent transit network?

THE TRANSIT INVESTMENT ADVANCES THE HIGH-FREQUENCY NETWORK IDENTIFIED IN PREVIOUS PLANS, AND MAXIMIZES THE REGION'S EXISTING RAIL AND FREQUENT BUS SERVICE.

No. As with the west alternative, this option does not allow for level of transit service consistent with city and regional plans for high-frequency network. The kind of local service required for this alternative would not further enhance high-frequency connections.

Does it support the stability of local neighborhoods and businesses?

THE TRANSIT INVESTMENT ENHANCES THE POTENTIAL MARKET FOR SMALL BUSINESSES AND BENEFITS LOCAL RESIDENTS THROUGH IMPROVED ACCESS TO WORK, SCHOOL, AND SERVICES.

No. This alternative directly penetrates the established neighborhoods east of Federal. While providing simple walk links to transit is positive, transit improvements along lower speed or more residential streets have the potential to change the established land use patterns of these neighborhoods over time. Select areas, such as the Stadium District, could be planned around this option; however, areas like Sun Valley have invested significantly in building consensus around their development plans with the local community. Introduction of this service could conflict with those plans.

Does it integrate multimodal options?

THE ALTERNATIVE PROMOTES MULTIMODAL CONNECTIVITY WITH THE NEW TRANSIT SERVICE AND SUPPORTS THE RECOMMENDATIONS OF MULTIMODAL PLANS INCLUDING BLUEPRINT DENVER AND DENVER MOVES: PEDESTRIANS AND TRAILS.

No. The East Alternative serves pedestrian priority routes, but the walkshed is limited due to the closer proximity to natural barriers, such as I-25 and the South Platte River to the east. This alternative also conflicts with existing and planned bicycle routes in the north end along Zuni Street and 50th Avenue. Additionally, adjacent streets to this alternative, predominantly in the southern and far northern segment, are identified in Denver Moves: Pedestrians and Trails as having too narrow of sidewalks, which impedes pedestrian connectivity and limits ADA accessibility.

Does it bring together the various, diverse communities served by Federal with a single, comprehensive vision for mobility?

THE TRANSIT INVESTMENT NOT ONLY IMPROVES ACCESS AND MOBILITY, BUT CREATES A COMMUNITY FOCAL POINT, PRIDE, AND FOCUS FOR FURTHER MOBILITY ENHANCEMENTS.

No. This alternative focuses on the east side of Federal and does not cohesively bring together the range of neighborhoods east and west of Federal. The East Alternative also limits the potential for areas of significant population to access the stops. The discontinuous street network between Federal and I-25/South Platte River create limited options for connectivity to stops from areas of sizable populations.

Does it enhance safety?

THE ALTERNATIVE HELPS TO SUPPORT THE CITY'S VISION ZERO AND OTHER SAFETY INITIATIVES.

No. The East Alternative does not address the safety issues on Federal identified in multiple plans such as the Denver Vision Zero Action Plan and the Federal Boulevard Corridor Plan. Additionally, high-frequency buses on local streets with less right of way is likely to create increased congestion and conflicts with local traffic and existing bicycle and pedestrian routes.

Corridor Summary

The Level 1 evaluation identified two corridors that are generally able to meet the Denver Moves: Federal purpose, need, and vision. A summary of this evaluation is included in Table 6-13. The Level 1 analysis noted stronger performance related to those corridors that directly served Federal Boulevard. Those corridors west and east of Federal were deemed to be fatally flawed and removed from further consideration. Additional information on the Level 1 corridor screening is included in Appendix 3.

Table 6-13: Level 1 – Corridor Screening Summary

Corridor	Further Analysis	Rationale
Corridor Screening Summary		

Corridor	Further Analysis	Rationale
Federal Boulevard: Enhanced Transit	ADVANCE	Enhanced transit operating in mixed traffic along Federal has the potential to address the core purpose and need for the project, although it does not provide the infrastructure investment necessary to fully realize the community's vision. This alternative is carried forward in part to offer a baseline for detailed analysis.
Federal Boulevard: Exclusive Transit	ADVANCE	The dedication of roadway space to transit in at least part of the corridor allows for several possible configurations that have the potential to satisfy the project's purpose and need. These configurations will be defined and tested in future rounds of detailed analysis.
West Alternative: Enhanced Transit	NOT ADVANCED	The introduction of transit service in mixed traffic along neighborhood streets west of the corridor does not address the purpose and need of the project or serve the key transit destinations along Federal Boulevard.
East Alternative: Enhanced Transit	NOT ADVANCED	The introduction of transit service in mixed traffic along neighborhood streets west of the corridor does not address the purpose and need of the project or serve the key transit destinations along Federal Boulevard.

7 Final Screening and Results (Level 2)






The final screening evaluation (Level 2) analyzed the corridors advanced from the Level 1 with additional rigor. Prior to the Level 2 evaluation, the components of the remaining corridors were further defined to specify the features of the transit, roadway, and urban realm. With the additional design refinements, Level 1 'corridors' were transformed to Level 2 'alignments'. The sections below provide additional information on the criteria, the Level 2 alignments, and how each performed in the Level 2 analysis.



7.1 Level 2 Criteria

The evaluation criteria applied for Level 2 expanded upon the original categories and included additional quantitative and qualitative methods of comparison. Table 7-1 presents a summary of the range of criteria applied in Level 2.

Table 7-1: Level 2 – Criteria and Methods

Purpose and Need Category	Criteria Decision Factor	Method
Create Community Supported Mobility Vision	Agency support	Greater support as indicated by agency engagement = higher score.
	Community support	Greater support as indicated by public engagement = higher score.

Purpose and Need Category	Criteria Decision Factor	Method
	Change in vehicle miles traveled	Lower miles traveled by vehicles = higher score.
	Potential property needs	Less private property conflicts = higher score.
Enhance Safety 	Pedestrian access to transit stations	Additional infrastructure improvements focused on safety (i.e. shorter pedestrian crossing distances) = higher score.
	Vehicle access and turning	Fewer conflicts points for pedestrians/other modes = higher score.
	Vehicular speed	Better controlling high speeds (beyond speed limits) along Federal = higher score.
Improve Local and Regional Connectivity 	Regional connectivity	Greater or simple access to regional connections = higher score.
	Transit demand	Higher projected transit use = higher score.
	Transit reliability	Greater on time reliability of transit = higher score.
Integrate Multimodal Options 	Multimodal access and integration	Providing simple and intuitive access between transit, walking, rolling, and biking = higher score.
	Person-trip capacity	Moving more people through the Federal corridor = higher score.
Provide Greater Transit Access 	Access for underserved communities	Improved transit connections for low income and historically disadvantaged groups = higher score.
	Pedestrian access and integration (local businesses and schools)	Improved comfort and simplicity for pedestrians accessing transit = higher score.
Support the Creation of a Frequent Transit Network	Boarding efficiency	Faster boarding and disembarking of transit = higher score.

Purpose and Need Category	Criteria Decision Factor	Method
	Cost	Greater benefits compared to the budget/cost = higher score.
	Transit expansion potential	Provides more simple and cost effective means to expand the transit investment = higher score.
	Transit travel time	Shorter travel time on transit = higher score.
Support the Stability of Local Neighborhoods and Businesses 	Construction impact	Ability to minimize impact from construction (residents, businesses, users) = higher score.
	Community serving economic development and neighborhood stability	Greater economic development benefits for existing local businesses and residents = higher score.
	Equity	Aligns focus of investments with areas where inequity is currently high.

7.2 Level 2 Alignments

The Level 2 alignments were built from the corridors advanced through Level 1. Each alignment was further refined to provide additional design details and improve the alignments' performance when compared to the study's draft purpose and need statement. The Level 2 alignments were reviewed with local agency partners and stakeholders to verify their configurations before proceeding with the application of Level 2 criteria.

7.2.1 Level 2 – Segments

Due to the unique characteristics of the study area for Denver Moves: Federal, the corridor was further subdivided into four study segments for evaluation purposes in Level 2. Study segments were determined by various physical and community features present along this north/south urban arterial. Some segments of the corridor are more commercial in nature, with wider right-of-way and shared center lanes facilitating left turns. Other segments include more residential homes directly facing Federal, with narrower right-of-way. Multiple segments include landscaped center medians.

All segments link to the capital and operational termini that define the end points of the transit alternatives, as described in Section 2.2. These study segments allow for more detailed evaluation and analysis of specific social, environmental, and design features of each alignment. Most Level 2 criteria are analyzed by these four segments; however, a select number of criteria are considered along the entire alignment and are not applicable to the segment level of detail. Following are the four study segments:

- Segment 4: Between 17th and 52nd.
- Segment 3: Between Alameda and 17th.
- Segment 2: Between Vassar and Alameda.
- Segment 1: Between Floyd and Vassar.

7.2.2 Level 2 – Transit Stops/Stations

For purposes of analysis within Denver Moves: Federal, the study team determined reasonable, draft assumptions for bus stop or BRT station locations for each Level 2 alignment. Denver Moves: Federal is the first step in a multi-stepped process to continue to define and refine transit improvements along Federal. The stop and station assumptions presented here are not intended to be final locations, but to provide a reasonable comparison between the alignments, align with potential transit demand, and fit within BRT planning guidelines for stop spacing. The recommendations presented in Denver Moves: Federal will require additional planning, design, and stakeholder engagement to further refine the transit stops/stations in future phases of work.

7.2.3 Level 2 – Speed, Reliability, and Transit Priority

Capital improvements such as transit signal priority and transit preferential treatments are considered to reduce transit congestion and improve the performance of transit. These investments can improve speed and reliability and are focused on areas where transit experience the most delay. Treatments can include transit signal priority, queue jumps, business access and transit (BAT) lanes, and exclusive transit lanes. These improvements are described below and incorporated into the Level 2 alignments, where possible and appropriate.

Transit Signal Priority

Transit signal priority is used to reduce the amount of delay that buses experience at traffic signals. When implemented along corridors, transit signal priority substantially improves travel time reliability. Transit signal priority systems can detect arriving or late transit vehicles approaching an intersection. The system can adjust the signal timing/phase to provide priority for the transit vehicle, while working to limit the impact to other signalized traffic movements. Signal phase modifications can also have potential safety benefits when permissive phases are converted to protected phases. Other vehicles making the same movement also experience reduced delays at the intersection.

Transit Queue Jump

Queue jumps can potentially save transit significant amounts of time at intersections where through-traffic queues are long. Typically, the right turn lane or shoulder is controlled for exclusive transit use at an intersection to bypass the queue of traffic stopped for a signal. The bus is provided its own signal, allowing it to move in front of the queued traffic. Pedestrians can also benefit from queue jumps if right turns are controlled with a restricted turn phase, which reduces the number of interactions with right-turning

traffic. If right turns are restricted, this also reduces delay by allowing pedestrians to begin crossing earlier along with the transit vehicle.

Business Access and Transit (BAT) Lanes

BAT lanes support more efficient movement of transit vehicles and other traffic by providing better access to businesses. BAT lanes are typically curb lanes for use by transit vehicles and turning traffic accessing adjacent businesses. The success of BAT lanes varies depending on the ability to develop reasonable access controls along the alignment. The BAT lanes must balance the mix of transit vehicles, while providing appropriate access to businesses.

Exclusive Transit Lanes

Providing exclusive or semi-exclusive lanes for transit can significantly improve transit travel times and travel time reliability. The magnitude of the benefit depends on factors, including the ability of transit vehicles to avoid delays from right-turning traffic, illegal stopping and parking activity in the lanes, and the level of congestion that existed on the roadway prior to the implementation of the exclusive transit lanes. Additional space is typically required beyond standard lane widths to provide physical separation barriers or painted buffers to denote the exclusive space for transit. These buffers can vary depending on the context of the alignment.

7.2.4 Level 2 – Conceptual Operating Plan/Service and Vehicles

For Level 2, it is assumed that service along the alignments would operate 20 hours a day weekdays and 16 hours per day on weekends. While low-floor, hybrid diesel-electric, electric, or other transit vehicle technologies may be considered as future phases of work; this comparative analysis assumed RTD's existing 60 foot, diesel transit vehicles to determine speed and capacity for the Level 2 analysis. The assumptions for the scheduled headways vary throughout the day and week as follows:

- Weekday peak (7 to 9 a.m., 4 to 6 p.m.): 5 to 10 minute scheduled headway.
- Weekday (4 a.m. to 7 a.m. 9 a.m. to 4 p.m., 6 p.m. to midnight): 10 to 15 minute scheduled headway.
- Saturday (6 a.m. to 10 p.m.): 7.5 to 15 minute scheduled headway.
- Sunday (6 a.m. to 10 p.m.): 15 minute scheduled headway.

The proposed service would replace any duplicate services along the alignment. There are various existing transit routes primarily traveling east to west that use Federal Boulevard for a small segment. These services are assumed to be maintained.

7.2.5 Level 2 – Alignment Alternatives

Federal Boulevard: Bus Rapid Transit (Center-Running)

The Center-Running BRT alignment proposes high capacity transit along Federal, with two exclusive transit lanes (one lane in each direction) in the center of Federal

Boulevard. BRT stations would be located adjacent to the center alignment at major destinations and transfer points. Stations would include all of the defining features of BRT such as:

- Fast boarding with precision docking (bringing the bus closer to and level with the station platform).
- Off board fare collection.
- Real time bus information.
- Weather shelters.
- Lighting and safety systems.
- Simple and ADA compliant access for pedestrians, cyclists, people with disabilities, and seniors.
- Unique signage, branding, and wayfinding information.

If this alignment were advanced for analysis beyond this study, additional examination of specific station locations and configurations would be required. To simplify the Level 2 analysis, BRT stations were assumed to be split stations with one station platform on each side of a given intersection (southbound station and northbound stations split). The stations would be accessed by signalized crosswalks on each side of the intersection. This split station configuration was assumed, because it requires less space in constrained urban roadways.

The BRT does not mix with general traffic and is provided a unique signaling system at intersections. While Center-Running BRT could receive priority at signals, generally it can move at the same time as intersection through-traffic without conflicts. This would require that left turns for general traffic at intersections be controlled.

This alignment assumes that four general traffic lanes (two lanes in each direction) would be retained. Locations with a third travel lane, parking, shared center left turn space, or medians would be repurposed to provide space for the BRT and minimize property impacts adjacent to the alignment.

Center-Running BRT could be defined by physical barriers or markers between the general traffic lanes and the BRT lanes. Alternatively, the BRT could be identified by pavement paint or markings to clarify the BRT only space. A key benefit of Center-Running BRT is that the system does not conflict with traffic access points along the outside curb of the boulevard.

The BRT alignment in the center of the boulevard is not designed to be crossed or used by turning traffic. Therefore, un-signalized intersections along the alignment would be limited to right turns in and right turns out. Exclusive left turn lanes for general traffic are assumed at all intersections where they currently exist, including all major intersections.

Figure 7-1 provides a graphic depiction of the extent of the Center-Running BRT alignment and typical cross sections. Table 7-2 presents the physical features of the Center-Running BRT alignment.

Figure 7-1: Level 2 – Bus Rapid Transit (Center-Running) Alignment

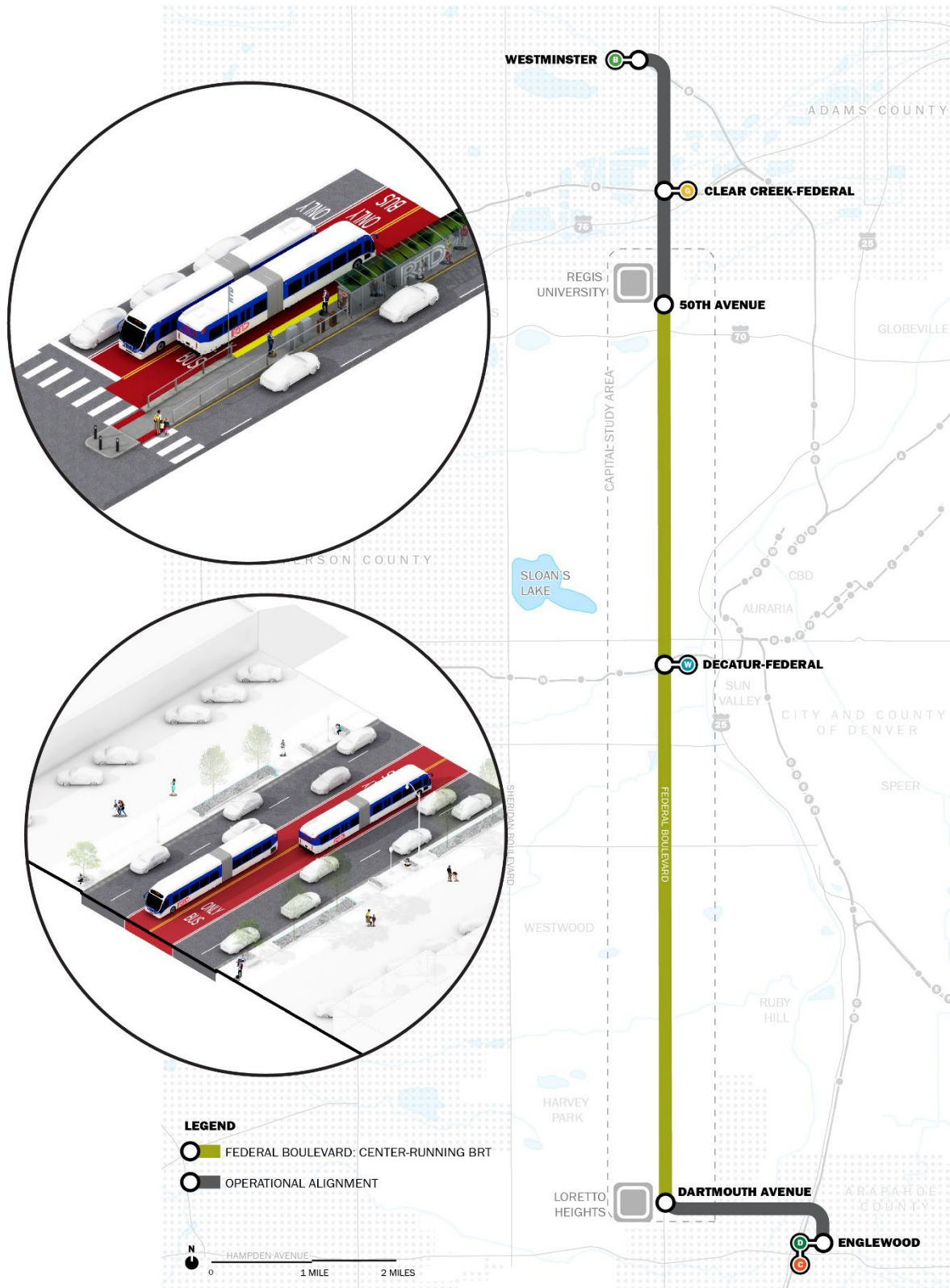


Table 7-2: Level 2 – Bus Rapid Transit (Center-Running) Alignment Assumptions

Elements	Assumptions
Assumed Operations/Service Plan	<ul style="list-style-type: none"> • Weekday peak (7 to 9 a.m., 4 to 6 p.m.): 5 minute scheduled headway. • Weekday (4 a.m. to 7 a.m. 9 a.m. to 4 p.m., 6 p.m. to midnight): 10 minute scheduled headway. • Saturday (6 a.m. to 10 p.m.): 7.5 minute scheduled headway. • Sunday (6 a.m. to 10 p.m.): 15 minute scheduled headway.
Transit Signal Priority	A signaling system will be provided for the Center-Running BRT; however, at intersections the BRT can typically move with general through-traffic.
Transit Stops/Stations	Station spacing assumptions followed best practices for BRT design to avoid overlap of station walk catchment areas. BRT is designed for speed, predictability, and reliability, typically with less stops than an urban bus route. This is a key difference between the BRT and Enhanced Transit alignments. For Level 2, stations were assumed at major activity centers, intersections, and transit connection points including light rail and commuter rail stations. These station locations are for Level 2 analysis only and would require additional evaluation beyond this study.
BAT Lanes and BRT Lanes	Exclusive BRT only lanes are assumed in the center of Federal Boulevard for the length of the capital study area from Loretto Heights to Regis University. It is possible that the entire extent of the capital study area may not fully accommodate BRT lanes. In this case, alternate design options may be developed.
Capital Northern Terminus:	The assumed northern end point for the exclusive BRT lanes and other capital improvements associated with this alignment is approximately 50th Avenue and Federal, adjacent to Regis University and the Aria Denver development. Operationally, the service would continue north to connect to RTD's G-Line and B-Line commuter rail stations/transit centers in Adams County and the City of Westminster. These connections do not include any proposed physical changes to Federal outside of the City and County of Denver limits.
Segment 4: Between 17th and 52nd.	From approximately the southern capital terminus at Loretto Heights/Bates Avenue to the northern capital terminus at 50th Avenue (Regis University), the alignment within all segments (1-4) proposes two exclusive center transit lanes and four general travel lanes (two lanes in each direction). This would require the repurposing of existing shared center left turn space, small areas of parking, painted medians, and the existing medians. Reconstruction of portions of the urban realm and sidewalks is assumed in areas where the existing right-of-way is constrained. The Level 2 analysis will examine if sufficient right-of-way exists throughout the corridor to fully accommodate the proposed cross section.
Segment 3: Between Alameda and 17th.	
Segment 2: Between Vassar and Alameda.	
Segment 1: Between Floyd and Vassar	
Capital Southern Terminus	The assumed southern end point for the enhanced transit service capital improvements would be at approximately Dartmouth Avenue and Federal, near the Loretto Heights redevelopment. North of Dartmouth, the Center-Running BRT guideway would end and transition to in-street running BRT. Operationally, the service would continue east along Dartmouth to connect to RTD's light rail (D-Line) and transit center (note: C-Line discontinued January 2021). These connections do not include any proposed physical changes to Federal outside of the City and County of Denver limits.

Federal Boulevard: Bus Rapid Transit (Side-Running)

The BRT (side-running) alignment proposes high capacity transit along Federal, with two semi-exclusive lanes (one lane in each direction) on the outer most lanes of Federal Boulevard. The Side-Running BRT lanes provide unique space for transit to move outside of mixed traffic but allow vehicles to enter the lane for access to properties adjacent to Federal.

BRT stations would be located within the urban realm area. Similar to the Center-Running BRT, the Side-Running BRT stations are larger than standard bus stops and provide more amenities to support users and the reliability of the BRT service. Stations would include all of the defining features of BRT stations as noted in the section describing the Federal Boulevard: Bus Rapid Transit (Center-Running) alternative.

If this alignment were advanced for analysis beyond this study, additional examination of specific station locations and configurations would be required. To simplify the Level 2 analysis, BRT stations were assumed to be split stations with one station platform on each side of a given intersection (southbound station and northbound stations split). The stations would be accessed from the sidewalks adjacent to Federal. This split station configuration was assumed, because it requires less space in constrained urban roadways.

This alignment assumes that four general traffic lanes (two lanes in each direction) would be retained. Locations with a third travel lane, parking, shared center left turn space, or medians would be repurposed to provide space for the BRT and minimize property impacts adjacent to the alignment.

Side-Running BRT lanes are typically identified by pavement paint or markings to clarify the BRT only space; while continuing to allow access to adjacent properties. At intersections, traffic turning right would also share the space with BRT, but this lane would also be provided with right turn signals to clear the right turning traffic and position the Side-Running BRT to advance without delay. Exclusive left turn lanes for general traffic are assumed at all intersections where they currently exist, including all major intersections.

In addition to improving transit travel time and experience, a significant benefit of Side-Running BRT is that it requires less space at intersections to implement. This is due to the shared BRT and general traffic right turn lanes. Figure 7-2 provides a graphic depiction of the extent of the BRT (side-running) alignment and typical cross sections. Table 7-3 presents the physical features of the BRT (side-running) alignment.

Figure 7-2: Level 2 – Bus Rapid Transit (Side-Running) Alignment

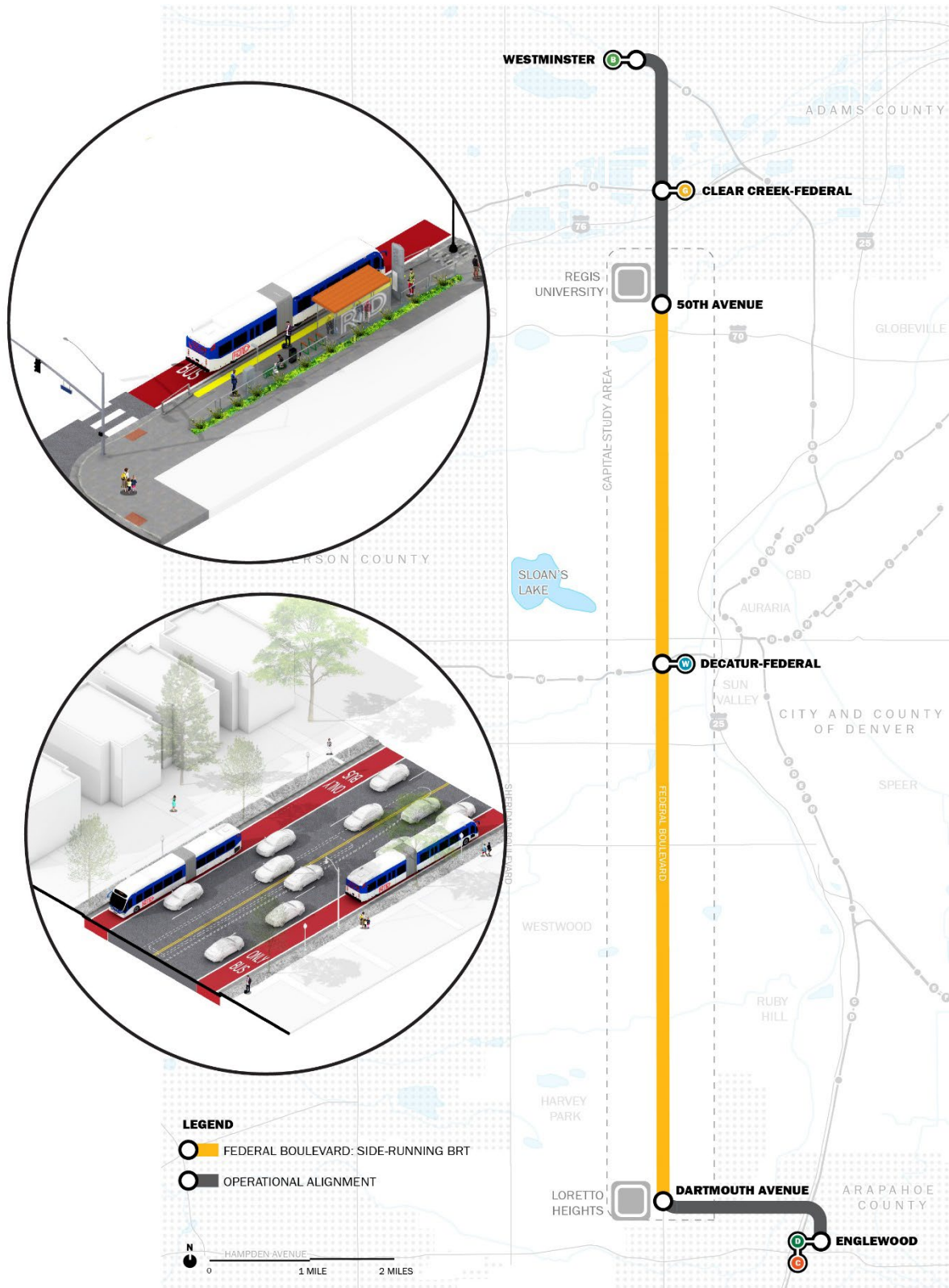


Table 7-3: Level 2 – Bus Rapid Transit (Side-Running) Alignment Assumptions

Elements	Assumptions
Assumed Operations/Service Plan	<ul style="list-style-type: none"> • Weekday peak (7 to 9 a.m., 4 to 6 p.m.): 5 minute scheduled headway. • Weekday (4 a.m. to 7 a.m. 9 a.m. to 4 p.m., 6 p.m. to midnight): 10 minute scheduled headway. • Saturday (6 a.m. to 10 p.m.): 7.5 minute scheduled headway. • Sunday (6 a.m. to 10 p.m.): 15 minute scheduled headway.
Transit Signal Priority	A signaling system will be provided for the BRT (side-running) to provide priority or queue jumps at select intersections. When BRT space is shared with right turns this lane would also be provided with right turn signals to clear the right turning traffic and position the Side-Running BRT to advance without delay.
Transit Stops/Stations	Station spacing assumptions followed best practices for BRT design to avoid overlap of station walk catchment areas. BRT is designed for speed, predictability, and reliability, typically with less stops than an urban bus route. This is a key difference between the BRT and Enhanced Transit alignments. For Level 2, stations were assumed at major activity centers, intersections, and transit connection points including light rail and commuter rail stations. These station locations are for Level 2 analysis only and would require additional evaluation beyond this study.
BAT Lanes and BRT Lanes	Semi-exclusive BRT only lanes are assumed on the outer most lanes of Federal Boulevard for the length of the capital study area from Loretto Heights to Regis University. It is possible that the extent of the capital study area may not fully accommodate the BRT lanes. In this case, design options may be developed.
Capital Northern Terminus	The assumed northern end point for the exclusive BRT lanes and other capital improvements associated with this alignment is approximately 50th Avenue and Federal, adjacent to Regis University and the Aria Denver development. Operationally, the service would continue north to connect to RTD's G-Line and B-Line commuter rail stations/transit centers in Adams County and the City of Westminster. These connections do not include any proposed physical changes to Federal outside of the City and County of Denver limits.
Segment 4: Between 17th and 52nd	From approximately the southern capital terminus at Loretto Heights/Bates Avenue to the northern capital terminus at 50th Avenue (Regis University), the alignment within all segments (1-4) proposes two semi-exclusive side (or curb) transit lanes and four general travel lanes (two lanes in each direction). This would require the repurposing of existing shared center left turn space, areas of parking, painted medians, some tree lawns areas, and the existing medians. Reconstruction of portions of the urban realm and sidewalks is assumed in areas where the existing right-of-way is constrained. The Level 2 analysis will examine if sufficient right-of-way exists throughout the corridor to fully accommodate the proposed cross section.
Segment 3: Between Alameda and 17th	
Segment 2: Between Vassar and Alameda	
Segment 1: Between Floyd and Vassar	
	The assumed southern end point for the enhanced transit service capital improvements would be at approximately Dartmouth Avenue and Federal, near the Loretto Heights redevelopment. North of Dartmouth, the Side-Running BRT guideway would end and transition to in-street running BRT. Operationally, the service would continue east along Dartmouth to connect to RTD's light rail (D-Line) and transit center. These connections do not include any proposed physical changes to Federal outside of the City and County of Denver limits.

Federal Boulevard: Enhanced Transit

The Enhanced Transit alignment serves as the basis for transit improvements along Federal. This alignment general keeps the existing service with targeted improvements such as transit signal priority, queue jumps, stop upgrades, and access improvements to stops (walking and biking). The City and County of Denver and RTD are currently advancing a program to improve transit speed and reliability along Federal. This alignment alternative builds on that work set to begin in late 2020.

The Enhanced Transit alignment proposes maintaining the existing configuration of travel lanes along Federal and assumes no widening of Federal. Other than minor improvements where needed, this would preserve the current curb locations, lanes, medians, etc. Segments of Federal are currently unbalanced with three travel lanes in one direction and two travel lanes in the opposite direction. Where this imbalance exists, the additional third lane could be assigned for transit only use, where the transit only lanes improve the reliability of the bus service. Figure 7-3 provides a graphic depiction of the extent of the Enhanced Transit alignment and typical cross sections. Table 7-4 presents a description of the physical features of the Enhanced Transit alignment.

Figure 7-3: Level 2 – Enhanced Transit Alignment

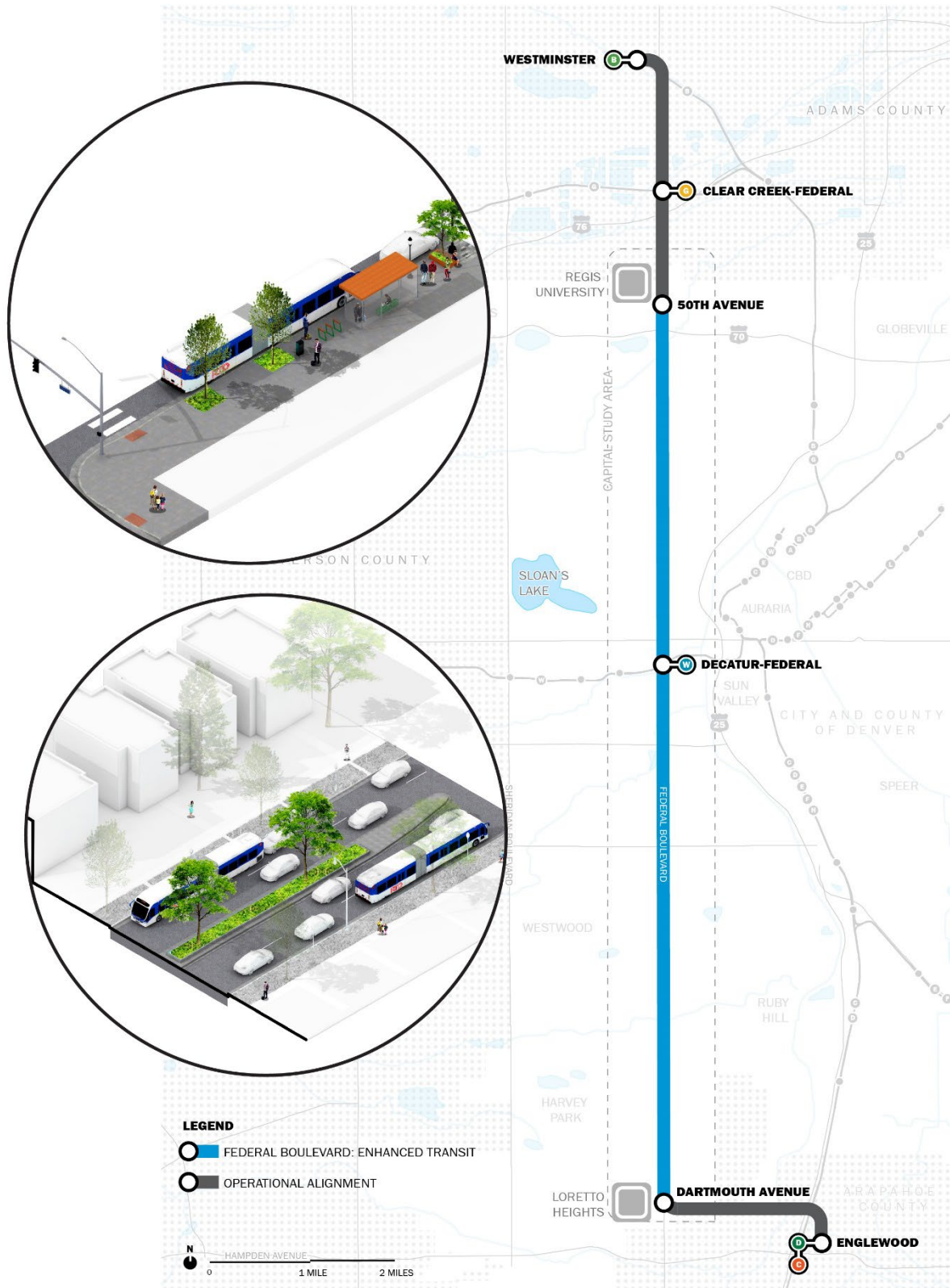


Table 7-4: Level 2 – Enhanced Transit Alignment Assumptions

Elements	Assumptions
Assumed Operations/Service Plan	<ul style="list-style-type: none"> • Weekday peak (7 to 9 a.m., 4 to 6 p.m.): 10 minute scheduled headway. • Weekday (4 a.m. to 7 a.m. 9 a.m. to 4 p.m., 6 p.m. to midnight): 15 minute scheduled headway. • Saturday (6 a.m. to 10 p.m.): 15 minute scheduled headway. • Sunday (6 a.m. to 10 p.m.): 15 minute scheduled headway.
Transit Signal Priority	Transit signal priority is assumed at the following intersections: 38th, 32nd, Speer, 29th, Howard Pl, Holden Pl, 10th, 8th, 6th, Alameda, Mississippi, Florida, Colorado, Jewell, and Evans.
Transit Stops/Stations	The stops generally mirror the existing bus stops along Federal, with some assumed minor location adjustments. This analysis assumes that stops would remain within the urban realm/adjacent sidewalks. Improved stop infrastructure (shelters, seating, etc.) are assumed. Additional stop analysis and consolidation may be necessary if planning for this alignment is advanced beyond this study.
BAT Lanes and BRT Lanes	BAT lanes (delineated by painted barriers/no physical barriers) are assumed in limited areas between 17th Avenue and the southern capital terminus at Loretto Heights. BAT lanes are only included where three travel lanes currently exist, allocating the third lane to BAT use. The alignment consistently maintains four general travel lanes (two lanes in each direction).
Capital Northern Terminus	The assumed northern end point for the enhanced transit service capital improvements would be at approximately 50th Avenue and Federal adjacent to Regis University and the Aria Denver development. Operationally, the service would continue north to connect to RTD’s G-Line and B-Line commuter rail stations/transit centers in Adams County and the City of Westminster. These connections do not include any proposed physical changes to Federal outside of the City and County of Denver limits.
Segment 4: Between 17th and 52nd	From approximately the southern capital terminus at Loretto Heights/Bates Avenue to the northern capital terminus at 50th Avenue (Regis University), the alignment within all segments (1-4) generally maintains the existing configuration. This typically includes four lanes of travel (two lanes in each direction) and the shared center left turn lane or landscaped median. Transit and other vehicles would continue to travel together in mixed traffic. The only exception is the development of limited BAT lanes along portions of the alignment where three general travel lanes currently exist. The third lane would be limited to BAT use where this provides strategic transit reliability improvements.
Segment 3: Between Alameda and 17th	
Segment 2: Between Vassar and Alameda	
Segment 1: Between Floyd and Vassar	
Capital Southern Terminus	The assumed southern end point for the enhanced transit service capital improvements would be at approximately Dartmouth Avenue and Federal, near the Loretto Heights redevelopment. Operationally, the service would continue east along Dartmouth to connect to RTD’s light rail (D-Line) and transit center. These connections do not include any proposed physical changes to Federal outside of the City and County of Denver limits.

7.3 Level 2 Evaluation and Results

More detailed qualitative and quantitative criteria were applied to each Level 2 alignment to identify the most suitable alternatives. Ultimately, the Level 2 evaluation results in a recommended hybrid alternative that included many of the best features of each and is most suitable for Federal.

Level 2 analysis built from the foundation established through the Level 1 process, carrying forward common themes and conclusions based on previous analysis of existing conditions, existing planning studies, and ongoing public and agency input.

In addition to these inputs, the alternatives shown in Level 2 were subjected to a series of quantitative analyses focused on demographics, ridership, traffic, potential property needs (right-of-way), and cost.

7.3.1 Level 2 – Alignment Screening and Results

The sections below provide details on the evaluation of the alignments against the qualitative and quantitative Level 2 criteria. Each criterion is presented individually for ease of comparison of the three alignments. The evaluation of each criterion resulted in a unique score for the three Level 2 alignments, ranging from one (low) to three (medium) to five (high). Scores were calculated or applied first by segment to take into consideration the specific conditions along Federal. The scores for each segment were then averaged to provide the final scores for each criterion under each alignment.

The higher scores identify the most positive results while less desirable outcomes are indicated by the lower scores. No single score was a cause for elimination of an alignment. The project team considered the complete analysis to determine the ultimate recommendations of the study.

Create Community Supported Mobility Vision

What is the level of agency support?

This qualitative criterion represented the cumulative input provided through our agency coordination activities over the course of the project. This included direct and ongoing coordination with key agencies such as CDOT, RTD, and FTA. These agencies and others were also key members of the project's technical group. The technical group was engaged at key milestones throughout the project to provide input and guidance from our partners and technical staff. This criterion considered the positive and negative aspects of the three alignments of concern to the agencies; while considering each agency's long term goals for Federal.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4 (Medium).** The Federal corridor has been identified as a high priority candidate for BRT improvements by several studies, including the RTD BRT Feasibility study and Denver Moves: Transit. Center-running operation likely entails a more difficult project to implement in phases than side-running, making it less aligned with agency goals and short-term capital plans. Implementing exclusive Center-Running BRT would require a complete reconfiguration of the boulevard from its initial inception. Concerns were noted regarding the space required to accommodate exclusive center-running transit and the potential impact to the current general travel lanes on this regionally important corridor. The tradeoffs were discussed by the agencies regarding removing recent center median improvements and limiting vehicular access to key intersections. When considering the

challenges, the center-running alignment continued to address many agency goals for improving mobility and person trip capacity along Federal Boulevard.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **5 (High).** The partner agencies expressed support for the concept of semi-exclusive, Side-Running BRT. It was noted that side-running operation is better positioned for phased implementation of BRT when compared to center-running. Side-Running BRT allows for incremental improvements to the existing transit service on Federal's curbside to build ridership and the physical foundation for phased implementation of BRT over time. The opportunity to develop funding and phase development of BRT over time was generally desirable from the agency perspective.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **5 (High).** Support for enhanced transit is reflected in the current plans to implement the speed and reliability improvements along the corridor. In addition, enhanced transit likely represents the least impact to recent or planned infrastructure improvements (medians, urban realm, etc.) along Federal. However, this alignment does not on its own meet Denver's vision for the creation of a frequent, reliable transit network to support its mode-shift goals. This alternative also does not reflect the recommendations found in RTD's Regional BRT study. In general, the agencies supported enhanced transit in the near term based on advancing current plans, combined with the lower level of physical impacts/change to the current configuration of the boulevard.

What is the level of community support?

This qualitative criterion considers the significant engagement with a wide range of residents, registered neighborhood associations, mobility advocacy groups, non-profits, business organizations, etc. that represent the communities along Federal Boulevard. As detailed in Section 5 Public and Agency Engagement, the process of stakeholder engagement was multilayered. At its core, the CAT team provided consistent engagement with the local community representatives as a method to convey project information through their constituents. The evaluation conducted through this criteria considered the detailed input received through the CAT, online questionnaires, and other engagement activities completed at each major milestone (before advancing the project to the next stage). The team considered all feedback (positive and negative) to form a general position on the three alignments. The results summarized in Table 7-5 (in full version of the document) present the input of over 200 members of the public – over 60% of whom live in the neighborhoods adjacent to the corridor, and over 80% of whom live within City boundaries. This represents a snapshot the input received but is not intended to encompass every opinion expressed through the process.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **5 (High).** Past planning projects along Federal have resulted in considerable public support for transit improvements (RTD's BRT Feasibility Study, Denver Moves: Transit, Federal Boulevard Corridor-wide Study, etc.). Stakeholder engagement activities, the CAT, and multiple project focused questionnaires during Denver Moves: Federal, suggest high levels of community support for BRT generally. Because of its level of exclusivity, the center-running operation was perceived as a high quality transit investment, on par with rail. However, comments were noted that center-running creates challenges for pedestrian access and is the highest cost option. It was noted that with the center-running configuration, pedestrians must cross to the center of the street to access the BRT platforms and wait adjacent to moving traffic. This may be challenging for those with limited mobility (seniors and persons with disabilities). Center-Running BRT provides the highest level of reliability of all alternatives.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **5 (High).** Stakeholder feedback gathered during previous planning efforts as well as working groups and questionnaires held during Denver Moves: Federal, suggest high levels of community support for BRT generally. Side-running operation has generally been preferable to center-running, because of the ability to integrate station platforms directly into the urban realm along Federal. This provides simple access for users, places users closer to their destination (local businesses, homes), and provides the potential to improve the existing urban realm.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **3 (Medium).** The community has expressed the need for improvements to transit service along the Federal corridor. The City and RTD are advancing speed and reliability improvements that can serve as an initial investment in BRT service. While the operational and amenity improvements associated with the enhanced transit alternative represent an acknowledgement of the community’s desire for transit improvements, it does not fully commit to the desired transformation of the roadway.

What is the change in vehicle miles traveled?

This criterion calculates the change in vehicle miles traveled (VMT) associated with each of the proposed alignments. In plain terms, this analysis tells us if introducing each of these alignments to the transportation network results in people driving more or driving less. VMT is a critical measure used by the City and County of Denver as well as state and federal agencies to calculate environmental benefits. Table 7-6 shows the relationship between VMT and common pollutants.

Table 7-6: Relationship Between VMT and Pollutants (Automobile)

Pollutant	Emissions (kg) per 1,000 VMT
Carbon Monoxide	16.77
Mono-Nitrogen Oxides	00.91
Volatile Organic Compounds (VOC)	00.60
Particulate Matter	00.01
Greenhouse Gasses (Carbon Dioxide Equivalent)	00.53
Energy Use - British Thermal Units (BTU)	33.15

Source: Final Interim Policy Guidance Federal Transit Administration Capital Investment Grant Program, 2016

VMT is also related to safety benefits. While the primary impact of a major transit project on corridor safety has to do with changes to the roadway infrastructure, and not the associated reduction in VMT, there is some expected reduction in serious crashes. Table 7-7 shows the relationship between VMT and crash types.

Table 7-7: Relationship Between VMT and Crashes (Automobile)

Incident Type	Incidents per 10,000,000 VMT
Fatality	0.13
Injury	1.95

Source: Final Interim Policy Guidance Federal Transit Administration Capital Investment Grant Program, 2016. Note that transit projects can help reduce serious crashes not just through VMT reductions, but also through changes to roadway infrastructure.

Automobiles are involved in fatal crashes ten times more frequently than buses on a per-mile basis. And while buses do not necessarily offer the same advantages in terms of injuries or pollutants, buses offer significantly more capacity per vehicle than

automobiles, meaning that the environmental benefits of buses are a great deal higher than automobiles on the basis of total miles traveled by all people (or person miles).

The team's calculation of change in VMT utilizes the outputs from RTD's regional travel-demand model conducted for the three alignments. This model uses demographic projections and roadway characteristics to forecast the impacts of changes to the transportation system in the future.

The team used ridership forecasts from the RTD model to estimate reductions in VMT. The methodology for these forecasts uses assumptions established by the Federal Transit Administration (FTA) as part of its transit capital improvement program. These include the following expectations:

- The average share of new transit riders that switched from driving to using transit is 20%.
- The average automobile occupancy is 1.15 people.
- The average transit trip is approximately 50% of the corridor length. In the case of Federal Boulevard, the operational alignment is 13 miles long, so the assumption used here is that the average person rides the bus for 6.5 miles.

The VMT calculations also factor the increase in bus trips associated with each alternative. These were calculated using the service plan for the alternatives as compared with existing service levels.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

● **5 (High)**. Center-Running BRT resulted in a reduction of approximately 1 million automobile VMT per year – a conservative estimate that does not account for the possible changes to trip choices beyond the immediate ridership of the BRT service itself. This results in a reduction of certain pollutants, most notably eliminating some 15 metric tons of carbon monoxide emissions per year. The increase in bus VMT (approximately 70% more than existing conditions) offsets some of the pollution reduction associated with decreasing automobile traffic.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

● **5 (High)**. Side-Running BRT along Federal Boulevard results in similar beneficial reductions in VMT as center-running. The ridership model predicted that Side-Running BRT is expected to attract marginally fewer riders than center-running, the associated reduction in VMT would also be slightly lower. However, the forecasted difference is not significant. To the extent that environmental benefits can be monetized and expressed in terms of capital investment, Side-Running BRT (with its lower cost) offers a greater benefit on a per-dollar basis. While this is an important consideration for identifying funding sources, it is not the focus of this particular evaluation criteria. As a result, side- and Center-Running BRT both earn a maximum score of 5.

FEDERAL BOULEVARD: ENHANCED TRANSIT

● **4 (Medium)**. Enhanced transit also results in overall reduction in VMT, but the effect is less than the BRT alternatives. Enhanced Transit builds ridership over the existing

service, but generates the lowest increase of the three alternatives. The efficiencies in transit service achieved through this alternative do not result in dramatic increases in people choosing transit instead of automobile in the model results. However, the mode shift gains seen in this alternative also come with very little increase in bus VMT, which results in only moderate reductions in expected environmental benefits for the enhanced bus alternative.

What is the extent of potential property needs?

The project team utilized the City's property information and ROW boundaries for Federal Boulevard to determine the existing public property available for transportation use along the corridor. The team verified the GIS data (block by block) to the existing conditions by measuring the existing distance from curb to curb and measuring the assumed property boundaries (ROW) on aerial images. This information allowed the team to understand where the three alignments may expand beyond the existing ROW and potentially require the purchase of additional property. The team assumed reasonably constrained cross sections for each alignment to include all elements needed in the roadway for BRT, pedestrians, and drivers. This included two lanes of travel in each direction, two lanes of BRT, left turn lanes and key/signalized intersections, sidewalks/urban realm space, and station platform (16 locations). Right turns were assumed to be shared with the outside travel or BRT lane.

The analysis assumed that all of the ROW space (City and CDOT property) along the corridor could be utilized or repurposed for transit use. Therefore, ROW space with center medians or areas of City or CDOT ROW that may currently be used by adjacent properties for parking, etc. could be repurposed to accommodate the alignments. Center medians are present in many segments of the Federal corridor and others are currently under construction from Vassar Avenue to Alameda Avenue. These medians and other ongoing improvements to Federal represent a significant investment in the corridor's infrastructure, urban realm, and safety. Near term improvements to the corridor should not be delayed by this alternatives analysis, as they provide immediate benefit to users and the corridor's communities. The Denver Moves: Federal project is examining the long term transit improvements (likely ten years or beyond). Therefore, the project considered the range of changes to achieve the future vision for Federal, including repurposing the median spaces. Use of this space provides an appropriate trade off to community impacts associated with purchasing adjacent private properties and further widening of the boulevard.

This analysis is not intended to provide details on exact acquisition of property, but to highlight those areas where it may be challenging to build within the existing ROW boundaries to compare the three alignments. Future analysis will be required to determine specific property acquisitions as recommendations advance and design is further developed.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **1.8 (Low).** The Center-Running BRT alignment provides high capacity transit and reliability with exclusive lanes and the most operational predictability. The level of exclusivity and reliability does require the most physical space of the three alignments.

The critical difference is primarily at station locations. Center-Running BRT requires an additional 10-11 feet of space to accommodate space for the station platform in the center of the street, resulting in a wider cross-section (space for all elements of the roadway) at station locations. Both the Side-Running BRT and enhanced transit locate station platforms in the sidewalk space on the outside of the lanes of travel, effectively sharing space and narrowing the space needed at station locations. Of the proposed station locations, most would require some acquisition of property, with the exception of wider portions of the roadway at the intersections of Alameda, 8th Avenue, and Howard Place. Others may require varying levels of acquisition at station locations with the greatest need in the northern segment four representing the segment with the narrowest ROW.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

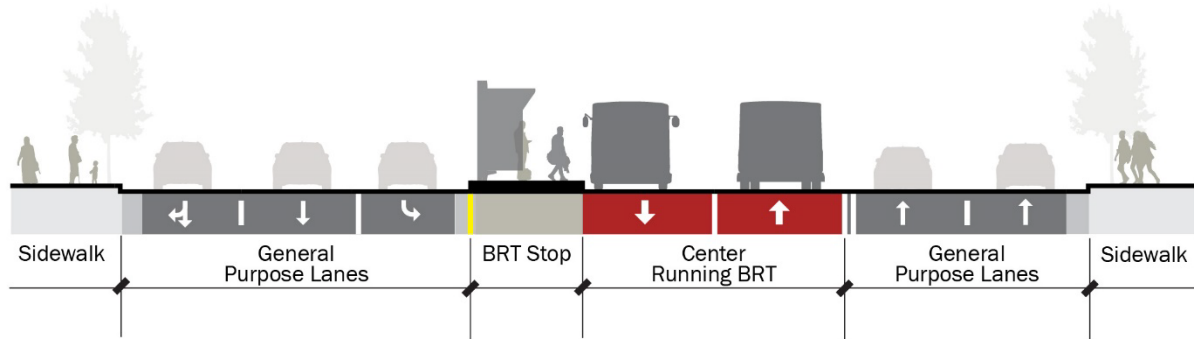
- **3 (Medium).** The side-running alignment also requires property acquisition at station locations, but at a less significant scale as the center-running option. With its narrower cross section, Side-Running BRT would require less property acquisition at station locations when compared to center-running. This is a base assumption and would be dependent on specific conditions at each station location. Side-running assumes station platforms are integrated into the sidewalk/urban realm space on the curb side of the street. This configuration requires less overall space and provides simple access for users access the station or those departing the BRT to access surrounding businesses and neighborhoods. A station platform could be 10-11 feet in width and would likely require the expansion of the existing sidewalk to accommodate the station, plus appropriate space (minimum 6-8 feet) for other sidewalk users adjacent to the platform. Similar to Center-Running BRT, segment four is the most challenging area of the corridor for side-running due to the constrained ROW.

FEDERAL BOULEVARD: ENHANCED TRANSIT

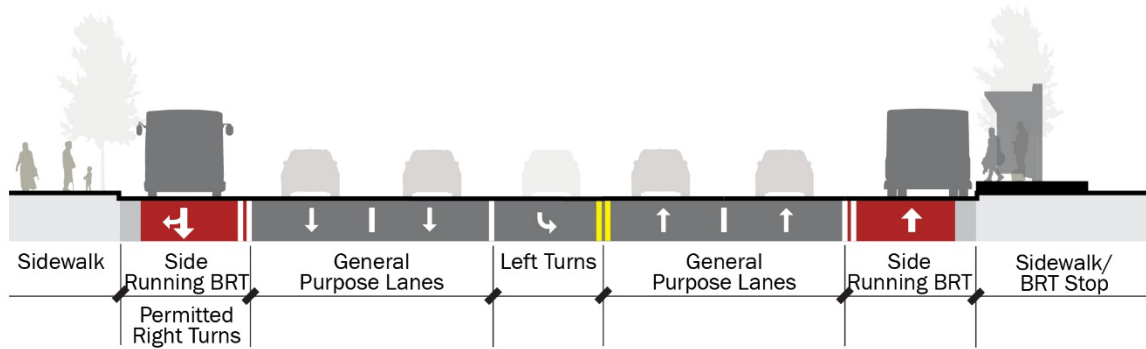
- **4 (High).** The enhanced transit alignment is the narrowest of all the alternatives. This alignment maintains the configuration of the current boulevard, including maintaining the existing/developing center medians. This alignment works with the current space available within the street to provide higher quality transit. The key trade off to this approach is transit would continue to be mixed with traffic. Exclusivity (BAT lanes) for transit would only be provided in limited segments where three general travel lanes currently exist. The additional lanes would be repurposed as a BAT lane. Similar to the other two alignments, enhanced transit consistently maintains at least two lanes of travel for general traffic in both directions. Enhanced transit stops are integrated into the curb side, similar to the existing bus stops today. The enhanced transit stops could provide additional amenities similar to BRT, but not all. This approach minimizes the space needed at stops and could avoid the acquisition needs presented in the two other alignments.

Figure 7-4: Example Cross Section at Station Location

CENTER-RUNNING BRT – EXAMPLE AT STATION LOCATION



SIDE-RUNNING BRT – EXAMPLE AT STATION LOCATION



ENHANCED TRANSIT – EXAMPLE AT STATION LOCATION

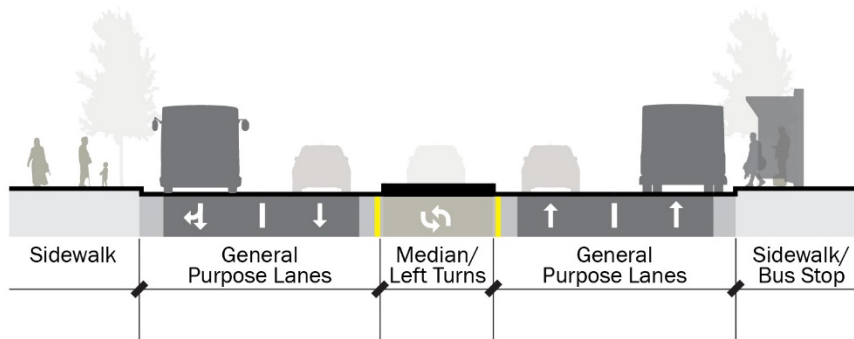


Table 7-8: Level 2 Screening – see full version of document

Enhance Safety

What is the level of change in pedestrian access to transit stations?

The project team examined the existing pedestrian network to potential transit station locations (assuming stations at major intersections). Based on the research completed for the State of the Corridor memorandum, the team reviewed the range of existing and future priority pedestrian and bicycle connections. To understand the actual challenges of the users, connectivity is analyzed from the perspective of those with limited mobility and people with disabilities. This includes considering the length of the connection and the ability to move comfortably and efficiently to/from the station. The team considered both the physical connections and the quality of those connections including size, simplicity, condition, amenities, and level of comfort for the user. Additionally, the team assessed the potential for improved connectivity if a station was developed. This assessment examined other critical connections in the area to tie into; as well as the potential ROW space to achieve future connections with limited impact to surrounding properties. All stops and stations developed would be ADA accessible.

The same station locations were assumed for all of the alternatives to provide a common basis for the connectivity analysis. Station locations were assumed at critical transfer points and areas that are generally accessible today; however, walking and rolling improvements are needed, specifically with the introduction of high capacity transit.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **3 (Medium).** Implementation of Center-Running BRT would potentially require the most acquisition of property at station locations. While this presents an opportunity to reconfigure important walking and rolling connections, this could be at a higher cost and create impacts to surrounding properties. Another key trade off associated with center-running is that station facilities are located in the center of the street, between the lanes of travel. Center-Running BRT users would be required to connect (at a signalized crossing) to the middle of the street. This could create additional conflicts with turning vehicles and jaywalking concerns, specifically in situations where a bus is approaching and the rider has insufficient time remaining in the pedestrian cycle to cross legally. Additionally, those walking and rolling to a station would have a longer distance to connect, presenting greater challenges for those with limited mobility and people with disabilities.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4 (High).** The side-running alignment integrates station platforms into the sidewalk/urban realm space on the curb side of the street. This configuration requires less overall space and provides shorter and more simplified access for users directly from the sidewalk. Additionally, this provides more direct access to/from the BRT to the surrounding businesses and neighborhoods. Integration of the station platforms into the sidewalks provides an opportunity to improve the urban realm in these areas with improved connectivity to other sidewalks, trails, and formal facilities for pedestrians and cyclists.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **3 (Medium).** The enhanced transit alignment provides an opportunity to improve connectivity in conjunction with transit improvements; however, this is likely at a lesser scale when compared to the BRT alignments. Enhanced transit would attempt to incorporate high capacity transit with the least changes to the existing street configuration. By its nature, improvements at stops would maximize the existing connectivity, but limit major infrastructure changes to minimize impacts and cost. Similar to the side-running alignment, enhanced transit stops would be integrated into the urban realm (curb side) to provide shorter and simpler access for those with limited mobility and people with disabilities.

What is the level of reduction of potential conflict points as a result of vehicle access and turning?

The project team's traffic analysis examined the potential future configuration of each Level 2 alternative for their potential to simplify and minimize conflict points and resulting safety issues. This examination helped the project team gain an understanding of the trade-offs associated with implementation of each of the Level 2 alternatives.

Along Federal Boulevard, the existing right-of-way ranges between 80 to 100 feet, including sidewalk, curbs, and all travel lanes. The far northern and southern portions are generally narrower than the central section of the corridor. The corridor ranges between four to six travel lanes, with turn lanes dispersed throughout. Multiple segments of the corridor currently have center medians or they are under construction. Major intersections are signalized and the speed limit ranges from 30 to 40 mph. In the southern portion of the corridor, the speed limit was reduced to 30 mph in 2019 through the City's Vision Zero efforts.

Along Federal the unpredictability, varying speeds, and random access control can create congested areas with safety challenges including speeding, rear-end crashes, broadside crashes, vehicle/pedestrian/cyclist conflicts, jaywalking, etc. The City, CDOT, and multiple partners have continued collaboration and implementation of safety improvements through the ongoing Vision Zero efforts along Federal.

Additional traffic analysis will be completed on the recommended alignment. This will include modeling (Synchro software) of the future traffic conditions assuming the final recommended transit improvements.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4 (High).** The project team examined the center-running alignment's ability to mitigate conflict points and address other safety issues. The Center-Running BRT alignment introduces the most significant level of exclusivity for transit in the center of the street. This configuration would create access control along the corridor, limiting left turns to signalized intersections. With this level of traffic control throughout the corridor, predictability would be increased and conflicts decreased to the greatest extent when compared to other alignments.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **3.5 (High).** The side-running alignment would limit use of the BRT lanes to transit vehicles and traffic entering or exiting businesses and residences along the corridor; as well as right turning traffic at intersections. General through traffic would not be permitted in these lanes. This results in a higher level of interaction between traffic and transit vehicles compared to the Center-Running BRT, but would introduce higher predictably and traffic control over the existing conditions. A review of access points along the corridor would be needed and consolidation of some accesses to focus and minimize conflict points with transit vehicles.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **2 (Low).** The enhanced transit alignment introduces high capacity transit under the existing configuration. Enhanced transit would mix with existing traffic and exclusivity for transit would be limited to certain segments where three travel lanes exist today (the third lane would be repurposed for transit only use). This alignment includes the highest level of interaction between general traffic and transit. Enhanced transit would be an improvement over the existing conditions, but not to the same extent as the other BRT options. A review of access points along the corridor would be needed and consolidation of some accesses to focus and minimize conflict points with transit and general traffic vehicles.

What is the level of reduction to vehicular speed?

Speed is a critical consideration in the level of safety of a corridor and the severity of crashes. According to the City's Vision Zero data, 28 people have been killed or seriously injured in crashes along Federal in 2020. Through the Vision Zero effort, the City, CDOT, and multiple partners have been working to reduce the overall speed along Federal through posted speed changes, infrastructure interventions aimed at slowing traffic, and behavior change. Speed is identified as a specific criterion because lowering the actual traveling speed along the corridor could result in lessening the number and severity of crashes.

While much of the Federal corridor currently has a posted speed limit of 35 mph, actual travel speeds are typically faster. The introduction of enhanced transit on the corridor supports the ongoing pedestrian and urban realm improvements. Successful integration of the transit and pedestrian improvements can result in traffic calming in response to the changed conditions (Project for Public Spaces, 2020). The project team examined the potential level of transit exclusivity, lane and ROW widths, adjacent land use, and the urban realm to determine the potential for reduction in actual travel speeds with the introduction of high capacity transit along Federal.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **5 (High).** Similar to the evaluation of traffic (conflict points), the Center-Running BRT introduces the most significant level of traffic control along the corridor. The introduction of exclusive transit lanes in the center of the street creates a new physical element to the roadway. This generally results in drivers slowing their speed in response. The narrowing

of travel lanes, creation of medians, and landscaping in the urban realm can create a similar result.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

● **4.9 (High)**. The side-running alignment also introduces a new physical element to the outside lanes with exclusive transit space. However, the interaction with vehicles entering and exiting adjacent properties creates more potential for conflict and uncertainty along the corridor. This uncertainty may reduce speeds, but not likely to the extent of the Center-Running BRT (with more significant and predictable traffic controls along the corridor).

FEDERAL BOULEVARD: ENHANCED TRANSIT

● **2.5 (Low)**. The enhanced transit alignment presents some improvements over the existing conditions, with likely consolidation of access points and improved infrastructure for pedestrian and bike connections to stops. However, this alignment presents the least overall change to the corridor and lowest level of improved traffic control. The introduction of enhanced transit would likely slow traffic due to the change in the corridor, but not to the same extent as the other BRT options.

Table 7-9: Level 2 Screening – Enhance Safety

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Pedestrian access to transit stations	● 3.0	● 4.0	● 3.0
Vehicle access and turning	● 4.0	● 3.5	● 2.0
Vehicular speed	● 5.0	● 4.9	● 2.5

Improve Local and Regional Connectivity

What is the impact on regional connectivity?

The introduction of high capacity transit along Federal has the potential to better connect area residents and workers to family, events, businesses, and jobs across the metropolitan area. Several key connections exist along Federal today including connections to commuter rail, LRT, and critical east-west bus services along Colfax Avenue. These connections and other important bus services interconnecting along Federal provide the links to the greater regional transit network. More reliable and frequent service along Federal has the ability to better connect with these other services, shorten transfer times, and improve the overall travel experience for users. Because all three alignments would provide connections to the same set of regional services, the project team examined this criterion based on the potential reliability of the transfer and the potential improvement in the travel experience.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4 (High).** Center-Running BRT would provide the maximum exclusivity for transit among the three alignments. This exclusivity would result in the highest potential level of reliability for on time service. Reliability of on time service ensures transfer time can be minimized to avoid slack included in the schedule and avoid additional wait time for users. Travel time is generally one of the top influencing factors for transit satisfaction. The center-running option has the potential to minimize travel time, waiting, and unpredictability. These factors could provide users with a better travel experience and higher level of satisfaction when compared to the other alignments.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4 (High).** With a lower level of exclusivity than Center-Running BRT, side-running may require additional recovery time built into the schedule to maintain adherence to the schedule and meet transfer times with other regional services. High quality side-running systems are reliable but would likely require additional time to account for the unpredictability of mixing with other traffic (even minimal levels of traffic). The additional travel time could impact the overall satisfaction of users connecting to regional services.

FEDERAL BOULEVARD: ENHANCED TRANSIT

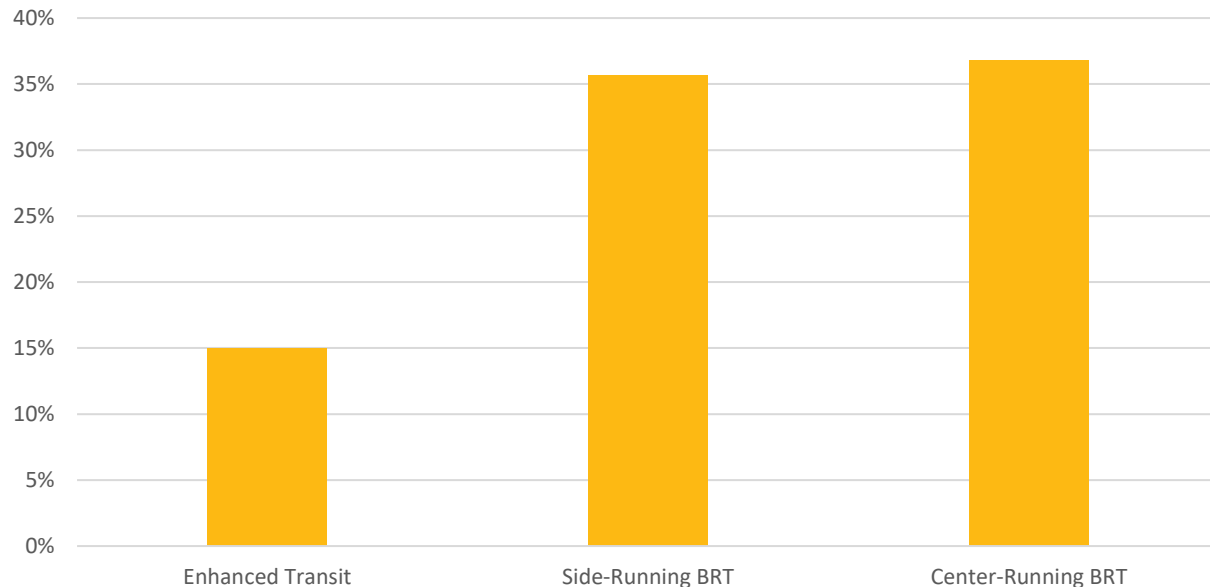
- **2.5 (Low).** Even though it would improve significantly on the existing conditions, enhanced transit has the highest level of unpredictability due to its significant mixing with local traffic. More significant recovery time would be needed in the schedule to ensure transfer points are met and regional connections can be achieved.

What is the impact on transit demand?

This analysis expresses transit demand primarily using ridership forecasting. All three alternatives improve transit operations along the Federal corridor by creating more efficient service patterns and prioritizing bus movement at intersections. The two BRT alternatives offer significant improvements to reliability by allocating exclusive transit space for buses through approximately three-quarters of the corridor's length. These kinds of transit service improvements are more reliably associated with increased ridership than other factors, including demographic variables. As a result, the three alternatives all result in demonstrable improvements to ridership.

In order to estimate the extent of these improvements, RTD conducted a ridership analysis of each of the Level 2 alternatives using a regional travel-demand model. This model uses existing demographic forecasts and roadway characteristics to forecast the impacts of changes to the transportation system in the future. The expected change in ridership (expressed as the percentage increase compared with existing conditions) for each alternative is shown in Figure 7-5.

Figure 7-5: Expected Change in Ridership per Alternative (2020)



Source: RTD travel demand model analysis.

While raw ridership estimates offer the critical baseline for comparing the way communities use transit, it is easier to understand the relative impact of a given alternative using measures of transit effectiveness. These allow for a greater understanding of how the level of improvement in transit service relates to increases in ridership. These measures also allow for apples-to-apples comparisons to system-wide averages. Additional discussion of modeling results is included in the analysis of each alternative below, but the critical effectiveness measures are summarized in Table 7-10 to simplify the comparison.

Table 7-10: Transit Effectiveness Measures

Effectiveness Measure (% difference from RTD Average)	Unlinked Trips per Vehicle Revenue Miles	Unlinked Trips per Vehicle Revenue Hour	Operating Expenses per Unlinked Passenger Trip
Center-Running BRT	50% more	146% more	53% less
Side-Running BRT	49% more	137% more	52% less
Enhanced Transit	42% more	111% more	45% less

Source: RTD Averages taken from 2018 National Transit Database agency profile (bus data only). Alternative estimates based on ridership modeling conducted by RTD and service patterns established by the project team.

Generally speaking, however, the critical variables originate as follows:

- Passenger trips were forecasted using RTD travel demand model.
- Vehicle revenue miles were estimated using headways and corridor length established in the service plan. Vehicle revenue miles refer to the time when paying passengers are traveling on board.

- Vehicle revenue hours were estimated using vehicle revenue miles previously calculated and average speeds based on observed corridor bus speeds and speed improvements established in the service plan.
- Operating expenses were estimated using an Excel-based model that builds from service plan details and system-wide cost averages reported in the National Transit Database.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

● **4.3 (High).** Center-Running BRT offers the most significant increase in transit demand, as well as the greatest relative effectiveness among the three alternatives. Current-year ridership is expected to be nearly 40% higher than existing conditions (resulting in approximately 1 million additional boardings per year). This alternative offers 50% more boardings per mile of bus travel than RTD’s system-wide average, and nearly 150% more boardings per hour of bus travel. The service also costs significantly less to operate per passenger than RTD’s system average. These factors all suggest the relative value of high-quality transit service along Federal.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

● **4.3 (High).** Side-Running BRT offers nearly identical benefits as Center-Running BRT in terms of overall ridership and effectiveness. Overall ridership is expected to be only slightly lower than Center-Running BRT (approximately 1 million more boardings per year than existing conditions). The most significant difference between the two is that side-running offers somewhat less reliability, represented in this analysis by average speed. This speed difference is shown most clearly in the comparison of passenger trips per hour of bus travel (137% more than system average for side-running and 146% more for center-running operations). Essentially, Center-Running BRT takes less time to cover the same ground as side-running. However, even this difference has only a marginal effect on overall ridership and expected operating cost (as shown in the nearly identical trips per mile and cost per trip measure summarized in Table 7-10 above).

FEDERAL BOULEVARD: ENHANCED TRANSIT

● **1 (Low).** Enhanced transit offers only marginal improvements to overall ridership as compared with existing conditions – approximately 10,000 additional boardings per year. This alternative does create a service that is significantly more effective than the average RTD bus route (as shown in Table 7-10 above). However, this is primarily a reflection of the baseline performance of the Federal corridor, which is one of the most effective in the RTD system. Essentially, the enhanced transit service attracts fewer riders than the BRT alternatives, but also attracts fewer riders as a share of overall service improvements than those alternatives as well.

What is the impact on transit reliability?

Overall transit reliability would be greatly improved with the introduction of any of the alignments. Infrastructure improvements at stops and stations would allow for more consistent and rapid boarding and alighting of buses. Consolidation of some

stops/stations would minimize the time to move through the corridor. Priority measures at intersections would allow buses to move more rapidly through congested areas with priority over general vehicles. Exclusivity for transit vehicles would allow buses to move faster through the corridor and reliability maintain the schedule. However, there are some variations among the three options.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4.5 (High)**. In general, the BRT options would reduce delay and improve reliability with the added level of exclusivity for transit. The Center-Running BRT alignment includes the greatest level of exclusivity and physical separation of existing traffic. Therefore, this option likely results in the highest potential for increased reliability. Reliability in the schedule of knowing a bus will meet a stop on time allows for important transfer points to be scheduled more closely. This could reduce the overall travel time of passengers.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4.1 (High)**. The Side-Running BRT alignment introduces a significant level of exclusivity for transit. However, traffic accessing adjacent driveways and right turning traffic would mix with transit in the alignment. While reliability is greatly improved over the Enhanced Transit alignment, Side-Running BRT provides slightly less reliability than Center-Running BRT.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **2.8 (Low)**. Enhanced Transit would improve reliability over the existing conditions. The consolidation of routes and stops would allow for significantly improved bus movement through the corridor, with less opportunities for delays. Improvements to stops would provide for more predictable boarding and alighting over current conditions. With limited exclusivity, the Enhanced Transit alignment does not rate as high as other alignments under the reliability criterion.

Table 7-11: Level 2 Screening – Improve Local and Regional Connectivity

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Regional connectivity	● 4.0	● 4.0	● 2.5
Transit demand	● 4.3	● 4.3	● 1.0
Transit reliability	● 4.5	● 4.1	● 2.8

Integrate Multimodal Options

What is the impact on multimodal access and integration?

Multimodal integration with transit enables users to combine modes (with transit) to complete their entire journey (origin to destination). In many cases multimodal integration refers to the first and last mile connections to and from the bus or BRT station/stop. Developing integrated and seamless connections between modes can encourage transit

use and reduce vehicle travel. Safe, comfortable, and high quality multimodal connections are required to achieve successful integration with bus and BRT services.

This criterion evaluated the existing multimodal connectivity and the potential for future improvements. Key stations/stop locations were examined for their ability to increase the accessibility to transit for the full range of users (commuters, seniors, students, etc.).

Some station/stop locations already have improved access (for example at the Decatur-Federal LRT station), but most are lacking high quality walking and biking facilities to access transit along Federal.

Opportunities for improvements are generally similar for all of the alignments; however, some minor variations were identified.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **3.8 (Medium).** Opportunities for multimodal access are similar for Center-Running BRT as other alignments. However, it may be more difficult for Center-Running BRT to fully integrate with other modes. With stations located in the center of the street, Center-Running BRT creates additional challenges with users crossing to access the BRT. This presents additional conflicts, specifically with turning traffic. The overall scale of infrastructure needed to develop Center-Running BRT also provides an opportunity for surrounding improvements to the mobility network.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4.8 (High).** Opportunities for multimodal access are similar for Side-Running BRT as other alignments. However, when compared to Center-Running BRT, Side-Running has higher potential for integration with other modes. Side-Running BRT stations would be located curbside, integrated directly into the urban realm of Federal. This integration creates more simple access for users and decreases the potential transit user/vehicle conflicts that may occur accessing center stations. Similar to Center-Running BRT, the overall scale of infrastructure needed to develop Side-Running BRT also provides an opportunity for surrounding improvements to the mobility network.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **2.8 (Low).** Enhanced Transit presents various conflicting considerations for multimodal integration. With stops located curbside, this alignment provides similar potential for direct integration with the urban realm as Side-Running BRT. However, may be limited because of the lower level of investment in enhanced transit. Less opportunity exists to adjust or re-imagine the infrastructure along Federal outside of the improvements directly associated with implementing Enhanced Transit.

What is the impact on person-trip capacity?

Person-trip capacity is a measure that describes the way available space is used to accommodate travel demand, regardless of mode choice. Because buses offer the ability to move significantly more people than automobiles, transit facilities have a higher person-trip capacity than regular travel lanes. Whether that capacity is actually maximized is a separate question – one addressed more directly in the transit demand

criterion above. Here, the discussion centers on the way the alternatives use available space to accommodate travel by any mode (including driving, riding transit, walking, and bicycling).

The analysis below is based on an application of standard cross-sections for each alternative to key segments and intersections of the Federal corridor. The team worked to identify trade-offs in these locations and determine likely planning-level design solutions. This resulted in various possible changes to existing roadway operations, including segments where turn lanes, medians, parking, and general purpose lanes were re-allocated.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4.5 (High).** Of the alternatives detailed in Level 2, Center-Running BRT is likely to generate the greatest increase in person-trip capacity. This is predominantly a function of its ability to move transit passengers slightly more efficiently than Side-Running BRT, and significantly more so than enhanced transit. Center-Running BRT would slightly decrease vehicle capacity by limiting left turn movements in certain locations. However, this loss must be weighed against the increase in expected transit ridership based on travel demand modeling (about a third more than the enhanced transit alternative). The improvement to person-trip capacity would likely be most significant in Segments 1, 2, and 3 (the length of the alignment south of 17th). Constraints to the right-of-way contribute to comparatively less expected capacity growth in Segment 4 (from 17th to Regis University).

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4.5 (High).** Of the alternatives detailed in Level 2, Center-Running BRT is likely to generate the greatest increase in person-trip capacity. This is predominantly a function of its ability to move transit passengers slightly more efficiently than Side-Running BRT, and significantly more so than enhanced transit.

Center-Running BRT would slightly decrease vehicle capacity by limiting left turn movements in certain locations. However, this loss must be weighed against the increase in expected transit ridership based on travel demand modeling (approximately 30% more than the enhanced transit alternative).

The improvement to person-trip capacity would likely be most significant in Segments 1, 2, and 3. Constraints to the right-of-way contribute to comparatively less expected capacity growth in Segment 4.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **1 (Low).** The enhanced transit alternative does not significantly alter the capacity of the corridor overall. While speed and reliability improvements would result in slight increases in the efficiency of transit service, these do not result in noticeable changes to the operating conditions of the corridor.

Table 7-12: Level 2 Screening – Integrate Multimodal Options

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Multimodal access and integration	● 3.8	● 4.8	● 2.8
Person-trip capacity	● 4.5	● 4.5	● 1.0

Provide Greater Transit Access

What is the impact on access for underserved communities?

Improving access for underserved communities is a key goal of the City’s overall mobility plan. Major transit investments, such as the three alternatives proposed on Federal Boulevard, can play a major role in meeting that goal in several ways. Most importantly, these alternatives make bus travel (which serves low-income communities) more competitive with automobile travel in terms of travel time, reliability, and comfort.

Analysis found in previous planning efforts recommending transit improvements for Federal do support the need for transit investments from a socioeconomic perspective. The State of the Corridor report developed as part of *Denver Moves: Federal* corroborated these previous recommendations. 5,000 households within one-half mile of the corridor do not have access to a vehicle, and are therefore more likely to be reliant on transit. This represents 12% of all households in this same analysis area – slightly higher than the citywide average. The greatest concentration of no-car households is located in segment 3 (Alameda to 17th). Limitations to transit access for these communities include a lack of consistent sidewalks and stop/station amenities, as well as unreliable travel times, particularly during peak periods.

This criteria involves two considerations: how does the alternative impact access, and to what extent does that impact benefit underserved communities. Demographic analysis detailed elsewhere in this report, including the State of the Corridor report and other analysis conducted in both Level 1 and Level 2, demonstrate the presence of underserved communities along the Federal corridor. Key indicators include the unusual share of affordable housing units (approximately double the citywide average) and households without vehicle access (12%). Therefore, the analysis in this criteria focuses on the specific ways each alternative impacts access, with the assumption that these improvements benefit underserved communities given that they apply to this specific corridor.

Access improvements, as defined here, includes the entire transit trip. This involves the experience of accessing the bus itself – the ease of getting to stops (mostly via pedestrian infrastructure) as well as the ease of getting on and off the bus. The analysis also considers the impact on people’s ability to access key destinations via transit, measured by the reliability and travel time associated with a given alternative.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

● **4.3 (High).** The BRT alternatives both offer significant improvements to access for underserved communities. These alternatives address several limitations of the existing

transit service. As explored in the State of the Corridor report, vehicle traffic in the peak commuting hours delays buses traveling Federal up to 30% under typical operating conditions. By operating in dedicated or semi-dedicated lanes, BRT would reduce or eliminate this travel time variance. Additional access benefits derive from planned improvements to stations and station areas. Filling gaps in the existing sidewalk network in these locations and updating stop amenities will improve access for both existing and future riders.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4.3 (High).** The Side-Running BRT attributes are the same as Center-Running, noted above.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **3 (Medium).** The enhanced transit alternative addresses some of the access issues at select locations by implementing operational and amenity improvements, but does not represent fundamentally change the transit experience for communities along the corridor.

What is the impact on pedestrian access and integration (to/with local businesses and schools?)

Physical access and integration to transit stops/stations would mirror the information presented in the previous section on multimodal integration (What is the impact on multimodal access and integration?). This criteria builds on this access information by examining access specifically to schools and businesses. This supports the component of the project's purpose and need statement that focuses on local needs and sustaining small businesses. Key existing and future educational, business, and employment nodes include 50th Avenue (near Regis University), Speer Boulevard (West High School), the future Stadium District/Colfax/Decatur-Federal area, Evans Avenue (Lincoln High School), and the Loretto Heights redevelopment (Denver School of Science and Technology), etc.

From the perspective of physical access, this criterion is not a discriminator among the alternatives. Each generally service the same locations and would provide improved access to schools and concentrations of businesses. The key differences that may impact accessibility include time and reliability; specifically, the journey time required by each of the alignments and the reliability of accessing your destination on time.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **3.5 (Medium).** With high potential reliability and one of the fastest potential travel times, the Center-Running BRT would provide high quality access for users to arrive at school, work, or a business destination on time. However, accessing the BRT platforms in the center of the street create a minor barrier for younger students.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4.0 (High)**. Similar to Center-Running BRT, Side-Running BRT provides high potential reliability and fast potential travel times. Overall, the BRT options provide the potential for simple, reliable, and fast access to corridor schools and businesses.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **3 (Low)**. Enhanced Transit presents an improvement over the existing conditions for access to schools and businesses; however, traveling in mixed transit creates potential reliability challenges and potentially longer travel times.

Table 7-13: Level 2 Screening – Provide Greater Transit Access

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Access for underserved communities	● 4.3	● 4.3	● 3.0
Pedestrian access and integration - Stability of local businesses and schools	● 3.5	● 4.0	● 3.0

Support the Creation of a Frequent Transit Network

What is the impact on boarding efficiency?

Transition to more efficient station designs with BRT can improve overall operations of the system. Combining the improved station design with off board fare collection and boarding from all doors can further enhance the efficiency of the service. This criterion examined potential stop improvements and operational enhancements for each alignment and their ability to simplify and speed boarding and alighting of passengers.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **5 (High)**. All three alternatives present improvements to stations/stops; however, the BRT alignments propose raised platforms at stations to allow for ease of movement in and out of the bus. The platforms would be level (or near level) with floor of the bus.

The buses are also designed differently. The interior of the BRT vehicle could include a continuous level surface, more open space for standing or wheelchairs, and seats organized similar to a light rail vehicle to provide more space for more passengers. Not only does this provide for more passengers, these improvements facilitate access by persons with disabilities or limited mobility. For example, a person in a wheelchair could simply roll on and off the BRT without assistance from the driver (via a lift or ramp). The use of lifts or ramps can add time to the boarding or alighting process and impact reliability. Users would not be required to maneuver stairs to enter or exit the BRT.

The implementation of off board fare collection and all door boarding is assumed and would also simplify the process. Faster boarding and alighting results in less time spent at stations/stops and overall faster travel time and reliability.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **5 (High)**. Side-Running and Center-Running BRT would provide the same improvements to improve boarding efficiency.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **1 (Low)**. Enhanced Transit proposes improved bus stop infrastructure over the existing conditions, but would not likely go as far as implementing level boarding. Stops for Enhanced Transit would be integrated with the existing sidewalk and would be curb height. Enhanced Transit stops would also implement off board fare collection and all door boarding to improve efficiency. People with disabilities and those with limited mobility would continue to be assisted with lifts, ramps, and/or hydraulic kneeling (a bus that can lower its body or entrance door to facilitate boarding).

What is the impact on cost?

Both capital and operational costs were estimated at a high level appropriate to an alternatives analysis.

CAPITAL COSTS

The capital cost estimates include the core components needed to construct the roadway elements, striping/signing, signal systems, stations/stops, vehicles (new buses), utilities, drainage, and support facilities. Capital costs also include funds to perform professional services (such as future design and construction management); as well as a significant contingency typical at this early level of estimating. Capital costs for the Level 2 alternatives were estimated using the FTA Standard Cost Categories (SCC) format. This format serves as both a structure and a summary for the capital cost estimate and provides a standardized format for comparing the alternatives. This approach makes it easy to track and control changes over time as the estimate evolves. The SCC format has 10 categories (not all elements are relevant to BRT):

10. Guideway and Track Elements
20. Stations
30. Support Facilities – Maintenance Facility
40. Sitework and Special Conditions
50. Systems
60. Right-of-Way, Land, and Existing Improvements
70. Vehicles
80. Professional Services
90. Unallocated Contingency
100. Finance Charges (not evaluated in this study)

Costs were estimated for each alternative based on real unit costs from recent projects in Colorado, Texas, and Minnesota. Additional unit costs were based on average cost

information available from the FTA. Appendix 4 includes additional information on each alternatives' costs in the SCC format.

The initial estimates were used as the midpoint to develop cost ranges for each alternative. A cost range of plus 15% and minus 5% was applied to account for the current (low) level of detail of the alternatives components and wide ranging design assumptions. The estimates are conservative and only presented for comparison among the three alignments in this analysis. As the project evolves and more engineering information is available, more detailed estimates will be developed to provide the refined costs. Table 7-14 presents the estimated range of capital cost for each alternative. This information is presented in current year (2020) dollars and future year (2027) dollars. For estimating purposes, the future year (2027) was selected as the assumed midpoint of construction. The 2027 figure has been escalated to account for increasing costs over time.

Table 7-14: Level 2 Screening – Capital Cost Estimates

Alternative	2020 (Current Year \$)	2027 (Future Year \$)
Center-Running BRT	\$137M to \$166M	\$174M to \$212M
Side-Running BRT	\$122M to \$148M	\$155M to \$188M
Enhanced Transit	\$60M to \$73M	\$77M to \$93M

OPERATIONAL COSTS

Operational costs are calculated as annual costs based on the assumed service plan presented in section 7.2.4 with travel time calculations based on bus speeds documented in 2019 RTD runboard data. The operational costs are presented here as a comparison among the alternatives and not as final costs. Future analyses will refine the assumptions related to operating plans, operators, support staff (maintenance of way and maintenance of equipment), administrative staffing, and propulsion systems (fuel, electric, natural gas, etc.). The operating cost is based on RTD's 2018 average of \$123.67 per revenue hour of service (Federal Transit Administration, 2019). Table 7-15 presents the operational costs in current year (2020) dollars, assuming a potential range of plus 15% and minus 5% from the midpoint cost estimate.

Table 7-15: Level 2 Screening – Operational Cost Estimates

Alternative	Operational Cost Range (Annually Current Year \$)
Center-Running BRT	\$8.3M to \$10M
Side-Running BRT	\$8.3M to \$10M
Enhanced Transit	\$5.7M to \$6.9M
Existing Service (provided for context)	\$5.4M

Note: Operating costs reflect the total estimate for the operational corridor (13 miles).

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **2 (Low).** The Center-Running BRT is estimated to be the highest capital cost. The higher cost is due primarily to the greater level of overall infrastructure required and potential property acquisitions (likely at station locations). Operational costs are similar between the Center-Running BRT and Side-Running BRT alignments.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **3 (Medium).** By comparison, the capital cost of the Side-Running BRT is approximately 11% less than the Center-Running BRT alignment. The operation cost is similar to Center-Running BRT. The expected difference in travel time between the two BRT alternatives is not significant enough to have a noticeable impact on operational cost.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **5 (High).** The capital cost of Enhanced Transit is approximately 63% less than Center-Running BRT. The operational cost of enhanced transit is approximately 44% less than the BRT alignments.

What is the opportunity for potential transit expansion?

Partnering with the adjacent local jurisdictions could be an option to expand the transit alignments north into Adams County and the City of Westminster, or south into the City of Sheridan and the City of Englewood. This criterion examined the potential complexity for future expansion of the capital improvements north or south (outside of the City limits).

The proposed improvements, within the City limits, potentially serve as a core capital investment to improve transit service and ridership. However, expanding these improvements (as envisioned in the RTD BRT Feasibility Study) could create impacts on regional mobility. The configuration of each alignment presents potential benefits or challenges to future expansion.

Similar to the City's work on this alternatives analysis, each adjacent community would determine the appropriate configuration for transit expansion in their communities. This may or may not reflect the configuration advanced by Denver and could require a transition to a different type of transit design. Maintaining a consistent configuration for BRT or Enhanced Transit throughout presents the most predictable scenarios. Both bus operators and other users of the corridor (drivers, pedestrians, etc.) would have a clear understanding of how transit functions and interacts with other modes throughout.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **2 (Low).** While future expansion is feasible for all alignments, Center-Running BRT likely presents the greatest challenges. Transitioning from Center-Running BRT to Enhanced Transit in mixed traffic or Side-Running BRT would require proper space, signaling, and bus priority to minimize impacts. Introducing a combination of side and center running transit in different locations can create confusion for other users of the

corridor. Physically expanding Center-Running BRT would require the most reconfiguration of the overall street to allocate space for BRT.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **3.5 (Medium).** Side-Running BRT would also require reallocation of space within the street, but to a lesser extent as compared to Center-Running BRT. Side-Running BRT generally maintains the expectations of users that transit would be operating at the curbside. Physically expanding Side-Running BRT would primarily require reconfiguration of street space at station locations, reducing the complexity of expansion.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **4.8 (High).** Enhanced Transit generally works within the existing street to provide improved transit service. Stops may require additional space for expansion, but in general this alignment is the least complex to expand.

What is the impact on transit travel time?

Transit travel time is a key measure of service quality. It is one of the most significant factors that determine whether transit is a viable option for many people. It also affects the operational cost of transit service, in that additional time brings with it additional costs for things like fuel and labor. Travel time was evaluated using expected changes in reliability applied to baseline analysis of existing corridor speed. Average speeds across all corridor segments are shown in Table 7-16.

Table 7-16: Average Speed – Federal Boulevard (August 2019 to January 2020)

Direction & Time Period	Average Speed (mph)
Northbound - AM Peak	17
Southbound - AM Peak	18
Northbound - Midday	17
Southbound - Midday	18
Northbound - PM Peak	15
Southbound - PM Peak	16
Corridor Average	16.8

Source: RTD runboard data.

Calculations of changes to transit speed resulting from each of the alternatives were based on the team’s previous modeling work on transit projects within Denver. These estimates of proportional time savings, based on dedication of guideway, transit signal prioritization, and boarding platform improvements were applied to existing speeds.

Quantitative analysis of travel time savings used for this criteria is intentionally conservative, because it does not quantify the additional travel time savings associated with optimization of the transit route (including eliminating transfers for many trips in the

southern segment of the corridor) or additional boarding speed associated with possible station-area improvements (particularly in the BRT alternatives), including low-floor vehicles and/or off-board payment. These additional time savings are considered qualitatively in the evaluation.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

● **5 (High)**. Center-Running BRT offers the greatest benefit of the alternatives to transit travel time. The exclusive transit space is responsible for much of this improvement. The center alignment also results in somewhat fewer conflicts with automobile traffic (at least from the perspective of bus operations). The service model assumes a 25% reduction in travel time in segments of the corridor with dedicated right-of-way. While the increased bus frequency associated with both BRT alternatives represent a 73% increase in bus miles traveled, the travel time savings for Center-Running BRT result in a much lower increase in bus operational hours (a 40% increase over existing conditions).

This alternative, as with Side-Running BRT, would also create significantly more reliable transit travel times throughout the corridor, and would likely reduce the time buses spend at stops (approximately 12 seconds per stop as of 2019, according to analysis of RTD runboard data).

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

● **4 (Medium)**. Side-Running BRT has many of the same travel time advantages as center-running – including the dedication of guideway, transit signal prioritization, and improved boarding platform operations. However, the side-running alternative shares space with automobiles more often, because of the presence of shared transit/right turn/business access lanes. This slight change is reflected in the model through an assumption of 20% travel time reduction in dedicated segments (5% less reduction than center-running). This impact plays out in the effectiveness measures, where the alternative has the same expected bus mile increase as center-running and a 50% increase in bus operational hours. Basically, this suggests that side-running would require 10% more bus operation time to deliver the same level of service.

FEDERAL BOULEVARD: ENHANCED TRANSIT

● **3 (Low)**. Enhanced transit does provide some travel time benefit through streamlining of service patterns and stop locations, transit signal prioritization, and boarding platform improvements. However, these change are not pervasive or consistent enough to deliver the kind of time savings shown in the BRT alternatives. More critically, this alternative assumes no dedication of lane space for transit vehicles. The service model assumes a 10% reduction in travel time associated with these improvements.

Table 7-17: Level 2 Screening – Provide Greater Transit Access

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Boarding efficiency	● 5.0	● 5.0	● 1.0

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Capital cost	● 2.0	● 3.0	● 5.0
Transit expansion potential	● 2.0	● 3.5	● 4.8
Transit travel time	● 5.0	● 4.0	● 3.0

Support the Stability of Local Neighborhoods and Businesses

What is the likely ability to minimize construction impacts?

Potential impacts related to construction were examined to compare and contrast the alignments' potential to create temporary issues beyond their permanent footprints. Typical construction impact considerations include temporary use of space (beyond the permanent property required) for staging, grading, utilities adjustments, etc. Beyond the physical presence, construction may create other concerns such as noise, business access challenges, traffic disruption, etc. As the recommendations of transit improvement advance (beyond this project) a more detailed examination of construction will be necessary to avoid and minimize the impacts. Construction would likely be staged along the corridor to avoid disruption along the entire length; however, it is too early to assume a specific method of construction.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

● **1 (Low)**. The Center-Running BRT would result in the most significant infrastructure development of the three alignments. The construction schedule could extend 24 to 36 months. Temporary construction impact would likely include traffic delays and detours, construction noise, and access impacts to adjacent properties. Depending on the level of reconstruction of the street needed, additional space beyond the public ROW may be needed (temporarily) to tie into the street improvements.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

● **2 (Medium)**. Side-Running BRT would likely require street reconstruction to accommodate the proposed configuration. The construction schedule could extend approximately 24 months (depending on the design). Temporary construction impacts would likely include traffic delays and detours, construction noise, and access impacts to adjacent properties. Depending on the level of reconstruction of the street needed, additional space beyond the public ROW may be needed (temporarily) to tie into the street improvements.

FEDERAL BOULEVARD: ENHANCED TRANSIT

● **5 (High)**. Construction of the Enhanced Transit alignment could be phased over 6 to 12 months (depending on the design). This alignment would primarily use the existing configuration of the street (from curb to curb) with restriping. Most impacts would be apparent with the development of new stops at key intersections.

What is the opportunity of community serving economic development and neighborhood?

Stronger transit and mobility connections along the Federal corridor have the ability to support local businesses, encourage entrepreneurship, create jobs, attract investments, build community wealth, and generally support the livelihood of current residents. Improved transit can provide a direct connection between employers and employees, businesses and customers, as well as community services and clients. This criterion researched if any of the proposed alignments better supported local businesses and neighborhoods.

Approximately 25% of affordable housing within the City is located within the corridor. Additionally, approximately 1/3 of corridor businesses employ 50 or fewer people (as compared to 1/4 citywide for small businesses). Infrastructure projects that improve movement across the City are essential to create an accessible and equitable Denver. Major mobility investments are positive; however, if projects are not implemented with other community supportive policies, displacement and rising property values can price out long term residents and businesses. The loss of foundational businesses and residents can be detrimental to the community identity. Investment should be balanced with appropriate business and housing policies that help to avoid the negative impacts.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4 (High).** The significant investment in BRT creates access improvements beneficial to the local community; as well as creates opportunities for the growth of existing businesses. Both BRT options would likely result in high ridership delivering employees, customers, and clients efficiently along the corridor. The high level of access benefits residents through improved access to employment and opportunities. Businesses are also benefitted through efficient delivery of employees and customers to their establishments.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4 (High).** The Side-Running BRT attributes are the same as Center-Running, noted above.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **3 (Low).** Enhanced Transit provides strong transit connections with limited impacts to the existing business and community fabric. However, the alignments' configuration where it mixes transit with traffic results in potential reliability challenges (as compared to the BRT options). Lower reliability and longer travel times may impede some employees, customers, and clients from accessing local establishments. The overall lower level of investment in Enhanced Transit likely results in a similar scale of return on that investment.

What is the opportunity to address inequities?

This criterion focuses on the nature of likely benefactors of the transit improvements. All three Level 2 alternatives assume an accompanying land-use plan and policy framework

that supports the stability of existing neighborhoods and businesses. Therefore, this particular analysis focuses exclusively on the demographic conditions of the study area and not the nature of the transit improvement. For this reason, it does not differentiate among alternatives, but does offer insight as to corridor segments that present the greatest opportunity to address existing inequity.

Denver’s Department of Public Health and Environment (DDPHE) developed an ‘equity index’ in order to better understand factors that contribute to inequitable distribution of resources and opportunity. The index uses the following attributes to determine an overall score for each neighborhood within the City:

- Social determinants of health (including educational attainment and income level).
- Access to first-trimester healthcare.
- Childhood obesity.
- Life expectancy.
- Access to parks and full-service grocery stores.

Table 7-18 summarizes scores indicating the average equity index for each segment analyzed. Citywide, the equity index values range from a 2 (lowest) to 4.4 (highest). The lower the average number, the more likely residents face more significant hurdles to leading healthy lives. For context, the neighborhood of Montbello is a 2.4 on the equity index and the City Park neighborhood is at 3.8.

Table 7-18: Average Denver Equity Index Score by Analysis Segment

Segment	Average Denver Equity Index Score (1 higher challenges, 5 lower challenges)
Segment 4: Between 17th and 52nd.	2.8
Segment 3: Between Alameda and 17th.	2.25
Segment 2: Between Vassar and Alameda.	2.6
Segment 1: Between Floyd and Vassar.	2.5

Source: Blueprint Denver, 2019.

Additional demographic analysis conducted as part of the State of the System analysis for the Denver Moves: Federal project further indicates the opportunity to service historically disadvantaged communities through careful investment in mobility along the Federal Boulevard corridor. Approximately 14% of all housing units within walking distance of Federal Boulevard are designated affordable housing (twice the City-wide average). 25% of the City’s total affordable housing units are located in the larger study area. The study area also includes households without access to a vehicle (12% in the study area, compared with 9% in the City overall). These two factors in particular suggest a community that would be especially likely to gain new or improved access to jobs, commercial needs, and housing through the transit enhancements associated with all three Level 2 alternatives.

Finally, the Federal corridor has also been identified by both Denver Moves: Transit and RTD’s BRT Feasibility study as a top priority for transit investment in terms of its proximity to low-income and high-displacement-risk populations. This is particularly true in the southern and central segments of the study area.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (CENTER-RUNNING)

- **4 (Medium)**. See above criterion description – no differentiation between alternatives.

FEDERAL BOULEVARD: BUS RAPID TRANSIT (SIDE-RUNNING)

- **4 (Medium)**. See above criterion description – no differentiation between alternatives.

FEDERAL BOULEVARD: ENHANCED TRANSIT

- **4 (Medium)**. See above criterion description – no differentiation between alternatives.

Table 7-19: Level 2 Screening – Support the Stability of Local Neighborhoods and Businesses

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Construction impact	● 1.0	● 2.0	● 5.0
Community serving economic development	● 2.0	● 3.0	● 5.0
Equity	● 4.0	● 4.0	● 4.0

8 Level 2 Conclusions and Recommendations

Level 2 analysis provided significant information on the performance of the three alternatives. The comparative analysis revealed the positive and negative aspects of each alternative. All three alternatives improve transit and provide potential benefits to corridor residents and businesses. The sections below provide additional information of the general conclusions determined through the analysis; as well as the project team’s recommendations and justifications for advancing transit improvements along Federal.

8.1.1 Major Conclusions

Because all three alternatives promoted improved transit service, mobility, and access the differences between each were based on the degree to which they could each achieve these outcomes balanced with how they each compared on cost, implementation, and community benefits/impacts. Through Level 2, the project team examined these incremental differences and ultimately identified the common conclusions noted below.

- All Level 2 alternatives advance the project’s purpose and need elements.
- All Level 2 alternatives result in a significant improvement in local and regional mobility (i.e. sizeable ridership increases).

- No single BRT alignment configuration works for the entire corridor, if maintaining two travel lanes in each direction.
- Recent infrastructure investments/improvements (such as the development of center medians) presents challenges to implementation.
- Cost is comparable to similar systems in North America.
- All Level 2 alternatives are likely competitive for FTA Small Starts funding, based on our early (high level) analysis.
- In general, there is a strong case for improved transit along the Federal corridor.

Table 8-1 presents the average scores by criteria group, aligned with the themes from the purpose and need statement. The complete matrix and associated scores are presented for each criterion in Appendix 5.

Table 8-1: Level 2 Screening – Summary Scores

Criteria	Bus Rapid Transit (Center Running)	Bus Rapid Transit (Side Running)	Enhanced Transit
Create community supported mobility vision	3.9	4.5	4.0
Enhance Safety	4.0	4.1	2.5
Improve local and regional connectivity	4.3	4.1	2.1
Integrate multimodal options	4.1	4.6	1.9
Provide greater transit access	3.6	4.1	3.0
Support the creation of a frequent transit network	3.5	3.9	3.4
Support the stability of local neighborhoods and businesses	2.3	3.0	4.7
Overall Average Score	3.7	4.1	3.1

8.1.2 Recommendations

As noted in the general conclusions, each of the three Level 2 alternatives would provide transit improvements over the existing conditions. Additionally, the evaluation demonstrated similar results among many of the evaluation criteria. However, the Side-Running BRT option yielded the highest performance when compared across the majority of categories and when balancing cost, impacts, and benefits.

Based on the quantitative and qualitative analysis conducted through Level 2, Side Running BRT is recommended as the ultimate high capacity transit vision for the Federal corridor.

Advancing Side-Running BRT:

- Attracts approximately 30% more riders than Enhanced Transit in the horizon year (2040) and the same number of riders as Center-Running.
- Results in fewer property acquisition needs than Center-Running BRT, but more physical infrastructure and property needs than Enhanced Transit.
- Can be phased more simply and allows for re-use of any improvements completed before implementation of Side-Running is complete.
- Creates new transit demand and integration with regional service, but the effect is more pronounced between Alameda and Colfax, and the Decatur-Federal Station.
- Provides the lower cost option of the two BRT alternatives; while resulting in similar ridership and less potential impact than Center-Running BRT.
- Is the stronger potential alternative for funding because of its lower cost versus benefits (considering FTA Small Starts criteria).
- Provides better integration of transit into the existing urban realm (sidewalk) with simple access on the curbside between transit and local neighborhoods, businesses, and services.

Advancing the Recommendations

Additional work is needed to further advance planning, environmental, funding, and design to fully implement Side-Running BRT. BRT projects can require several years to work with the community to complete design and to qualify for the necessary funding.

Engagement with stakeholders and agency partners revealed the desire to advance improvements rapidly. Stakeholders noted they wanted quick win improvements that can build toward an ambitious long term transit vision. Changes in the corridor also necessitate transit improvements be implemented as quickly as possible. Increasing congestion and growth continue to strain the corridor and impact quality of life. For example, significant growth in both housing and employment is expected near the Sun Valley neighborhood. This is also the location with the corridor's highest concentration of no-car households per capita.

Set to begin in 2021, the City and RTD are also advancing transit improvements along Federal through the Speed and Reliability Project. This effort has funding to implement elements needed to support BRT. The Speed and Reliability Project will utilize this alternatives analysis as a base and work to implement the highest priority components to facilitate the future implementation of BRT. The improvements will be limited to the Speed and Reliability budget. Even with these limitations, the Speed and Reliability Project will begin to advance the Federal corridor transit improvements in the near term.

In response to stakeholders, immediate needs, and continuity with the Speed and Reliability Project, the project team is recommending to advance near-term transit improvements through the Speed and Reliability Project. In parallel, the planning and design would be advanced to support funding requests for full implementation of Side-Running BRT.

Advancing Speed and Reliability Improvements

The current Speed and Reliability Project would work within the existing street space along Federal to achieve as many of the Enhanced Transit improvements as possible, based on available (and future) funding opportunities. Advancing these improvements in the near term allows further planning and design to continue to seek out funding and realize the complete vision for BRT. The benefits include:

- Allows for near term implementation, consistent with the 2021 Speed and Reliability Project and provides a basis for future Side-Running BRT.
- Works within the existing street space with limited physical changes to the roadway.
- Works with existing medians and capital improvements.
- Improves ridership and continues to build a culture of transit along Federal, for future implementation of BRT.

Advancing Side-Running BRT

Side-Running BRT would require a longer time frame for ultimate implementation (potentially 7-10 years). Future planning for Side-Running BRT would include working with stakeholders to further refine the planning and design. This effort would develop and implement a process aimed at the highest probability funding sources to fully implement BRT along Federal.

Recommended Alternatives and Refinements

The section below provides details on the configurations of the recommendations. As the alternatives analysis progressed, adjustments were noted for each alternative to improve performance and to minimize impacts.

Recommendation – Advance Speed and Reliability

Federal Boulevard transit improvements are anticipated to be implemented over time, as funds are available. This begins with the Speed and Reliability Project beginning in 2021. Beyond these improvements, the City could continue to incrementally implement the additional priority components of Enhanced Transit. With the Speed and Reliability Project (and other potential transit improvements) as a base, the ultimate Side-Running BRT implementation can use or repurpose the transit improvements already in place. Figure 8-1, Figure 8-2, and Figure 8-3 display the desired elements of the Speed and Reliability Project, plus additional transit enhancements (similar to Enhanced Transit as presented in Section 7.2.5).

Figure 8-1: Recommendation – Speed and Reliability Example Cross Section

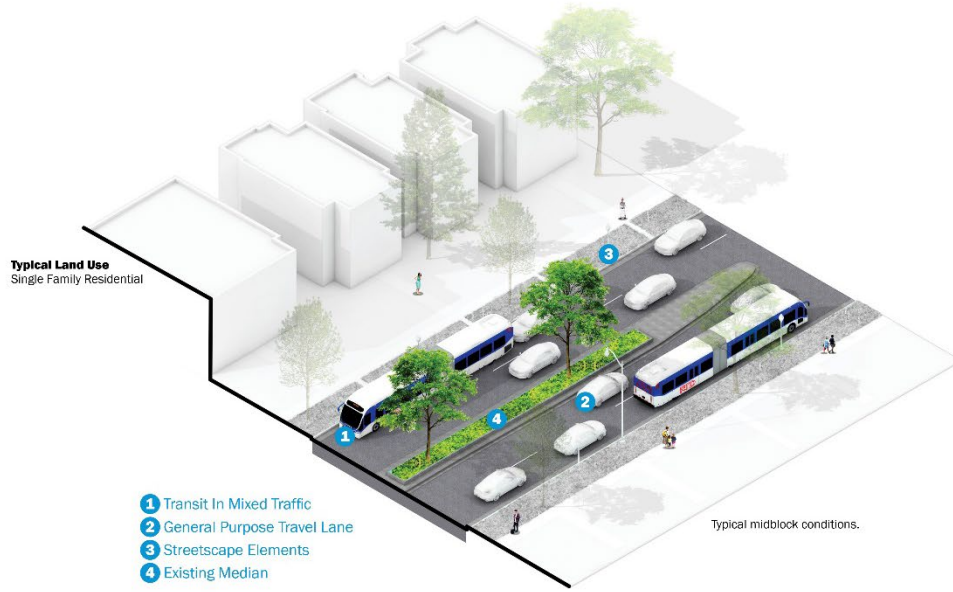


Figure 8-2: Recommendation – Advance Speed and Reliability

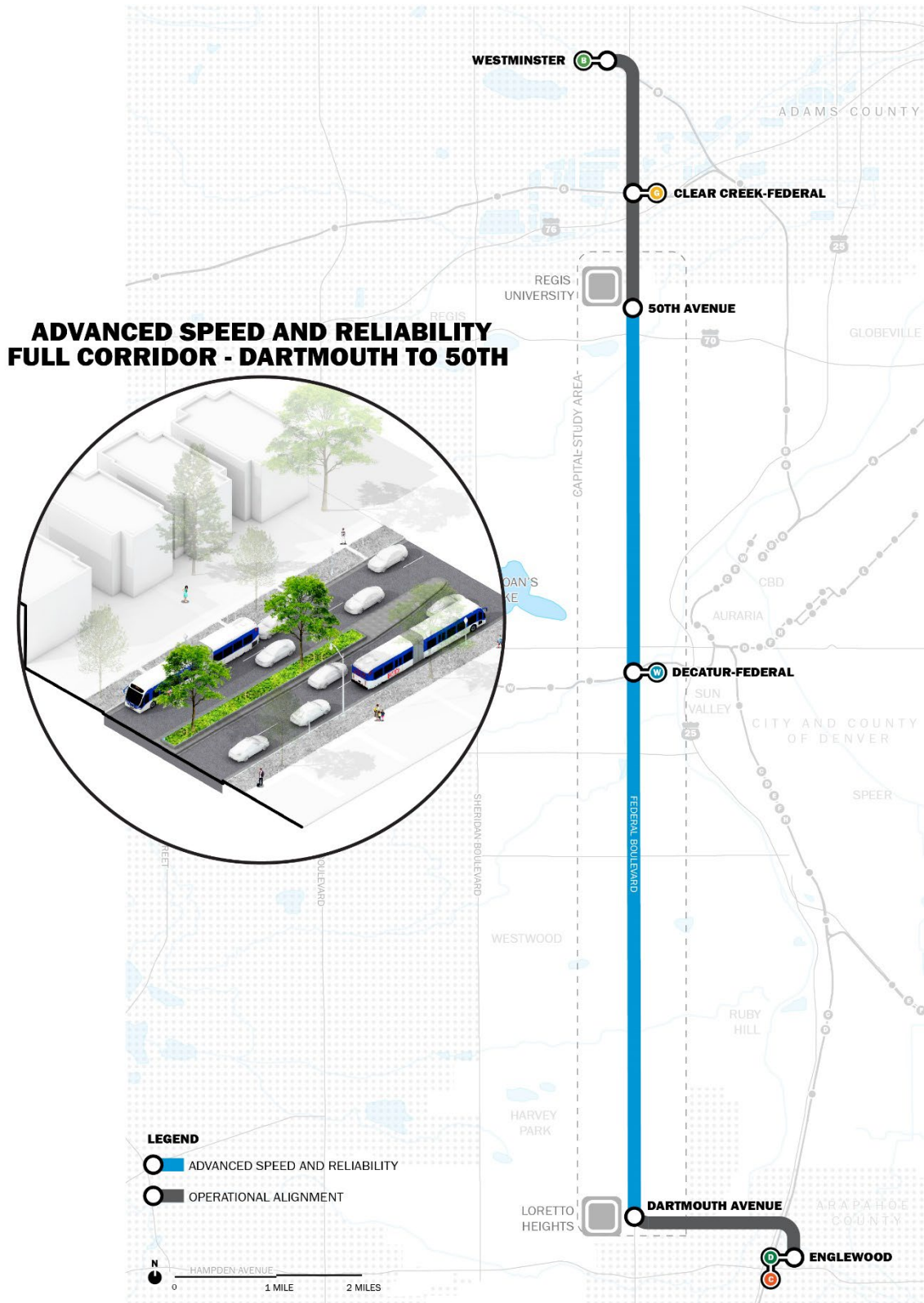


Figure 8-3: Recommendation – Speed and Reliability Example Stop Improvements



Recommendation – Advance Side-Running BRT

The Side-Running BRT alternative proposes formal BRT/BAT lanes on the curbside lanes of Federal Boulevard. These lanes are exclusive to transit and vehicles accessing residences and businesses along Federal.

As the team analyzed how BRT would fit with the existing right-of-way available, it was determined that segments of the corridor would be appropriate for formal BRT lanes; while other segments are too narrow to avoid significant property acquisition and impact. Therefore, the Side-Running BRT configuration was amended for the final recommendation to apply to the southern portion of the corridor from approximately 20th Avenue to Bates Avenue. All other measures for BRT improvements, stops, and priority would be applied throughout the entire corridor (50th to Dartmouth). The recommendations are based on high level information collected through the alternatives analysis. Additional design and impact analysis will be required to define the specific locations of exclusive lanes.

The final recommendations differ and have evolved from the descriptions noted in presented in Section 7.2.5 of the alternatives analysis. Figure 8-4, Figure 8-5, and Figure 8-6 display the elements of Side-Running BRT. It is important to note the exclusive transit lanes are proposed south of 20th Avenue in the ‘less constrained’ segment of the corridor (identified on the graphic).

Figure 8-4: Recommendation – Side-Running BRT

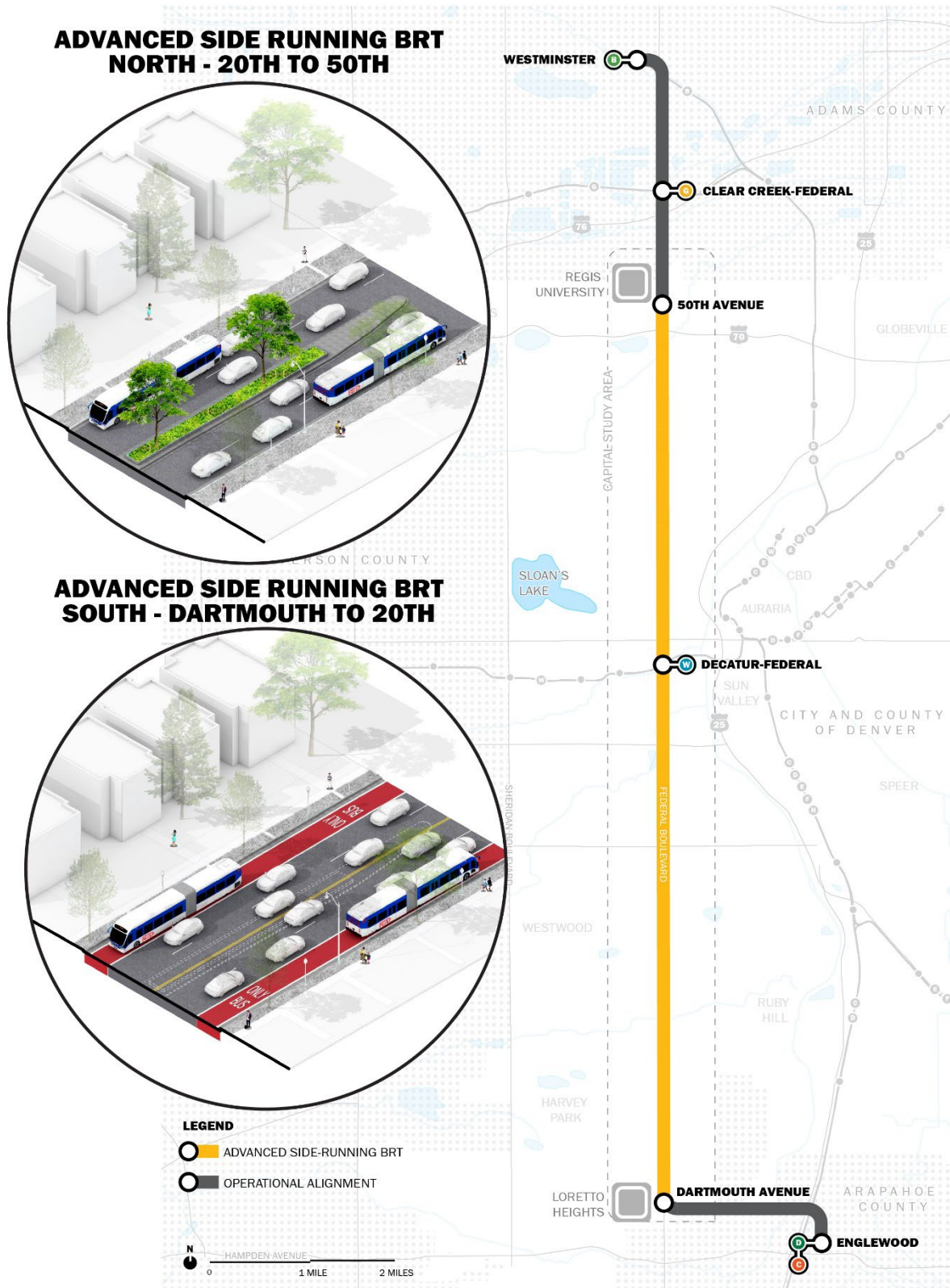


Figure 8-5: Recommendation – Side-Running BRT Example Cross Section

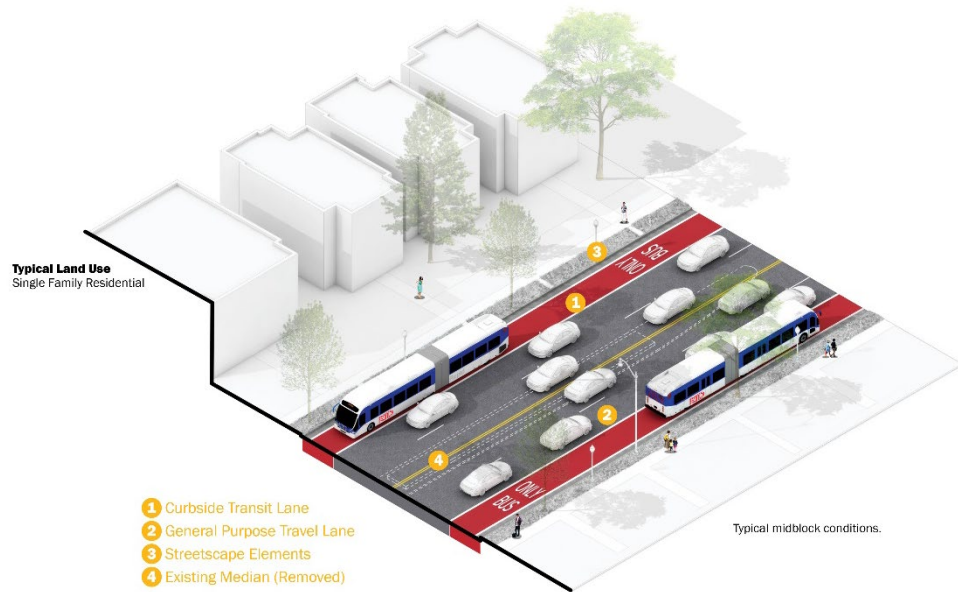


Figure 8-6: Recommendation – Side-Running BRT Example Station



8.2 Next Steps

Developing recommendations is a major milestone and provides direction for the critical next steps in the process. With the recommendations as a basis, the City will continue to advance towards implementation. Several critical refinements and further analysis are required to determine the ultimate design, final configuration, and funding sources. The following key steps are noted below.

Next Steps – Refinements and a Locally Preferred Alternative

During alternatives analysis, the project team identified potential impacts that influence the overall design of the recommendations. Specifically, focusing transit only lanes in the Side-Running BRT alternative from approximately 20th Avenue south. Additional design and consultation with stakeholders are needed to determine the exact configuration of the Side-Running BRT components. Additional refinements also hinge on potential partnerships. Coordination with communities to the north and south of the City limits could result in additional transit exclusivity in segments north of I-70 or elsewhere. Examination, impact analysis, and further design will be critical next steps to finalize the recommendations.

This alternatives analysis defines multiple critical elements to support a future locally preferred alternative (LPA) as defined by FTA. The purpose of an LPA is to define the transit option that best meets the project's purpose and need, and that will be carried forward to seek federal funding. It is possible the City could seek out Small Starts funding through FTA for the Side-Running BRT.

The recommendations presented in this report define mode and alignment; however, at the request of the City, the team did not specifically finalize the LPA. This approach was implemented to maintain flexibility as consultation with stakeholders, decision makers, and funding options (federal and other funding sources) are further explored. Additional design refinements and confirmation of station/stop locations will be needed to ultimately select Side-Running BRT as the LPA for Federal.

To conduct the alternatives analysis the project team identified a set of potential station locations for Side-Running BRT. These assumptions included stops at approximately 1/2 mile intervals between stops to reduce travel time. The set of stations were assumptions for the analysis and not intended to reflect the final station locations. During future planning these station locations will be refined to specific locations where the station footprint will best fit. Stations will be located and designed to safely accommodate pedestrians, bicyclists, and people using mobility devices.

Next Steps – Federal Funding

Future planning will continue to advance the analysis and a decision on the appropriate funding path for Side-Running BRT. Based on the project team's initial examination of Small Starts criteria for federal funding, this corridor is likely a strong candidate for the Federal Transit Administration's (FTA) Capital Improvement Grant (CIG) program. Based on estimated capital costs developed as part of the alternatives evaluation, Side-Running BRT meets the criteria for the Small Starts sub-program, meaning the City could be eligible for Federal funding covering a significant portion of overall cost.

The CIG program determines eligibility through a variety of factors. Many of these depend on the current and expected ridership of the corridor. There is a simplified application process for projects that qualify for project justification warrants – the thresholds for this expedited process are shown in Table 8-2.

Table 8-2: FTA Project Justification Warrants Thresholds

Total Proposed Small Starts Project Capital Cost (Year of Expenditure)	Existing Weekday Transit Trips in the Corridor
\$0 to < \$50 million	3,000 or more
\$50 to <\$100 million	6,000 or more
\$100 million to <\$175 million	9,000 or more
\$175 to < \$250 million	12,000 or more

Source: Documentation of Existing Transit Riders to Prove Eligibility for Warrants for New Starts and Small Starts Projects, FTA – 2015.

Using the ridership methodology provided by the FTA, the capital alignment of the Federal transit corridor serves approximately 8,500 weekday trips, based on 2018 and 2019 RTD data analyzed as part of the State of the Corridor analysis. The operational alignment serves approximately 9,000 trips. Using the latter alignment (as all Level 2 Alternatives do), the project likely qualifies for the simplified project justification warrants process as long as capital costs remain below \$175 million in the year of expenditure.

Estimated capital costs developed as part of the Level 2 evaluation suggest that Side-Running BRT is likely within the threshold for project justification warrants, although there is relatively little margin for error. The implication for future development of transit along the Federal corridor (assuming a goal of qualifying for the simplified FTA process) is that there must be careful consideration with regard to

- Maximizing qualifying ridership, by ensuring that the broadest definition of the corridor is included in the project (i.e. the operational alignment).
- Finding efficiencies in capital costs.

One way to manage capital costs in this context is by expediting the construction timeline, since overall costs escalate over time.

The City will continue to examine the Small Starts options, specifically the use of these Project Justification Warrants based on the existing level of transit ridership along Federal Boulevard. Use of warrants allow the project to automatically receive a medium rating for the Mobility, Cost Effectiveness and Congestion Relief criteria. Future analysis would only be required to address the remaining criteria: Land Use, Environmental Benefits and Economic Development.

Among these three, only Economic Development truly offers opportunities for proactive work in the near term. For the purpose of Small Starts ratings, 'Land Use' scores are based upon the demographic makeup of the corridor, and 'Environmental Benefits' scores are a function of expected changes in ridership compared with capital costs. The 'Economic Benefits' criterion, on the other hand, is based upon the policy and planning (both land-use and transportation) framework in place at all levels – from specific station areas to region-wide long-range plans.

Next Steps – Engagement

Continuing to build understanding and direct engagement in the project's decision making will be essential. A hallmark of this project has been significant community and agency partners' engagement throughout even while adapting to the changes presented by COVID-19. Next steps must build on this engagement and ensure that community voices inform and support the ultimate design, funding, and implementation of Enhanced Transit and Side-Running BRT along Federal.

9 Bibliography

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10 Appendixes (Available in Full Report)

Appendix 1: State of the Corridor Memorandum

Appendix 2: Technology Screening

Appendix 3: Level 1 Corridor Screening

Appendix 4: Draft (Concept Level) Cost Estimates

Appendix 5: Level 2 Alignments Screening



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