Mason Corridor Bus Rapid Transit Project; Fort Collins, Colorado

The Mason Corridor Bus Rapid Transit (BRT) Project is a 5.0-mile mix of bus guideway and arterial street treatments for buses that extends north from the new South Transit Center, along the eastern edge of the Colorado State University campus, to the existing transit center in downtown Fort Collins. The City of Ft. Collins now operates the Mason Corridor Express bus service, or MAX, on the project as part of its Transfort bus system. Figure 1 is a map of the project, its station locations, and the Mason Street corridor.

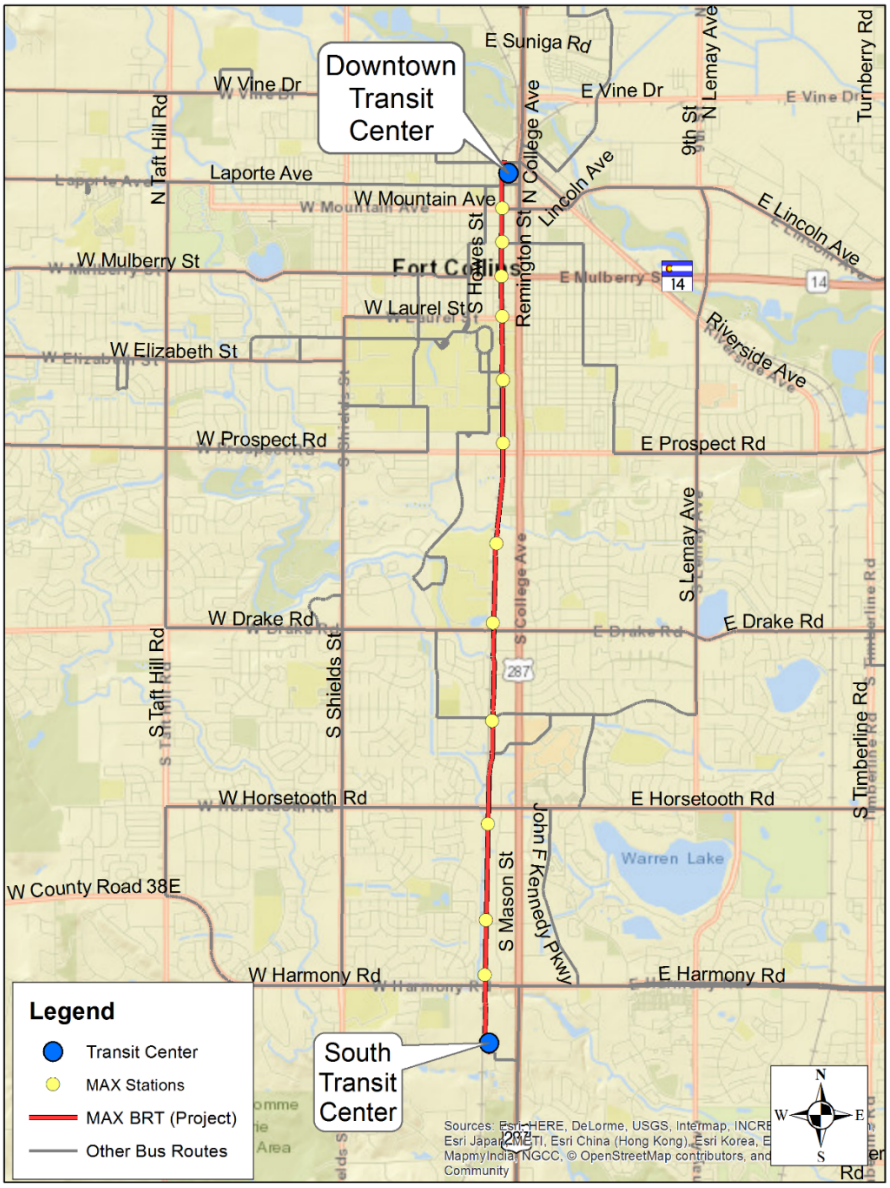

Figure 1. The Mason Corridor BRT Project

The City of Fort Collins planned and developed the project. In July 2004, an Alternatives Analysis for the corridor concluded with the adoption of a BRT facility as the locally preferred alternative (LPA). The City then included the BRT facility in the Mason Street Transportation Corridor Plan, adopted in October 2004. The project entered into Project Development in

November 2007; received a Project Construction Grant Agreement (PCGA) from the Federal Transit Administration in May 2012, and opened to service in May 2014.

Physical scope

MAX BRT service extends 5.0 miles from the South Transit Center to the Downtown Transit Center. In between, Mason Corridor bus facilities are adjacent to an active single-track freight line operated by the BNSF railroad. The corridor is continuous, although the street name transitions from McClelland Drive in the south to Mason Street in the north.

The project upgraded the physical and operating environment for BRT buses in several ways. Northbound from the South Transit Center, the BRT route is in a newly constructed, two-lane, 23-foot wide dedicated roadway for approximately 1.5 miles. It then transitions to in-street mixed-traffic running on the adjacent two-lane McClelland Drive for approximately 0.8 miles to the intersection with Drake Road. At Drake, the BRT service re-enters a dedicated two-lane guideway for approximately 1.2-miles where it narrows to one lane over the last 0.2 miles to University Avenue. At University Avenue, the dedicated guideway ends and the BRT route transitions to in-street mixed-traffic running for approximately 1.3 miles on Mason Street in the downtown area. Mason Street is a two-lane road located to the east of the BNSF track as it proceeds north from University for 0.3 miles to Laurel Street. At Laurel, Mason Street transitions into a couplet configuration with the BNSF track centered between the single northbound and southbound lanes of traffic. The BRT route ends at the Downtown Transit Center immediately adjacent to Mason Street in downtown Fort Collins. No lane reservations or signal priorities are provided for BRT buses where they operate in mixed traffic anywhere in the corridor. BRT buses operate only on the BRT route and make no turns to or from intersecting cross-streets. No other vehicles are permitted on the guideway.

BRT facilities are entirely at grade. The project included the construction of one new bridge over a creek and the reconstruction of an existing bridge over an irrigation canal. A concurrent project by BNSF, not included in the scope or budget of the Mason Corridor PCGA, reconstructed approximately 1.5 miles of track and reconfigured Mason Street into the two-way couplet north of Laurel Street. The project also made repairs to existing pavement; added or improved curbs, gutters, and sidewalks throughout the corridor, and added a right-turn lane at one traffic intersection.

Traffic signals, coordinated with train signals, control all intersections on the guideway segments of the corridor and some of the intersections on the street-running segments. Intersections with lower-volume streets have four-way stop signs. Signals are progression-timed to facilitate BRT bus movements.

The project built the new South Transit Center which provides three bays for BRT buses and eight bays for local buses. It modified the Downtown Transit Center, adding one BRT stop and remodeling the passenger service desk to support bus-pass processing and passenger assistance. The project built seven BRT stations on the guideway segments of the BRT route. Station platforms are centered between the two bus lanes and are offset by a lane-width to meet the BNSF requirement that passenger platforms be located outside of the railroad right-of-way. Southbound buses cross the northbound lane at grade to reach the far side of the center platforms so that buses in both directions can position their right-side doors at the platform. Passengers use crosswalks across the southbound lane to reach the station platforms. Platform elevations match

the floor elevation of BRT buses and a short ramp extends from the buses to provide roll-on access for passengers who need that accommodation. All stations are compliant with requirements of the Americans with Disabilities Act. Station amenities include canopies, fare vending equipment, audio announcements, emergency call boxes, and dynamic schedule information. The project built a parking lot at the new South Transit Center and the City arranged with nearby property owners at four other stations to designate existing spaces for transit riders. Together, the five stations with parking provide a total of 409 spaces. All BRT stations provide bicycle parking. Along the segments of McClelland Drive and Mason Street where the BRT route operates on the street, the project built bus stops on upgraded sidewalks with bus shelters, ticket vending machines, dynamic schedule information, and bicycle parking. A limited number of minor property acquisitions were needed for the project; easements were established where the project is located on BNSF right-of-way and for the designation of existing parking spaces for transit park-ride at four station sites.

The project enlarged the Transfort bus maintenance and storage facility by 16,000 enclosed square feet to accommodate the new BRT vehicles needed to provide service on the project.

The PCGA scope of the project included the purchase of six articulated, three-door, low-floor CNG buses and the City later purchased two more of these buses outside of the PCGA scope and budget. All buses have a kneeling capability to accommodate the different platform heights at BRT stations and off-guideway bus stops.

The anticipated scope of the project throughout its development matched the as-built project in terms of its termini, general alignment, reliance on mixed-traffic running on McClelland Dr. for a portion of its alignment, and the number and general locations of its stations. At PD-entry, the anticipated scope was different in several details. The southern-most guideway segment was 0.5 miles longer at that point; it was subsequently shortened during a value engineering exercise in PD to avoid right-of-way complications and costs associated with an irrigation canal running immediately adjacent to the railroad right-of-way. Two station locations were different because minor adjustments were later made to take advantage of better-suited parcels and one station was later reconfigured from a center- to side-platform design because of right-of-way constraints. The expansion of the bus maintenance and storage facility was half the size and under canopy rather than the 16,000-square-foot fully enclosed as-built facility. The anticipated scope had seven park-ride lots – two more than the actual outcome. Systems at that point had not been defined but were described in terms of their functional requirements – which were met in the as-built outcomes. The scope did not anticipate the real-estate takings or easements that emerged later as the project design advanced. The scope anticipated the need for only six BRT vehicles – two less than the outcome – because of an apparent underestimate of the necessary end-to-end running time on the facility.

Except for the number of vehicles needed, the PD effort resolved these differences so that the anticipated scope at the PCGA otherwise matched the actual outcomes. The City's purchase of the two additional BRT vehicles after the award of the PCGA was motivated by longer-than-anticipated runtimes that were evident throughout the testing period before MAX opening. End-to-end BRT runtimes averaged as much as 30 minutes, compared to the anticipated 20 minutes. The longer runtimes resulted from (1) slow maneuvering of vehicles by drivers at stations and other constricted areas and (2) delays at intersections because of unresolved issues with signal priorities on the guideway segments and signal progression through the mixed-traffic segments.

As drivers became more practiced and intersection issues were resolved, runtimes decreased and averaged 20 minutes by fall 2017.

Capital cost

The actual cost of the PCGA scope of the project was $82.4 million in YOE dollars with a mid-point of expenditures in June 2013. The City's purchase of two additional BRT buses added $1.4 million to the total cost of the as-built project. Sixty-two percent of the total cost of the PCGA scope was for project construction and systems, 14 percent for right-of-way acquisition, five percent for vehicles (not including the two additional vehicles), and 19 percent for professional services to help plan, design, and oversee construction of the project. Aggregate unit costs were $16.6 million YOE per mile total and $15.7 million YOE per mile without the vehicles. Vehicles cost $728,300 each.

The capital cost estimate prepared at PD-entry was $74.2 million YOE, an underestimate by $8.9 million (11 percent). Nearly all ($7.2 million) of the underestimate was caused by an anticipated schedule for project development that was short by more than three years: the anticipated mid-point of construction expenditures was February 2009 versus the actual mid-point in August 2012. The apparent accuracy of the baseline cost estimate in constant dollars was, in part, the result of modest offsetting underestimates of professional services costs and overestimates of construction costs.

The PCGA cost estimate turned out to be high by $3.8 million, almost entirely because the baseline cost estimate in constant dollars was high by $3.4 million – driven by an overestimate of the cost of right-of-way purchases and partially offset by a continued underestimate of the cost of professional services. The PCGA estimate accurately anticipated inflation costs with a generally accurate construction schedule and assumptions on annual rates of inflation. FTA later approved the expenditure of left-over PCGA funds on other improvements along the BRT facility.

The City's analysis of project capital costs identified many misclassifications of cost items into the FTA standard cost categories (SCCs) – both in the cost estimates and in the recording of actual costs. As a result, the City will pay closer attention to accurate classifications a priority for future Transfort projects.

Transit service

MAX provides service on weekdays between 5:30am and midnight with buses arriving at stations every 10 minutes in the morning and evening peak periods, every 15 minutes in the early morning and in the evening until 9:00pm, and every 30 minutes until midnight. All buses stop at every MAX station. On weekends, MAX provides service between 8:00am and 7:00pm with arrivals every 30 minutes throughout. End-to-end runtime is 20 minutes, an average speed of 14.3 mph over the guideway and mixed-running segments where the speed limit is 20 mph throughout.

No other Fort Collins bus routes operate on the BRT facility or the mixed-traffic segments on McClelland Dr. and Mason St. The regional FLEX route between Fort Collins and Boulder, 45 miles to the south, connects to the South Transit Center. Most FLEX trips terminate there, while a total of nine FLEX trips throughout the day use the BRT facility to travel to/from the Downtown Transit Center. Transfers between MAX and eight local Transfort routes are

available at the Downtown Transit Center, four local routes at the South Transit Center, and a total of six local routes at four of the intermediate line stations.

The MAX fare is the same as the fare for other Transfort local bus routes. CSU students, faculty, and staff can ride MAX and any local route fare-free.

With the opening of the BRT facility and start of MAX service, Transfort eliminated local Route 15 that had operated on College Ave., roughly 1.5 blocks to the east of the BRT project, connecting downtown, the CSU campus, and south Fort Collins (serving streets and a now-closed transfer center in the general vicinity of the new South Transit Center). Transfort also eliminated local Route 1 that had operated on local streets between downtown and the CSU campus. In the same timeframe, Transfort added two routes and modified four routes that connect to and work with MAX service. In addition, the BRT project was built at a time when Fort Collins was expanding its bus system into a more complete grid. Overall, in terms of vehicle-hours of service, Transfort increased service in the project corridor by 45 percent, on routes connecting with MAX by 40 percent, and in the rest of the system by 100 percent – resulting in a system-wide increase of 55 percent.

The opening-year service plans that the City prepared during the planning and development of the project accurately anticipated the service characteristics of MAX itself: MAX service would operate over the same span of service and at the same headways as the actual outcome and would replace Routes 1 and 15, which would be eliminated. However, as a simplifying measure, the service plans assumed that the rest of the Transfort system would remain largely at its then-current configuration and service levels – thereby omitting the substantial expansion of service soon to begin throughout the Transfort system. The only additional service included with MAX in the opening year service plan at PD-entry were the planned addition of two routes with MAX connections. In the service plan at the PCGA milestone, these two routes were dropped in favor of adjustments to other routes to serve the same markets.

Operating and maintenance costs

Transfort estimates that MAX operating and maintenance costs were $2.97 million in 2015, the first full year of MAX operations – 41 percent for operator wages and benefits, seven percent for fuel, 12 percent for fleet maintenance, eight percent for BRT facility maintenance, and 32 percent for support services (admin, TSOs, dispatchers, road supervisors, administration, and insurance). This estimate was based on actual BRT-facility maintenance costs plus a calculation of operating costs based on the fraction of system-wide vehicle-hours and vehicle-miles that operated by MAX vehicles. The calculation of operating costs was necessary because Transfort does not track MAX operating costs separately from the rest of the system and, therefore, relies on an assumption that the unit costs of MAX operations are the same as for local buses.

The City's records of predicted O&M costs prepared during project development are unclear. The best available evidence suggests a prediction of $2.19 million, escalated to 2015 dollars – an underestimate of $0.78 million (35 percent). Predicted costs apparently omitted the costs of support services, which represent approximately one-third of actual costs, and allocated on $40,000 annually to BRT facility maintenance which actual cost $240,000. These underestimates have been partially offset by a 17 percent overestimate in the aggregated costs of operator wages and benefits, vehicle maintenance, and fuel.

Ridership

Between fall 2016 and fall 2017, spanning an interval that was 18 to 30 months after MAX opening in May 2014, MAX ridership stabilized at 5,250 trips per average weekday. Ridership growth over those 30 months reflected the impact of the BRT project itself, increasingly transit-friendly changes at Colorado State University, and the substantial ongoing service improvements and ridership increases throughout the Transfort system. MAX ridership averaged 2,500 weekday trips throughout fall 2014 and spring 2015 – an increase of nearly 900 trips per day over the two corridor services, Routes 1 and 15, that MAX replaced. Beginning in fall 2015, however, as CSU students returned to campus for the new academic year, MAX ridership immediately doubled to 5,000 trips and then grew modestly to 5,300 trips by the following spring and remained in the fall.

Ridership on other Transfort routes serving the CSU campus also grew rapidly in 2015 and 2016 – from 5,400 to 9,900 trips per day, an 85 percent increase, driven by changing transportation options at CSU. These changes included free rides on Transfort for CSU faculty and staff starting in fall of 2015; 78 percent increases in the costs of parking on the CSU campus; major construction at CSU that closed two significant parking lots during the 2015-2016 academic year; and a new transportation demand management program implemented at CSU in fall of 2014.

Careful analysis of the timing of these changes and the individual ridership increases on MAX and other CSU-related routes concluded that the changes at CSU and in system-wide service were responsible for most of the growth in MAX ridership beyond the 2,500 weekday trips that MAX carried throughout its first year of operation. Using the growth in other CSU-connected routes as a measure of the likely impacts of those changes, the analysis concluded that (1) MAX ridership would have fully matured at approximately 3,200 trips in 2017 absent external changes and (2) those external changes were responsible for the additional increase to 5,250 trips by 2017.

A rider survey in fall 2017 documented the characteristics of MAX riders and confirmed its significant ties to CSU. Trips to and from activities at the university – by students, faculty, staff, and others – constituted 35 percent of all weekday trips on MAX. Comparison with a similar survey conducted in spring 2014 indicated that CSU students, faculty, and staff generated 46 percent of all ridership growth in the project corridor over that interval.

The largest single travel market using MAX (46 percent of all MAX trips) comprised the 2,400 trips to/from activities in the Fort Collins core – downtown and the adjacent CSU campus – almost entirely from the project corridor. Riders made these trips for a broad range of purposes – 20 percent was travel between home and work, 30 percent between home and the university, 25 percent between home and other activities, and 20 percent between two non-home activities. MAX trips made entirely within the core – largely between downtown and the CSU campus – added another 750 trips (14 percent of all MAX trips) to travel associated with activity locations in core. Fifty-four percent of this market was travel between non-home locations while 20 percent each was student travel and other non-work travel, and seven percent was travel between home and work.

A significant “reverse” market was evident in the 1,100 trips between downtown and other areas – primarily along the project corridor. Fifty-one percent of these trips were made between two non-home activities – for example, college students traveling from a classroom building on

campus to a part-time job. The remaining trips in the "reverse" market were made by residents of downtown and the campus (dorms) to/from jobs (20 percent) and non-work activities (30 percent) located outside the core.

The remaining 18 percent of all MAX trips were between areas throughout Fort Collins. Nearly half of these trips were made within the project corridor outside of the core. The others were made among widely distributed locations, using MAX to make connections through central Fort Collins to and from other Transfort routes. This market is also quite non-work oriented: only 30 percent were trips between home and work, 35 percent between home and non-work/non-college activities, and 35 percent between two non-home locations.

Additional comparisons between the 2014 and 2017 rider surveys indicated that average weekday transit ridership grew by 225 percent (i.e., more than tripled) from 1,600 trips on local Routes 1 and 15 to the 5,250 trips on MAX. Ridership increased at roughly the same pace for all trip purposes – slightly more for student trips to/from campus and slightly less for trips between home and work. Significant changes occurred in the way transit riders in the corridor traveled between their residences and the transit system. In 2014, nearly all transit travelers in the corridor walked to and from Routes 1 and 15. Park-ride access was effectively non-existent in the corridor. In 2017, however, some 1,275 MAX trips (25 percent of all MAX trips) relied on park-ride access (equivalent to approximately 600 vehicles parked in park-ride lots with occupants using MAX to travel each way between the lots and their destinations). Similarly, bicycle access went from 100 weekday trips to 500 weekday MAX trips. These increases were direct responses to the introduction of park-ride lots and bicycle lockers at MAX stations. Walk-access trips nearly doubled as well as part of the substantial overall increase in ridership, although the share of travelers who walked dropped significantly as park-ride and bicycle access grew more rapidly. Bus transfers remained a minor contributor, used by only three percent of all corridor travelers in both 2014 and 2017.

The ridership forecast prepared by the City during project planning in 2011 anticipated 4,050 weekday trips on the BRT project. This forecast assumed that the only change between 2011 and the 2014 project opening would be the introduction of MAX service on the completed BRT project. The forecast therefore did not recognize the changes in travel options that would soon occur at CSU, Transfort's system-wide improvements that would soon ramp up, or the robust pace of development occurring throughout Fort Collins and in the project corridor.

Compared to the 5,250 trips on MAX in the fall 2017 rider survey, this forecast is an underestimate by 1,200 trips (23 percent). Compared to the 3,200 trips that the careful timeline analysis concluded is a better measure of the direct ridership response to the BRT project, the forecast is an overestimate by 850 trips (27 percent).

While 3,200 trips may be a better measure of the actual ridership impacts of the BRT project and MAX service, detailed ridership data after project opening is available only in the 2017 rider survey which documents the 5,250 trips on MAX after CSU and Transfort changes had taken effect. Consequently, all predicted-actual comparisons have been computed against the 2017 data. These comparisons have led to three conclusions on the accuracy of the forecast.

First, while the forecast underpredicted 2017 MAX ridership by a relatively modest 1,200 trips (23 percent), that apparent level of accuracy is largely the product of large and offsetting under- and over-predictions of several major components of MAX ridership. Second, the forecast missed almost entirely the substantial MAX ridership that occurs for non-work purposes. In

2017, MAX carried 1,450 trips between residences and non-work activities and another 1,800 trips between two non-work activities. Together, these trips represent 3,250 MAX trips (62 percent of MAX weekday ridership) and do not include students using MAX to travel to/from CSU. The forecast anticipated only 700 and 400 trips for the two trip purposes, respectively – an underestimate by a total of 2,150 trips (66 percent). Third, the forecast substantially overpredicted the number of student trips between their residences and the CSU campus; MAX carried 900 of these trips on weekdays in 2017 while the forecast anticipated 2,100 – and overestimate by 1,200 trips (130 percent). The forecast yielded this overestimate even though it was aware only of the introduction of MAX itself and not of the changes at CSU, in Transfort, and in new development that also occurred at or soon after MAX opening.

The causes of these large differences in the predictions are not known. They may lie in the distorted properties of the ridership forecasting methods themselves, in inadequate testing of the methods against then-current ridership patterns when the methods were developed, in the limited information provided to the forecasting methods on the significantly changing conditions in the project corridor that accompanied MAX opening, or in unexpected reactions by travelers in the corridor to the introduction of the first fixed-guideway service in Fort Collins. Unfortunately, the City and its ridership-forecasting consultant have been unable to produce documentation of the properties or testing of the methods that the City employed to prepare the project forecasts in 2011. This limitation is particularly unfortunate because this project is one of the few BRT facilities for which a Before-and-After Study is required and might have yielded important insights into reliable ridership forecasting for the large number of emerging BRT projects likely to seek funding from FTA's Capital Investment Grant program.

Economic development

In the five years since the opening of the MAX BRT project in 2014, Fort Collins has been experiencing a high rate of growth supported by commercial and residential development throughout the community. City-wide, the value of construction was $2.3 billion, including 5,500 new housing units.

The City of Fort Collins began to promote transit-oriented development in the project corridor with the adoption of the Transit Oriented Development zoning overlay in 2007. The zoning overlay includes regulations and incentives to "encourage land uses, densities and design that enhance and support transit along the Mason Corridor". Regulations govern design elements such as building orientation, outdoor spaces, streetscape and pedestrian connections, and character and image. The overlay also provides an incentive in the form of reduced parking requirements. In addition, the City identified the Corridor as a "Targeted Redevelopment Area" and adopted an Urban Renewal Plan that provides Tax Increment Financing to private sector projects in the Corridor.

The private housing market began to respond to the MAX project immediately after opening with the construction of several projects adjacent to MAX stations. While most projects were concentrated on the north end of the corridor including in downtown, several have been built in the southern half of the corridor as well. Some, but not all, of these projects are exclusively geared towards the student market. A total of 845 new housing units and over 301K square feet of new commercial space has been constructed along the five-mile long Mason Corridor in the five years since the 2014 opening of the MAX BRT facility. The total construction value of these projects was $161 million. Assessed property values within one mile of the MAX facility

have increased by 43 percent in downtown Fort Collins and by 27 percent in the rest of the project corridor.

Many developers have cited the construction of MAX as a major factor in the decision to build along the Mason Corridor. New developments in the corridor continue to market MAX as a key feature of their locations.