Interregional Connectivity Study

Travel Demand Modeling Framework

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January, 2013

Table of Contents

List of Tables

List of Figures

1 INTRODUCTION

This document is the Modeling Framework Report provided for in Task Order 1 of the Colorado Interregional Connectivity Study (ICS). The purpose of the Modeling Framework Report is to review the context of the ICS travel demand modeling activity, and from this review to propose a methodology for developing ridership and revenue forecasts that meet the needs of the ICS. The context of the ICS demand modeling activity includes:

- the overall ICS project objectives;
- particular project issues or decisions that the travel demand modeling effort is expected to help analyze and clarify;
- background information about transportation in the study area, including relevant prior studies;
- data sources that are currently available for use by the ICS; and
- potential sources of original data that could be collected and used.

It is not possible at this stage of the ICS study and its modeling activity to define in complete detail the demand forecasting methodology that will be developed based on the above factors: many details of the methodology will be best worked out during the model development itself, based on experience gained and lessons learned during the process. Rather, the intent here is to motivate and describe at a high level the general approach that is proposed for the ICS demand model development, in sufficient detail to allow readers to understand the overall model architecture and its key methodological features. In addition, this report discusses new travel data collection activities that the ICS is undertaking to enhance the empirical basis of its travel modeling.

The travel demand forecasting element of the ICS is being carried out by Steer Davies & Gleave, a member of the CH2M Hill team working under contract to the Colorado Department of Transportation Division of Transit and Rail.

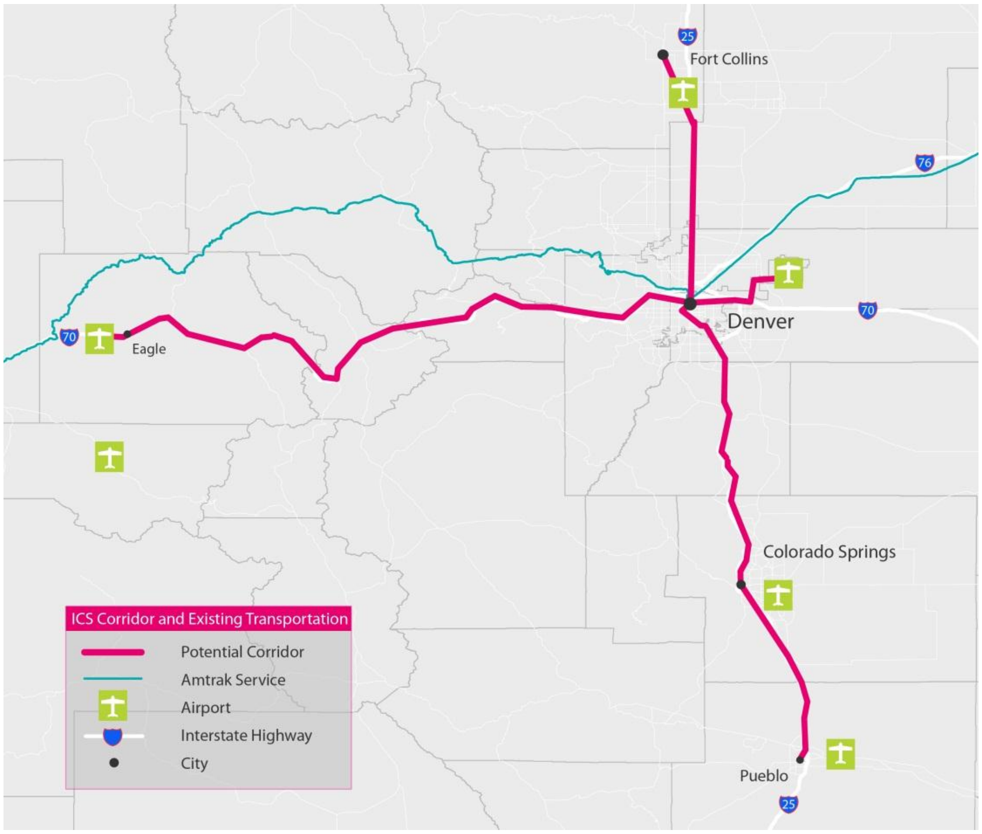
1.1 Project Characteristics and Study Scope

The ICS demand forecasting effort will consider two potential premium-quality rail services in Colorado:

- a Mountain Corridor service between Denver International Airport in the east and Eagle County to the west, running generally along I-70; and
- a Front Range Corridor service between Fort Collins in the north and Pueblo in the south, generally running along or near I-25.

Figure 1 identifies the two ICS corridors. Transfers from one service to the other will be possible in the Denver Metropolitan area, and it will be important for the forecasting effort to account for the ridership implications of this connectivity. The forecasting effort must also recognize the interactions between the rail services and the Denver metropolitan transportation system, and in particular must consider both the rail access/egress function played by the Denver transportation system, as well as the potential role of the rail services in providing metropolitan-area transportation.

Figure 1 - ICS Corridors



Although the ICS travel demand forecasting effort will consider both rail services equally, it is worth mentioning that the overall ICS scope is somewhat different in the two cases. In the I-25 Front Range Corridor, the ICS will identify possible alignments, technologies and operating characteristics for a rail service. The Advanced Guideway System (AGS) Study, which is being pursued in parallel with the ICS, will undertake a scope of services similar to that of the ICS for the I-70 Mountain Corridor for inclusion in scenario development. Findings from the screening conducted for the AGS Study will be used in the ICS.

1.2 Ridership and Revenue Results from Earlier Studies

Past studies that analyzed ridership and revenue potential for various intercity travel options in the study area include the Rocky Mountain Railroad Authority (RMRA) study[1]; the North I-25 EIS Study[2]; the I-70 PEIS Study[3]; a study undertaken by the Colorado Intermountain Fixed Guideway Authority (CIFGA)[4]; and the I-70 Mountain Corridor Major Investment Study (MIS)[5]. It is not easy to compare the results of these different studies because the projects that they evaluated were not necessarily comparable, and because they often did not produce results for the same forecasting or financial reference years.

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[1] High-Speed Rail Feasibility Study Business Plan, Submitted to the Rocky Mountain Railroad Authority, March 2010.
[2] North I-25 EIS, Final EIS, August 2011, http://www.coloradodot.info/projects/north-i-25-eis/Final-EIS.
[3] Tier 1 Draft PEIS, December 2004.
[4] Urban Maglev Technology Development Program, Colorado Maglev Project, Final Report, June 2004.
[5] I-70 Mountain Corridor Major Investment Study, Final Report, December 1998.

With these caveats, Table 1 attempts to summarize and compare the ridership, revenue, O&M costs and operating ratio figures found by these different studies. Note that the specific forecast variables as well as the level of detail presented in the study reports vary widely, with the RMRA study generally providing the most detail and the CIFGA study the least. Any empty cells in Table 1 indicate missing information in the study reports. In some cases (e.g. the RMRA study), only a subset of the study outputs (e.g. selected year and selected modes/technologies) is presented here to facilitate the comparison.

Table 1 shows a wide range of variations in the ridership and revenue figures among these studies (even recognizing that different studies produced forecasts for different years). Of the four studies of the I-70 corridor, the RMRA had by far the highest ridership, revenue and operating ratio figures.

2 CURRENT KEY TRAVEL MARKETS

The ICS rail projects address three principal travel markets:

- inter-urban travel market;
- intra-urban travel market including the airport access market; and
- airport choice market.

These are discussed in turn below.

2.1 Inter-Urban Market

For the purposes of this discussion, the inter-urban market includes travel between the urbanized areas located on the two ICS corridors. Such trips currently use any of four available modes:

- automobile;
- bus service;
- air service; and
- rail service.

2.1.1 Automobile

Automobile is the predominant travel mode in the corridor and diversions from auto to rail are frequently the principal source of ridership on new premium-quality rail services in medium-distance corridors such as those considered here. Accordingly, it is important for the travel forecasting effort to have a good understanding of automobile travel patterns and levels in the study corridors.

Unfortunately, there is no complete and detailed source of information on inter-urban automobile demand within the study area. Data on total traffic volumes on the major roadways – including I-70 and I-25, the two main inter-urban highways in the study area – are available from the Colorado DOT traffic count program. However, there is no readily available source of data on the composition of this traffic in terms of travel between specific origin-destination (OD) pairs in the corridors. This is not unusual: such data is not routinely collected in the US. It will therefore be necessary for the ICS to estimate inter-urban automobile travel demand characteristics from a variety of other sources.

Table 1 - Ridership and Revenue Results from Past Studies

RMRA Study[1]					
Technology[2]	**2035 Ridership**[3] **(millions)**	**2035 Ticket Revenue**[4] **(millions 2008$)**	**2035 Average Yield per Rider (2008$)**	**Total 2035 O&M Costs (millions 2008$)**	**2035 Operating Ratio**
125-mph maglev	27.57	$541.72	$19.65	$373.10	1.45
150-mph EMU	25.42	$529.75	$20.84	$416.09	1.27
220-mph EMU	34.53	$754.92	$21.86	$484.43	1.56
300-mph maglev	37.97	$905.41	$23.85	$448.38	2.02
Tier 1 Draft PEIS, December 2004					
Modes		**2025 Ticket Revenue (millions 2025$)**		**2025 O&M Costs (millions 2025$)**	**2025 Annual Operating Ratio**
AGS		$86		$180	0.48
Rail		$83		$135	0.61
Dual Mode Bus in Guideway		$74		$94	0.79
Diesel Bus in Guideway		$69		$99	0.70
CIFGA					
Modes	**2025 Ridership (weekends)**			**Annual O&M Costs (millions $)**	
Maglev	40,000 per day			$47	
MIS					
Modes	**2020 Ridership (millions)**			**Annual O&M Costs (millions 1998$)**	
Fixed Guideway Transit	1.74			$162	
North I-25 EIS					
Modes	**Annual Ridership (millions)**	**Annual Fare Revenue (millions 2009$)**	**Average Yield per Rider (2009$)**	**Annual O&M Costs (millions 2009$)**	**Annual Operating Ratio**
Package A					
Commuter Rail	1.09	$6.01	$5.51	$28.20	0.21
Commuter Bus, Express Bus, BRT	0.43	$1.24	$2.88	$4.70	0.26
Package B					
Commuter Rail					
Commuter Bus, Express Bus, BRT	1.77	$5.11	$2.89	$8.40	0.61
Preferred Alternative					
Commuter Rail	0.7	$3.86	$5.51	$31.70	0.12
Commuter Bus, Express Bus, BRT	0.98	$2.85	$2.91	$7.20	0.40

[1]Includes both ICS and AGS corridors.

[2]Comparable ridership and revenue figures for the FRA Developed Option were not available.

[3]From Exhibit 6-35 of the RMRA High-Speed Rail Feasibility Study Business Plan.

[4]From Exhibit 6-41 of the RMRA High-Speed Rail Feasibility Study Business Plan.

Table 2 sets out some recent year relevant annual average daily traffic (AADT) count data on I-70 and on I-25, and Figure 2 indicates the locations where these counts were taken.

Table 2 - Selected Traffic Counts

Location	AADT	Year	County
Location 1: On I-70 Northeast of State Highway 9 (Blue River Parkway) at Eisenhower Tunnel	29,000	2011	Clear Creek
Location 2: On I-70 Southwest of State Highway 9 (Blue River Parkway) in Silverthorne	41,000	2011	Summit
Location 3: On I-25 North of State Highway 66 in Mead	71,000	2011	Weld
Location 4: On I-25 North of State Highway 105 (2nd St) in Monument	59,000	2011	El Paso

Note: Traffic data is for road segments (rather than intersection points)
Source: CDOT; http://apps.coloradodot.info/dataaccess/

Figure 2 - Traffic Count Station Locations

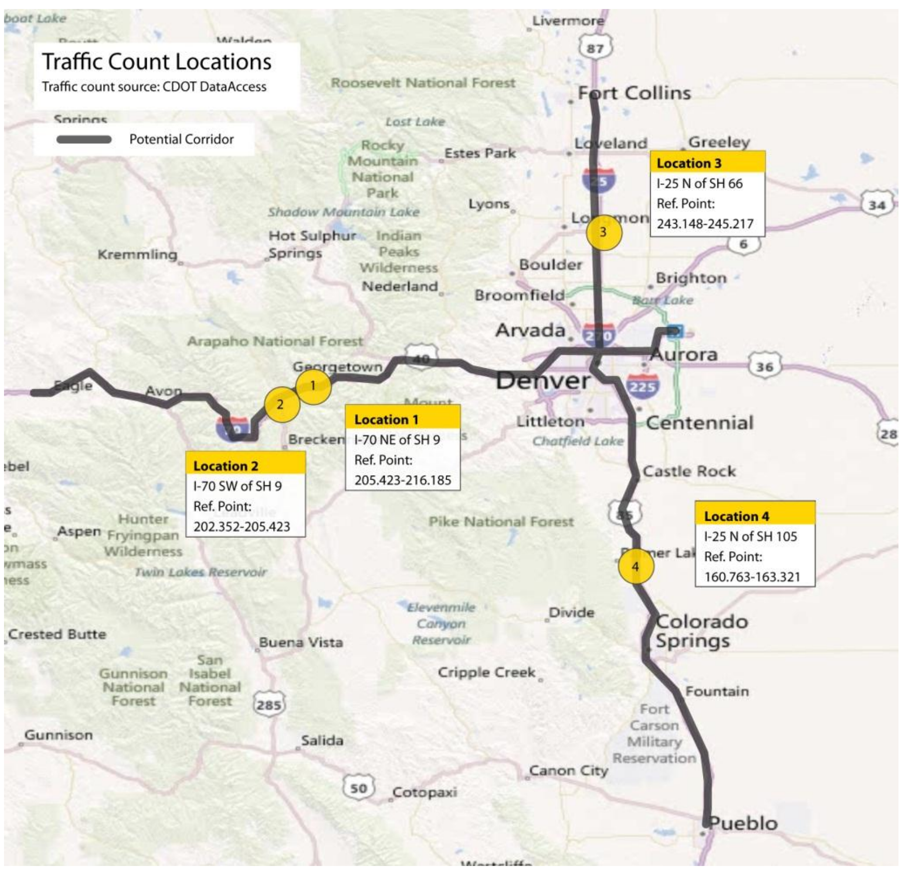


Table 3 shows automobile travel distances and times between the major cities in the study area. The data are obtained from Google maps and reflect speed limits and representative congestion levels on each route. This shows that the cities are separated by distances and travel times that are potentially addressable by a short- to medium-distance intercity rail service.

Table 3 - Automobile Travel Times and Distances Between Corridor Cities

Route	Distance (miles)	Time (min)
Denver - Fort Collins	65.9	75
Denver-Colorado Springs	68.4	80
Denver-Pueblo	112.0	118
Colorado Springs-Pueblo	43.6	46
Fort Collins-Pueblo	176.0	181
Denver-Vail	126.0	140

Source: maps.google.com

2.1.2 Bus service

Table 4 presents a summary of the regularly-scheduled bus services operating in the study area. (Charter bus operations are not included here.)

Table 4 - Bus Services Summary

City Pair	Route	Operator	Travel time (mins)	Frequency	Fare per seat mile	Full fare
Denver-Ft Collins	City to City	Greyhound	75	2x/day	$0.30-$.35, $0.42	$20.00-$23.00, $28.00
Denver-Ft Collins	City to City	Arrow / Black Hills Stage Lines	75 – 100	1x/day	$0.34	$22.65
Longmont-Ft Collins	City to City	FLEX	70 – 80	6x/day	$0.04	$1.25
Denver-Colorado Springs	City to City	Greyhound	70 – 90	3x/day	$0.18-$0.21, $0.28	$12.00-$14.50, $19.00
Denver-Colorado Springs	Airport to Airport	Colorado Springs Shuttle LLC	130	5x/day	$0.73	$50.00
Colorado Springs-Pueblo	City to City	Greyhound	50 – 60	5x/day	$0.27-$0.30, $0.39	$11.70-$13.00, $17.00
Denver-Vail	City to City	Greyhound	140	2x/day	$0.23-$0.25, $0.30	$29.00-$32.00, $38.00

Sources: Bus company websites: www.greyhound.com, http://www.coloradoshuttle.com, http://www.flexnoco.com, http://blackhillsstagelines.com

Locations of the main bus (and train) stations, and their proximity to downtown areas of the major study area cities, are set out in Table 5 for context. As can be seen, the locations (and related access/egress convenience) of these stations vary considerably among the cities in the study area.

Table 5 - Bus and Train Station Locations

City	Service	Description of Station Location / Pick-up Points
Denver	Greyhound	Central location; close to transit stop
	Arrow / Black Hills Stage Lines	Central location; same location as Greyhound station
	FLEX	Located in Longmont, 40 miles from downtown Denver; accessible to Denver by bus
	Colorado Springs Shuttle LLC	Located at Denver International Airport
	Amtrak	Central location, close to transit stop
Fort Collins	Greyhound	Central location
	Arrow / Black Hills Stage Lines	Central location; same location as Greyhound station
	FLEX	Central location; same location as Greyhound station
Colorado Springs	Greyhound	Central location; close to transit stop
	Colorado Springs Shuttle LLC	Located at Colorado Springs Airport
Pueblo	Greyhound	Near downtown Pueblo
Vail	Greyhound	Along I-70, near resorts

Sources: Bus company websites; www.greyhound.com, www.amtrak.com, http://www.coloradoshuttle.com, http://www.flexnoco.com, http://blackhillsstagelines.com

Commercial bus operators are generally reluctant to release ridership numbers. In the absence of any such information from the operators, approximate ridership estimates based on bus capacity and load factors can be prepared.

2.1.3 Air service

The study area is served by a large hub airport, the Denver International Airport (DEN), and three regional airports in Colorado Springs (COS), Eagle County (EGE) and Pueblo (PUB)[6]. Table 6 sets out a number of key characteristics of each of these airports, including its ranking among US airports in terms of 2011 domestic passenger enplanements, scheduled departures, passenger carriers operating at the airport, and enplanements per departure.

Denver International Airport located to the northeast of Denver, approximately 25 miles by car from the city center. It is the fourth busiest airport in the US, and a major hub for United Airlines, low-cost carrier

[6] Fort Collins Loveland Municipal Airport (FNL) is primarily used for general aviation - the only commercial air service is provided by Allegiant Travel Company, with roundtrip service to Las Vegas and Phoenix-Mesa. This airport does not serve any scheduled airline passengers within Colorado, and therefore will not be considered for further analyses.

Frontier Airlines and commuter carrier Great Lakes Airlines. It is also well served by Southwest Airlines. The airport functions as a gateway to the Colorado Rocky Mountain region, and is a major destination for domestic and international flights, as well as a connecting point for many longer-distance air trips. Colorado Springs Airport (COS), which is the second busiest airport in Colorado, and the other airports in the study area (EGE and PUB), are primarily served by feeder flights to DEN and other hubs; this obliges passengers traveling to other destinations to make a connection at these hubs.

Table 6 - Airport Characteristics

Code	Airport	US Airport Rank	2011 Passenger Enplanements	2011 Scheduled Departures	2011 Passenger Carriers	Enplanements per Departure
DEN	Denver International, CO	4	24,462,500	295,154	27	83
COS	Colorado Springs, CO	93	849,000	15,696	16	54
EGE	Eagle County Regional, CO	180	196,000	2,321	5	84
PUB	Pueblo Memorial, CO	320	14,500	1,155	8	13

Source: Airport Snapshots from www.bts.gov

Table 7 shows the total number of true OD (i.e. not connecting) trips between study area airport pairs by direction, with outbound passenger volumes shown to the left of the diagonal and inbound passenger volumes shown to the right of the diagonal. The data shown here are as reported in the DB1B airline ticket sample database, without additional processing.

Table 7 - Origin-Destination Air Trips by Direction, 2011

	Destination (To)			
Origin (From)	**Colorado Springs (COS)**	**Denver Intl. (DEN)**	**Eagle County (EGE)**	**Pueblo**
COS		3,290	10	
DEN	4,610		1,170	20
EGE	10	990		
PUB		20		

Source: DB1B Market data for number of passengers between airport pairs for 2011 Q1 to 2011 Q4, extracted from www.bts.gov

2.1.4 Rail service

Amtrak's California Zephyr service, connecting Chicago and San Francisco, currently operates one train a day in each direction between Denver and Glenwood Springs with intermediate stops at Fraser and Granby. The westbound train leaves Denver at 8:05am and the eastbound train leaves Glenwood

Springs at 12:10pm, taking 5:48 and 6:28 respectively to complete the end-to-end trip. The adult one-way fare is between $41 and $80 and the amenities offered are comparable to those provided on Amtrak's other long-distance trains. This service is not a direct competition to the projects considered here as its alignment is considerably north of the ICS project alignments (see Figure 1). The fares are approximately $0.27 to $0.51 on a per mile basis[7].

Amtrak maintains detailed station-to-station trip data that could be analyzed if needed. However, given a number of factors – the likely absence of any competition between the Amtrak and the AGS or ICS projects, Amtrak's material travel time disadvantage compared to the auto mode, its low frequency of service and the focus of Amtrak's marketing for this service towards longer-distance (including end-to-end) trips – it was not felt necessary to investigate this market in detail.

2.2 Intra-Urban Market

Interactions between the proposed rail system and Denver metropolitan transportation system are a key focus area of the ICS travel forecasting effort. Denver-area travelers will use the metropolitan transportation system for the access and egress legs of longer rail trips, and conversely the level of service experienced on the access/egress legs affects the attractiveness of rail for longer distance trips. Furthermore, the presence of multiple rail stations in the Denver area (including at the airport) means that the rail system will function as an urban travel mode that may both complement and compete with the other modes that serve the metropolitan area. All of these considerations point to the importance of studying the intra-urban travel market in the ICS. In addition to the access/egress legs of longer trips, three main types of intra-urban rail trip are of interest here:

- journeys to work (most likely between the suburbs and the city center);
- trips for leisure and other non-commute purposes; and
- trips to access the airport, as part of a longer trip (where the ultimate destination is outside the study corridor, and where the longer trip itself is not in scope to shift to the rail service).

Denver area trips will be modeled using a modified version of the existing DRCOG Compass travel demand model (as described below in greater detail). The resulting forecasts will then be overlaid onto the forecasts of inter-urban trips.

As shown in Table 8 below, other ICS corridor cities have transit systems that may interact with the proposed rail system. In these other cities such interactions will be represented and analyzed in a more aggregate way than will be the case in Denver.

2.3 Airport Choice Market

The introduction of premium rail service with a station at a hub airport may cause some air passengers – those whose trips begin at smaller regional airports and involve a change at the hub – to access the hub airport by rail rather than by air. Data on the total number of passengers traveling between the key airport pairs was examined to establish the potential size of this airport choice market. This differs from the data shown above in Table 7, which shows only the passengers traveling between each point, and does not include those connecting to flights to other national and international destinations.

[7] 157 highway miles

Table 8 - Transit Services in Corridor Cities

City	Type of Service(s)	Coverage in City	Coverage in Corridor	Typical Fares
Denver	RTD - Bus, light rail	Bus lines run throughout the Denver metro area; bus lines extend northwest to Boulder, south to Pinery, and west to Bergen Park / Evergreen. Light rail runs through Denver and extends south outside the city to Lincoln and Littleton	Bus lines extend north to Longmont	Local $2.25, Express $4.00, Regional >$5.00
Pueblo	Pueblo Transit - Bus	Bus routes cover downtown Pueblo; one route extends north on I-25 through Belmont and Eden	None	$1.00
Eagle	ECO Transit - Bus	None	Bus routes service Gypsum to EGE airport, Eagle, Avon, and Vail along I-70; bus also services throughout Minturn and Beaver Creek	Regular $4.00, Premium $7.00
Colorado Springs	Mountain Metro - Bus	Bus routes cover downtown Colorado Springs	None	$1.75
Fort Collins	Transfort - Bus	Bus routes cover downtown Fort Collins	None	$1.25
Summit	Summit Stage - Bus	None	Bus routes service several locations along I-70: Silverthorne, Dillon, Keystone, Frisco, Breckenridge and Copper Mountain	Free
Vail	Vail Transit - Bus	Bus routes service Vail only	Bus routes service Vail along I-70	Free

Sources: Local transit agency websites; http://www3.rtd-denver.com, http://www.eaglecounty.us/Transit, http://www.pueblo.us/index.aspx?NID=307, http://www.springsgov.com/Page.aspx?navid=996, http://www.fcgov.com/transfort, http://vailgov.com/subpage.asp?dept_id=46, http://www.co.summit.co.us/index.aspx?NID=586

Table 9 shows segment-level traffic information for the corridor airport pairs. The table includes total passengers, scheduled seats, scheduled departures, average daily frequency, average seats per flight, and average passengers per flight for 2011.

Comparing airport pair passenger volumes on these routes with the corresponding true OD traffic presented in Table 7, it can be seen that about 95% of corridor air passengers currently make connections in Denver or Colorado Springs.

Given the high share of connecting traffic and short travel distances between Denver and these other airports, it is plausible that air travelers between these smaller airports and Denver could consider the ICS rail projects as possible alternatives to feeder air, if the rail system provides good access to DEN.

Table 9 - Corridor Air Services Summary, 2011

City Pair	Passengers	Seats	Scheduled Departures	Flights / Day	Seats / Flight	Pax / Flight
DEN-COS	271,893	384,124	6,082	16.66	63.16	45.42
DEN-EGE	51,855	95,577	1,234	3.38	77.45	43.56
DEN-PUB	8,698	22,471	1,124	3.08	19.99	7.98

Source: T-100 segment data for scheduled passengers in corridor for 2011 Q1 to 2011 Q4, extracted from www.bts.gov

3 TRAVEL DEMAND FORECASTING METHODOLOGY

Figure 3 graphically illustrates the demand forecasting methodology that we propose to address these key travel markets and their forecasting challenges. This general approach has been applied in many rail studies in the US and internationally, and it has shown that it can facilitate the successful development of robust and credible rail ridership and revenue forecasts.

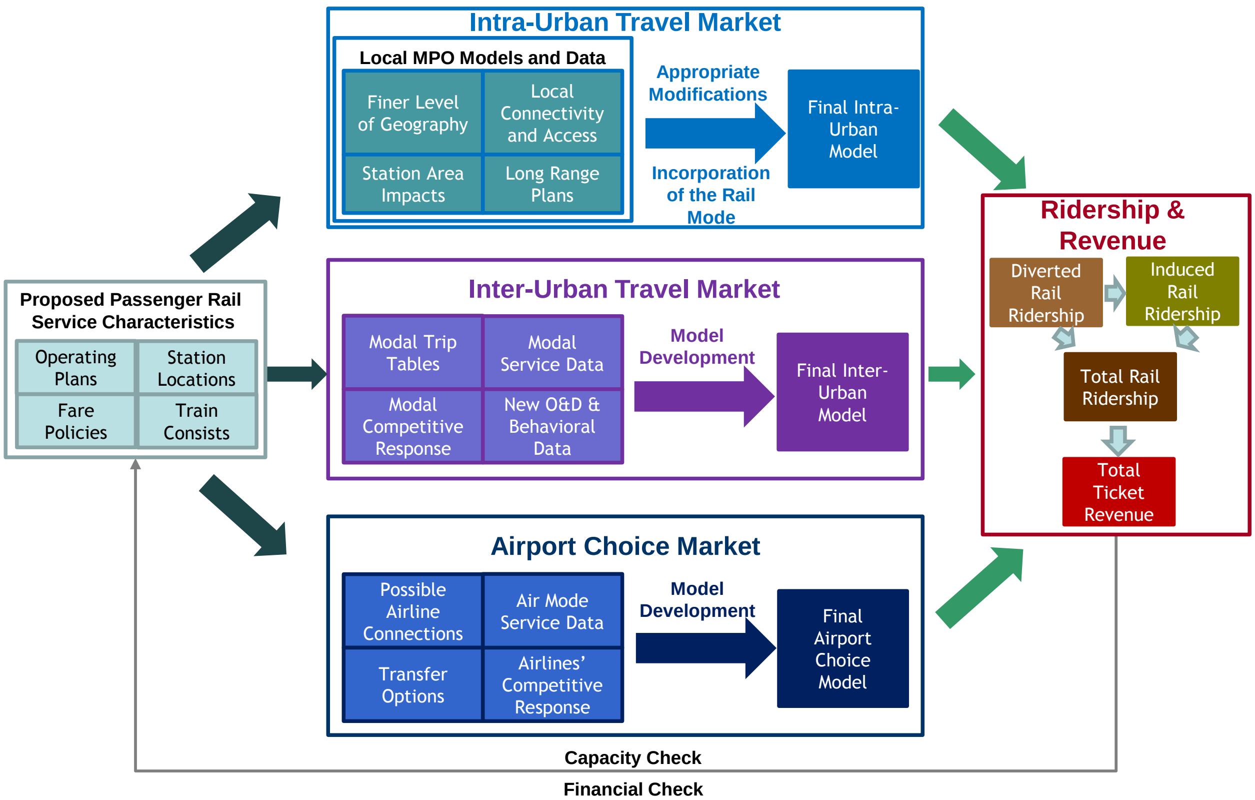
Service characteristics of the proposed passenger rail service alternatives (combinations of technology and speed, alignments and stopping patterns) are required as model inputs for the three markets. These may include:

- operating characteristics: stopping patterns, running and dwell times, schedule or frequency;
- station to station fares;
- station locations and connectivity/accessibility/parking; and
- train passenger carrying capacities, obtained from information on train consists.

Detailed descriptions of the modeling steps for each of these markets are provided below. As noted earlier, model development is an inherently exploratory process. While the modeling methodology will follow the general directions indicated here, it is expected that adjustments and modifications will be required as the model is developed and tested.

It is important to emphasize that all steps of the modeling approach will be open, transparent and free of proprietary software or methodology.

Figure 3 - General Ridership and Revenue Forecasting Framework



3.1 Inter-Urban Travel

The proposed approach to forecasting the potential ridership and revenue of the proposed rail services for the inter-urban market entails five broad steps:

1. establish the study area geographic scope and its zone structure;
2. define and establish all required input data including service characteristics for each mode and each zone pair;
3. estimate the current in-scope travel market;
4. estimate how this market will grow in the future; and
5. estimate the potential market share that the new rail service will capture (i.e. the ridership).

3.1.1 Establish the geographic scope and zone structure

The intercity model will cover a geographic area that generally follows the corridors and extends approximately 50 miles on each side of the proposed alignments, which is a typical planning assumption for the catchment area of high speed rail services. However, the 50-mile distance is indicative rather than absolute, and may be adjusted as appropriate in specific instances.

The study area defined in this way will be split into a number of zones. The four corridor MPOs (Denver Regional Council of Government [DRCOG], North Front Range MPO [NFRMPO], Pikes Peak Area Council of Government [PPACG] and Pueblo Area Council of Governments [PACOG]) have travel forecasting models that define zone systems within the MPO model areas. Given the size of the ICS study area, we propose to base the ICS model zone structure on the MPO model traffic analysis zones (TAZs) or some aggregation of them for the MPO areas, and on zones used in the I-70 PEIS for other areas. We specifically intend to use the DRCOG model TAZs for this study since the connectivity of the proposed ICS rail service with the Denver area transportation system is a key issue of interest. For the other MPO model areas we will likely use an aggregation of the TAZs defined in the MPO models. This strikes a good balance between the need to consider a large study area while having sufficient detail to reflect important geographic differences in modal service characteristics. This also provides a more detailed representation of the urban areas, while maintaining a manageable number of zones.

Figure 4 illustrates the MPO model coverage areas in the region and the I-70 PEIS zone boundaries outside the MPO jurisdictions.

3.1.2 Prepare input data

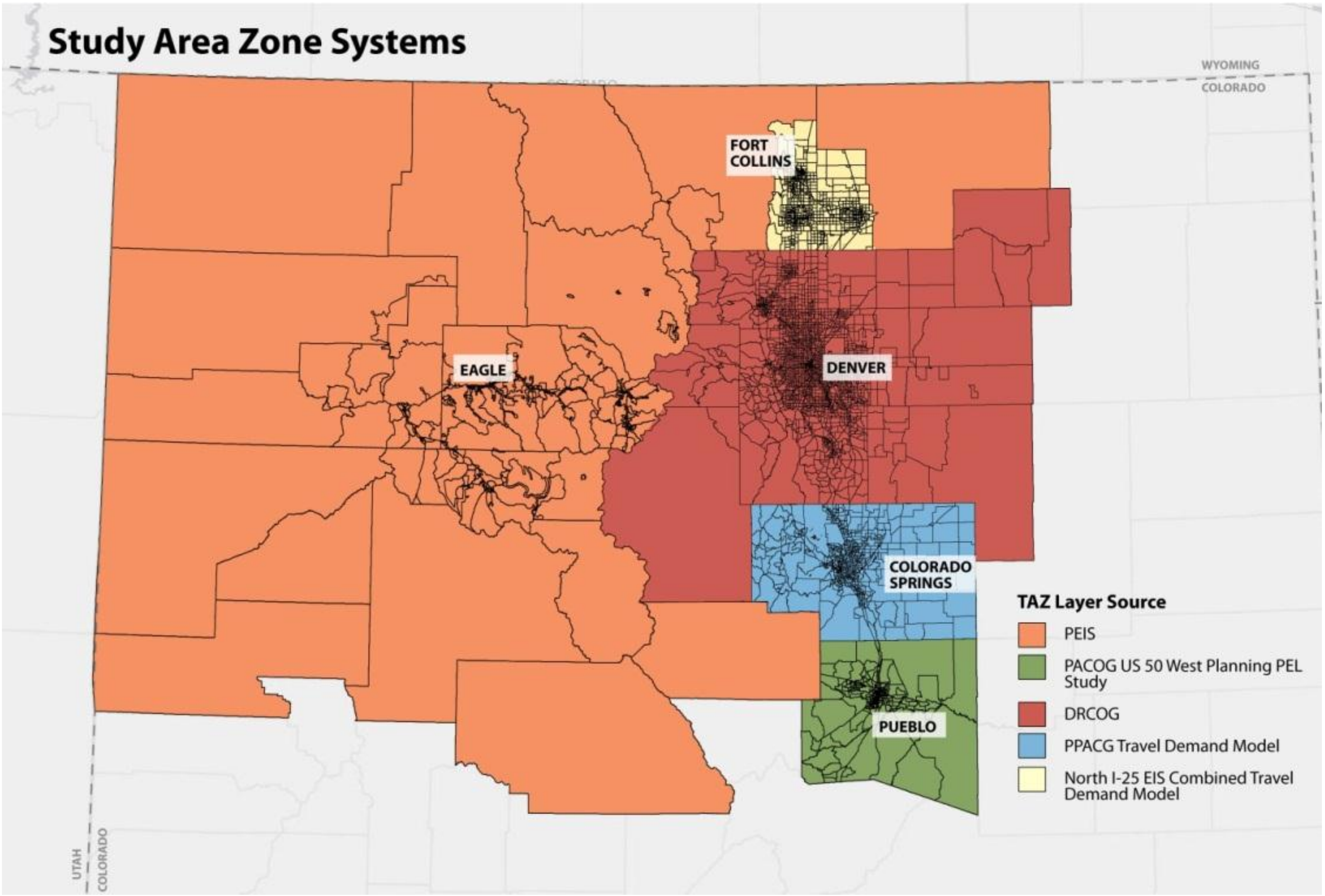
We will first establish the demand modeling base year and future forecast year(s) based on input from CDOT and other project proponents, and then collect or develop modeling input data for these years. These will include the study area network, historic and future socio-economic and exogenous variables (employment, population, income, general economic conditions, information on visitors, patients, students, commuters etc.), information about the service characteristics[8] of existing and future travel modes and about patterns and levels of trip making on these modes. This information will be collected from the MPO models, existing studies and other sources as applicable.

Accurate establishment of modal travel times is particularly important, and two approaches are commonly used to estimate these in travel forecasting. The first is to prepare a representation of the network using network modeling software and then use this to estimate travel times. The second is to estimate the times using empirical sources, for example commercial trip planning software (MapQuest and Google Maps) supplemented with real time travel alert websites (e.g. www.sigalert.com, www.beatthetraffic.com and www.cotrip.org). These data can then be combined with other assumptions (regarding vehicle operating costs, fares or service frequencies) to estimate modal service characteristics between individual zone pairs.

Irrespective of the method used to calculate the modal service characteristics, network modeling software can be useful for developing our forecasts, as it offers the capability to hold and manipulate the large volumes of data created in preparing demand forecasts, and has other useful functionality. In addition, travel times calculated from network modeling software can be used to check those obtained through other processes.

[8] For a trip by common carrier mode (including ICS rail service), this takes into account the in-vehicle time, frequency of service, fare, and time/cost needed to access and egress the mode's station from the trip's actual origin and destination. For a trip by automobile, this takes into account the OD travel time (including any delays due to road congestion) and vehicle operating costs (largely fuel cost).

Figure 4 - Zone Systems Used in the ICS Model Area



3.1.3 Estimate the current in-scope travel market

The inter-urban travel market includes trips by air, bus, train and private automobile, and for different travel purposes. Section 2 of this report has reviewed at a high level the salient characteristics of these travel markets. For the purposes of forecasting model development and application, data on these markets will need to be developed on a much more detailed zone-to-zone basis, as outlined below.

3.1.3.1 Air

Current true OD volumes and patterns of corridor travel by air (local air trips) can be determined by reference to standard sources such as the DB1B and T-100 databases from the Bureau of Transportation Statistics (BTS). These local airport-to-airport volumes can be allocated to OD zones, and their trip purpose (business vs. non-business) distribution can be estimated using data from the Census, County Business Patterns, and Woods and Poole.

Similarly, air passengers who are connecting between the study area airports during the first or final legs of their trips can be quantified from segment level data of the T-100 databases.

3.1.3.2 Intercity bus and transit

As mentioned before, bus ridership data tends to be treated as commercially sensitive by the bus operators, so intercity bus and other intercity transit (including shuttle services to ski areas) OD trip tables will primarily be developed using supply side research and assumptions (from existing frequency of service and appropriate load factor assumptions) to get zone pair volumes in the study area.

3.1.3.3 Rail

Trip tables for existing rail services (Amtrak's California Zephyr) can be prepared using Amtrak data at the station-pair level, and allocated to zones and trip purposes as described above. However, as was noted before, the Zephyr service is not a direct competition to the ICS rail service, so we do not feel that detailed investigation of its ridership characteristics is likely to be useful. We believe that it would be more advantageous to focus modeling resources on the modes that carry the majority of inter-urban trips, and to address a secondary mode like rail through post-model adjustments, if required.

3.1.3.4 Auto

In forecasting intercity passenger rail ridership and revenue, the accuracy of the auto trip tables strongly influences the overall accuracy of the forecasts. However, in contrast to the air mode, relatively little data on intercity automobile travel is collected at the national level, and in the US there currently is no standard up-to-date source of information about intercity auto trip making that is sufficiently detailed to be used in project-level forecasting.

Moreover, in the study area itself there is no single source of information on inter-urban auto travel. The estimates of inter-urban travel volumes used in the I-70 PEIS and the North I-25 EIS are possible sources of such data. However, the trip tables used in these studies were not based on original OD surveys. Moreover, the inter-urban trip tables from the I-70 PEIS are now over a decade old, certainly requiring an update and making their use for the ICS subject to question and possibly criticism.

Study area MPOs have recently participated in the Front Range Travel Survey (FRTS), which covered both local travel in the participating MPOs as well as longer distance travel. At the time of this writing the FRTS results were being finalized (issues related to the appropriate weighting of the raw survey data were being worked out). We expect the FRTS to be a very useful reference data source on inter-urban travel characteristics and patterns for the ICS.

All of the four corridor MPO travel models incorporate a representation of internal/external and external/internal auto trips (those that enter/exit the model area from/to elsewhere), but do not provide detailed identification of the external origins and destinations. Data in the individual models is not specific enough by itself to allow the individual model trip tables to be "woven" together into a single trip table covering the entire corridor and providing information on, for example, the number of auto trips from a particular zone in Denver to a particular zone in Colorado Springs.

The 1995 American Travel Survey (ATS), which focused on long distance tripmaking by households, was considered as a possible source of data, but was not used for several reasons. The information is starting to be quite dated. Moreover, the low sample size used in this survey (80,000 households across the U.S.) seriously constrains its accuracy at a detailed geographic level such as a corridor.

Information on journey-to-work travel in the corridor can be obtained from the year 2000 Census Transportation Planning Package (CTPP)[9]. In particular, within the limits of the Census long form sample rate (roughly 15% of households), the CTPP gives detailed information on work commute volumes and patterns by mode, including auto. Although the information dates from year 2000, with suitable factoring it is an adequate basis for establishing current inter-urban commute travel volumes and patterns, as well as for checking the estimates made for other modes and using other data sources.

On the other hand, a significant portion of inter-urban travel in the corridor is auto trips for purposes other than the journey to work (e.g. leisure trips to the ski area by study area and non-study area residents). As discussed above, investigations to date have not revealed any readily useable source of data on these trips.

Of course, traffic volume and classification counts are available for the major corridor roadways. The problem is that the traffic data combines both travel within the corridor and longer-distance travel, as well as travel for different purposes, without distinction or identification of origin and destination.

The lack of detailed up-to-date data on inter-urban automobile travel in the study corridor prompted the investigation of a new program of original travel data collection. Among possible data collection efforts, conducting new surveys to establish intercity automobile travel patterns and levels is quite resource intensive. Moreover, there are other issues that may limit the usefulness of new surveys. On the one hand, intercept surveys conducted directly on major roadways such as I-70 or I-25 would likely encounter logistical difficulties and other obstacles, while surveys of drivers at off-mainline locations such as rest stops tend to give highly biased results. On the other hand, interview or travel diary surveys

[9] The Census long form questionnaire from which the CTPP data is extracted was discontinued following the 2000 Census.

of randomly selected households in the corridor would duplicate work done by the FRTS, and collecting information on inter-urban travel in this way can sometimes be challenging because of the relative infrequency of these longer-distance trips.

Anonymous cell phone data was determined to be the best way to understand the origins and destinations of auto travelers in the corridor. A firm called AirSage was engaged for this purpose. AirSage has a contract with Sprint to obtain the communications protocol data exchanged between mobile devices and communications towers; these data allow the movements of mobile devices to be analyzed in a way that preserves the anonymity of device owners and the privacy of their communications. Archived data are available from January 2010. This is a newly available and rich data source with great potential given the large sample size, wide geographic coverage, availability of prior years' data, and ongoing collection without intervention by users or network operations staff.

We have used AirSage data for a number of rail forecasting studies. The technology is still developing and we are familiar with its challenges and with robust approaches for extracting useful travel information from the data. This will be an efficient way of obtaining useful data on travel patterns in the study area. Key advantages for the ICS include:

- ready availability of a large sample of several years of anonymized cell phone movement data;
- ability to obtain current or retrospective information for multiple seasons – very useful for the ICS/AGS due to travel seasonality in the study area;
- ability to aggregate data to different time periods (weekday/weekend; periods within the day);
- less expensive than most other OD data collection methods; and
- travel time data for the analyzed time periods can also be obtained (at additional cost).

However, there are also some issues with this kind of data including:

- limited applicability in the context of urban tripmaking. (Location accuracy is generally not adequate to provide useful geographic resolution in urban environments);
- lack of direct information about trip or tripmaker characteristics other than origin and destination;
- it is based on an evolving technology that has not yet attained complete maturity.

It was necessary to identify representative time periods for which cell phone data are obtained and processed. Based on an examination of CDOT data on the monthly distribution of traffic volumes at rural locations on I-70 and I-25, it was decided to prepare intercity auto trip tables for three month-long periods in 2011. The selected months were mid-February to mid-March, and all of July and October. The first represents a typical winter period; July generally has the highest traffic volumes on both facilities; while October is a "typical" month in terms of volumes and likely mix of trip purposes. The trip table(s) developed in this way will be validated against information from the Front Range Travel Survey and trip tables from other studies if available.

3.1.4 Estimate future growth of the in-scope market

These estimates will reflect socio-economic trends (such as changes in population and employment) and assumptions regarding the sensitivity of changes in trip making behavior to these trends.

Separate mode-specific econometric models (also called direct demand models) will be used to estimate the volume of OD trips by zone pair in future analysis year(s) by auto and bus based on exogenous socio-economic characteristics and modal levels of service. These direct demand models capture exogenous demand growth and have the following general functional form:

$$T_{OD}^{m} = f(P_{OD}, E_{OD}, LOS_{OD})$$

where

T_{OD}^{m} = number of trips by mode m made between origin O and destination D;

P_{OD} = population estimates related to O and D;

E_{OD} = socio-economic and other exogenous variables related to O and D;

LOS_{OD} = level-of-service variables (including prices) for the existing modes between O and D.

Given the current data described earlier, the direct demand models allow us to develop projections of future year trip volumes by auto and bus based on changes in the relevant input variables. We then use survey data and other sources to estimate, for each mode, the shares of total trips that are made for business and nonbusiness purposes.

Future year air trip tables will be prepared based on published FAA Terminal Area forecasts of total annual airport enplanements for each of the study area airports as these are a generally-accepted standard source.

3.1.5 Estimate the rail project market share

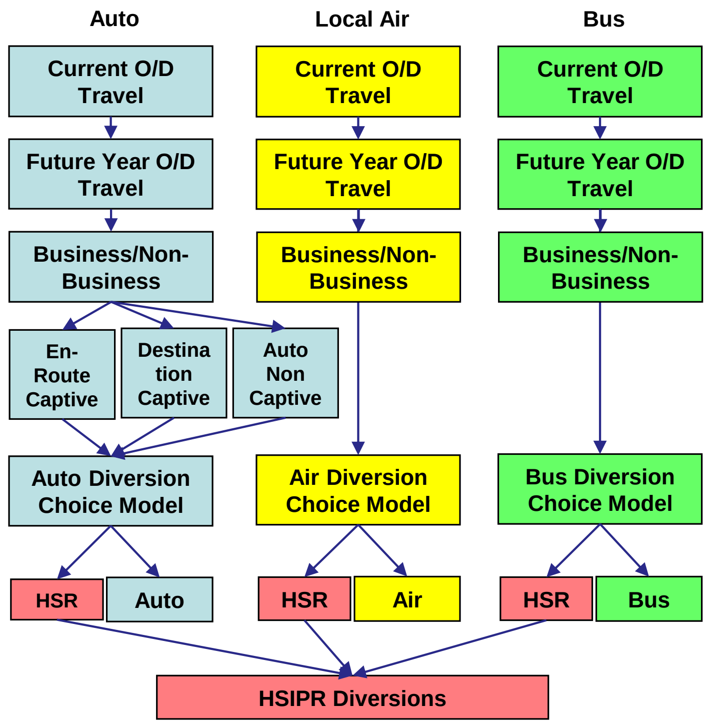
For the inter-urban market forecasts, we propose to apply a method that we have used on numerous FRA- and USDOT-funded studies. The key feature of this method is its use of separate binary (two mode) logit relationships to predict traveler diversions from each existing mode to the new rail service. Binary logit models are one of the standard methods used to predict the market share of new or improved travel modes. Compared to other forecasting approaches, we have found these models to be transparent, readily explained and assessed, robust and practical. They reflect a theoretically satisfying choice structure, and generally avoid many of the issues that other approaches often encounter.

As noted, this approach is similar to that adopted in our other ongoing FRA funded demand forecasting projects for HSIPR services in the Chicago-St. Louis corridor, Atlanta-Charlotte corridor, Oklahoma City-South Texas corridor and for a sketch-planning demand forecasting tool developed for the FRA's National Rail Planning Study. Forecasts produced using this methodology have been benchmarked to Amtrak's Acela Express and Northeast Direct ridership and revenue in the Northeast Corridor.

This forecasting approach is graphically shown in Figure 5. Travel market segments are carefully defined based on a combination of current mode, trip purpose and other traveler and trip characteristics. Market segments include:

- local air travel;
- inter-city auto travel; and
- inter-city bus or other transit travel.

Figure 5 - Inter-Urban Modeling Framework



This market segmentation approach to premium rail mode choice modeling is based on the recognition that people's current choice of intercity modes reveals a great deal about their preferences for the various features of travel modes. For this reason, we expect that a market segmentation based in part on the current preferences of intercity travelers in the ICS study area for air, private vehicle and bus will also capture significant differences between the segments in their attitudes and preferences towards premium rail. Incorporating trip purpose in the market segmentation further captures known behavioral differences between people traveling for different purposes.

For each combination of trip purpose and current mode, we calibrate relationships of the following form that express the fraction of travelers who would divert from the existing mode to the premium rail mode as a function of the respective modal service attributes. These relationships are then applied to predict the volume of travel on the modes that will divert to rail. Induced (new) travel on the rail mode is separately forecast using models based on changes in composite traveler utility. Total rail ridership is obtained by summing the predictions for the individual market segments and OD pairs.

$$S_{OD}^{m,HSR} = f(time_{OD}^{m,HSR}, cost_{OD}^{m,HSR}, freq_{OD}^{m,HSR}, QOS_{OD}^{m,HSR}, const_{OD}^{m,HSR})$$

where

$S_{OD}^{m,HSR}$ = share of existing mode m trips between O and D that will divert to premium rail;

$time_{OD}^{m,HSR}$ = access, egress, line-haul, and processing time components for mode m and rail;

$cost_{OD}^{m,HSR}$ = access, egress, and line-haul travel cost components for mode m and rail;

$freq_{OD}^{m,HSR}$ = measures of the frequency for mode m and rail;

$QOS_{OD}^{m,HSR}$ = quality of service measures (comfort, reliability, etc.) for mode m and rail; and

$const_{OD}^{m,HSR}$ = effect of unquantified characteristics of rail relative to the existing mode.

As shown in Figure 5, we will use a set of binary logit models to predict diversions to premium rail by each mode and trip purpose; each such model compares the attractiveness of premium rail against one existing mode (local air, auto, bus, as applicable) for one trip purpose.

The modal diversion process is further refined by distinguishing between three groups of auto travelers: (1) those who need a vehicle at their final destination ("destination-captive"), (2) those who do not ("non-captive"), and (3) those who need to make stops en route during their trip ("en route-captive"). Many analyses of intercity travel assume that intercity trip makers are not captive to a particular mode, but empirical work indicates that this is not the case, particularly for private vehicle travelers. The likelihood of selecting premium rail for intercity travel will be very different for the three groups of auto travelers since, for example, those who need a vehicle at their final destination (group 1) will have to arrange for other transportation, typically by paying for the additional cost of renting a vehicle for the duration of their stay and spending extra time renting and returning the vehicle. In addition, private vehicle travelers who need to make stops en route during their trip (group 3) are considered not to be "choosers"; that is, they are not eligible for diversion to rail.

Each diversion model computes the probability that a traveler would choose rail over the current travel mode, given the modes' respective service characteristics. Characteristics include time, cost, frequency, reliability, and quality of service, for rail and the current mode, with time and cost typically broken down into their access, egress, transfer, terminal and line haul components. Mode-specific constants account for the effects of other (not explicitly modeled) characteristics of rail relative to other modes.

Rail access/egress, transfer and terminal characteristics by different RTD modes in the Denver metropolitan area will be explicitly modeled. The DRCOG Compass model system will be used to represent transit access/egress connectivity to the ICS premium rail projects. Conversely, for trips within the Denver area, the ICS projects may provide an alternative to RTD modes for some station pairs, and again the DRCOG model will be used to analyze this competitive situation (as discussed later).

In order to assess the attractiveness of a proposed new mode relative to other existing modes, data are required about traveler responses to the new mode. These data are sometimes obtained from surveys called Stated Preference (SP) surveys. SP surveys are used to elicit traveler preferences and tradeoffs involving different modal attributes. Survey data can then be used to develop choice models involving the new mode, such as the binary models described above. Both the I-70 PEIS and the RMRA studies undertook SP surveys.

Despite our best efforts to locate detailed survey data from the RMRA, we were not able to do so. The consensus among Denver-area transportation planners that we contacted about this is that the data are simply not available.

In contrast, we received SP survey data from the I-70 PEIS and assessed its potential applicability to the ICS study. We concluded that this dataset is not usable for this current study, as our investigation of this dataset revealed a number of potentially serious issues:

- the PEIS had difficulty using this data to develop its models. Standard statistical analyses produced unreasonable values for many key parameters, so the PEIS model development team was forced to constrain (fix) their values – a procedure that is generally considered less than desirable;
- the number of new modes considered in the PEIS and its SP survey was very large[10] – shuttle van, tour bus, guideway bus, train or monorail – and in some cases the presentation of these modes to survey respondents may have been unclear. SP survey respondents tend to become confused or fatigued when presented with large numbers of very different choices, and this can ultimately lead to the survey producing poor quality data;
- the number of modal attributes incorporated in the survey was also very large and may have overwhelmed the respondents, again possibly compromising the quality of the survey results; and
- travelers' behavior may have fundamentally changed in the last decade.

Ideally, forecasting efforts should be based to the extent feasible on recent locally-collected data. The advantages of this are that it provides the best possible empirical basis for accurate forecasts, it allows incorporation of conclusions and results from earlier efforts, and it guards against possible criticisms regarding lack of local relevance in mode choice modeling. Other useful characteristics of study area travel such as auto captivity, travel party size, travel purpose, etc. can also be obtained via a survey. Hence, it was decided to undertake a new but limited SP survey for the ICS and to develop new mode choice models based on this data.

An internet-based SP survey was developed and conducted by the well-known travel survey firm Resource Systems Group, a subcontractor to the ICS team. Due to time constraints, the survey focused on study area residents who were members of a market research survey panel; it was not possible within these constraints to survey visitors from outside the study area. However, efforts to contact visitors via email lists from study area resorts may be pursued with CDOT support.

Approximately 950 complete survey responses were obtained from the SP survey of study area residents. These data are currently being used to develop mode choice models (as described above) that will calculate traveler diversions from existing modes to the proposed new rail mode. Model development will also incorporate relevant information from other sources (e.g. USDOT guidance on values of time for intercity travel), and professional judgment based on forecasting best practices as required.

[10] This is in contrast to the ICS, which has a relatively narrow range of alternatives to define and evaluate.

3.2 Intra-Urban Travel

The ICS project may include a station at Denver International Airport (DEN) and elsewhere in the Denver metropolitan area. The project could provide local rail service via these stations.[11] The ICS forecasting activity will investigate interactions between the rail project and the Denver metropolitan transportation system both as regards the metropolitan access/egress portion of inter-urban ICS rail trips, as well as the functioning of the ICS project as a local travel mode within the Denver area.

The DRCOG Compass[12] model has been developed to predict travel flows and conditions in the Denver metro area.[13] The model uses multinomial logit mode choice models that predict travelers' choices between several auto mode options as well as a variety of transit modes with their access/egress components. Existing and possible future RTD modes are represented within the transit modes of the Compass model. In effect, for any particular OD trip, the Compass model assesses the mode choices by comparing the time, cost and other modal service attributes of each available mode; the comparison also includes a term (mode specific constant) that reflects travelers' intrinsic preferences for each mode, other things equal. In addition, alternative specific dummy variables are used in the model to account for four geographic market segments – trips attracted to Boulder; trips attracted to the Denver CBD; trips attracted to DIA; and all other trips. The mode choice model parameters including the mode specific constants and the geographic market specific dummies were adjusted during the model calibration process to obtain a statistically satisfactory match between model results and observed market shares.

The ICS travel demand forecasting activity will use DRCOG's Compass model to forecast Denver-area ICS project travel demands, treating the rail project as an additional transit mode within the already-defined mix of transit modes and with adjustments as required. This approach makes maximum use of the detailed understanding of Denver-area travel patterns and behavior already embodied in the Compass model system. It does require, however, decisions about the appropriate representation of ICS rail within Compass' current mode choice model components. Rail service characteristics such as speed and fare translate directly into the model's service attribute variables such as travel time and cost. It is also necessary to represent the extent to which travelers may prefer a premium rail mode, other things equal. This is typically done via a model adjustment termed a modal constant.

We intend to use data from the recently concluded SP survey to determine an ICS rail modal constant for use in the Compass model system. This option is based on original data collected from potential rail users themselves. Although the focus of the SP survey was on inter-urban travel, it will provide useful insight about how residents value the rail *vs.* auto modes even for intra-urban travel.

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[11] Intra-urban travel impacts of the ICS rail project are likely to be less significant in the Colorado Springs, Fort Collins and Pueblo urban areas. These areas will be adequately handled by the inter-urban travel modeling approach described earlier.

[12] The RMRA study used a proprietary forecasting model that was also called COMPASS but that was completely unrelated to the DRCOG Compass model. Any reference to Compass here is to the DRCOG model.

[13] DRCOG has recently also developed a next-generation forecasting model called Focus. As Focus has not yet been applied for production use outside of DRCOG, the ICS forecasting effort preferred to rely on the better-established Compass model and avoid the risks inherent in early applications of a new model system.

In summary, our proposed approach to model ICS rail in the Denver metropolitan area is to extend and adapt DRCOG's trip-based Compass mode choice models. This adaptation will be done using data from the recently conducted SP survey, to the extent possible and applicable, as well as other applicable references and sources.

3.3 Airport Choice

In general, the introduction of a high-speed rail service with a station at a hub airport can produce changes in air demand levels and patterns. Air travelers who begin their trip at a regional airport and change planes at a hub airport may prefer to access the hub airport by rail, or indeed may in some cases change their choice of hub. The ICS travel demand forecasting effort will develop an airport choice model to forecast these potential shifts.

Because of the attractiveness of Denver International Airport (DEN) as a hub (due to the large number of destinations served, and the presence of major carriers there), the main issue here is modeling the behavior of air travelers who begin their trip in other relevant[14] study area regional airports - Colorado Springs (COS) and Eagle County Regional (EGE) - and who have the option of taking a connecting flight at DEN to their destination. This connection at DEN may be obligatory (no other flight from the regional airports is viable) or optional (direct flights from the other airports or viable connecting flights via other hubs are available from the regional airport). When considering a connection at DEN, the choice then is whether to begin the trip at the regional airport, fly to DEN and connect there to the onward leg; or to access DEN via a surface mode (including possibly ICS rail) and begin the air leg there. Similar but reversed choices confront air travelers who end their trip in the three regional airports.

Information necessary to size this market (i.e. to determine the volume of trips between COS/EGE/PUB and other airports, including via connections at DEN) is available from data sources such as the BTS DB1B database.

For a variety of reasons, it is proposed to develop a model of airport choice using any already-available airport passenger surveys, from available research on this topic and from similar models that other studies have developed: it is not proposed to conduct air passenger surveys for this purpose. Such surveys would involve close coordination with the airports and be logistically complex. Experience has shown that the modeling of these choices is typically fraught with problems due to data limitations and econometric difficulties; it is preferable to rely on work that has already dealt with these problems elsewhere, rather than to devote significant project resources to addressing them here.

Premium rail access to DEN may affect trips from the regional airports that have other air travel options (direct flights from COS/EGE/PUB or connecting flights via other hubs). This is highly dependent on the competitive response of the air carriers to the presence of rail service between the regional airports and DEN (e.g. code sharing with the rail service, air carriers swapping slots for the feeder services in favor of slots for long-haul air services). Our analysis will be confined to a limited number of the highest volume airport destinations from the regional airports and, for each of these, will compare the non-DEN option

[14] Meaning that there are significant connecting air trips between DEN and the study area airport. Pueblo Memorial (PUB) is not mentioned here because of its very low volumes.

to a connection at DEN accessed via the premium rail service. The comparison will incorporate possible airline connections and transfer options by including trip cost, together with access, wait, transfer and line haul times, appropriately weighted, and will be based on a simple model estimated from current volume shares of different routes, as obtained from USDOT DB1B and/or T-100 databases.

There are also significant seasonal variations in available air service in EGE. During the first quarter of the calendar year (winter months), there are 16 flights daily as opposed to 4 flights a day during the rest of the year in and out of EGE. The resulting variations in possible airline connections and transfer options for the air mode as well as with the ICS rail mode will be analyzed separately to account for the potential differences in rail demand between the first quarter and the rest of the year.

The ICS demand forecasting team is familiar with issues related to air-rail competition and complementarity, as highlighted in our study[15] of this topic for the European Commission. We will draw on this experience and knowledge for this current study.

3.4 Induced and Suppressed Demand

Induced travel refers to trips that were not made before a project opens, but which come to be made as a result of the mobility and accessibility improvement that the project brings about. Two different sources of induced travel can be distinguished:

- people decide to not make a trip when the disutility of travel is greater than the utility that they derive from making the trip. A transportation system improvement reduces the disutility of travel, so when people re-assess their former decision to not make a trip, some may find that the trip has now become worthwhile and decide to make it.
- over time, the mobility and accessibility changes brought about by a transportation system improvement will produce changes in the type, intensity and location of land uses and economic activities in the improvement's impact area. The transportation improvement will affect the socio-economic system. Increased population and economic activity will lead to increased travel.

Very succinctly, the former is travel induced as a result of movement along a demand curve, while the latter is travel induced by a shifting of the demand curve itself.

The ICS travel demand modeling effort will consider the former form of induced travel. However, it is beyond the scope of this effort to predict the land use and economic changes that might result from the presence of the premium rail service in the corridor. If other groups prepare forecasts of the effects of new rail service on socio-economic development patterns in the corridor, these can be used to assess the impacts of this growth on travel flows and conditions in the corridor.

With this understanding, it is proposed to forecast the induced travel resulting from the introduction of the premium rail service using a simple elasticity-based approach, where the elasticity is expressed as the percentage impact on travel volumes resulting from a percent change in accessibility. Accessibility, in turn, will be defined in terms of a generalized cost or logsum variable computed from the mode choice model. Reasonable elasticity values (or a range of values for sensitivity testing) will be proposed if no local source of data for estimating these is identified during the study.

[15] http://ec.europa.eu/transport/rail/studies/doc/2006_08_study_air_rail_competition_en.pdf

Suppressed demand is a related issue. It has been noted that congested traffic conditions on I-70 may dissuade some people from making trips that they might otherwise take, for example recreational trips to Eagle County. According to this argument, observations of current travel patterns and levels do not necessarily provide accurate information about the trip volumes that would result from a substantial improvement in corridor travel conditions. The induced demand modeling approach described above is in principle able to capture such suppressed demand effects, as both suppressed and induced demand represent movements along a demand curve. However, we will review the issue in greater detail during the project, including the analysis of this phenomenon that was carried out in the PEIS, and may adapt our induced demand analysis if appropriate.

3.5 Modeling Alternatives

Our demand modeling methodology will be flexible and able to model a range of project alternatives. At a minimum, the model will be able to accommodate:

- multiple alignments within the study area;
- multiple train technologies (variations of top and average speeds, which will deliver different station-to-station travel times); and
- multiple service patterns (including the number of stops en route – all stop vs. skip stop services, the frequency of service, and the fare levels).

Note that there are limits to this flexibility. For example, alternatives with more than one station within the same zone cannot be easily modeled via the approach proposed here, and in some cases situations involving multiple characteristics will be represented in terms of an average rather than individually.

Ridership and revenue forecasts will be produced for base and future forecast years. As reliable forecasts of socio-economic data for study area counties are only available through 2040 from third party vendors such as Woods and Poole, socio-economic forecasts beyond 2040 will be extrapolated. All revenue numbers for the base and horizon years will be reported in common year constant dollar values (2012$). Ridership and revenue forecasts for all years between base and future forecast years can be produced by interpolation.

3.6 Rail Ridership and Farebox Revenue

Premium rail ridership diverted from different existing modes for the three markets are combined to produce total diverted ridership to the ICS rail mode. The induced rail volume is then added to the diverted ridership to calculate total rail ridership. As discussed above for airport choice modeling, if we anticipate that other modes will modify their service characteristics in response to rail competition, we also take this into account in the modeling. As was seen above, our models directly estimate diversions from other modes to rail. Consequently, impacts such as ridership and revenue losses on competing modes can be directly calculated from model outputs.

All ridership forecasts will initially be produced at the rail station pair level. Ridership at this level will then be multiplied by the corresponding fares to obtain ticket revenue for the station pair. Detailed ridership and revenue forecasts will be produced including OD trip tables at zone- and station-pair levels; station boardings and alightings; and rail diversions by source mode. These outputs will be suitable as inputs for other elements of the planning and environmental assessment process.

Each of the premium rail modeling alternatives developed by the study process will be appropriately represented. Demand impacts will be forecast for all components of the study area transportation system, not only the ICS rail mode.

In addition to being able to model project alternatives, the model will be specified to carry out a range of sensitivity analyses to determine the effects of the changes in the values of key endogenous (fare and level of service attributes of the rail mode, competitive factors with other modes) and exogenous (socio-economic characteristics, gas price) variables on ridership and revenue and consequently on project finances and other project impacts. This capability also provides a useful tool for checking the model's reasonableness and robustness.

We will also investigate alternate ICS rail fare policies in order to identify those that maximize revenues in the absence of capacity or other constraints. We have successfully conducted such analyses to determine revenue maximizing fares; key to these analyses is a detailed understanding of the relationship between ridership and fare levels.

3.7 Capacity and Financial Information Feedback

Our demand analysis will take into account train passenger capacity to avoid a potential mismatch between the forecast ridership and available passenger carrying capacity as specified by the service plans. In the event of a mismatch, we will work with the study team to revise the rail service characteristics discussed above and will reforecast. The study team may also evaluate various financial metrics (ticket revenue, operating ratio) which may warrant further revisions to the plans for the proposed rail service. In the event of such revisions, the demand forecasts will be redone as well.

4 SUMMARY, DECISIONS AND NEXT STEPS

This Modeling Framework Report has summarized the context in which the ICS travel demand forecasting activities will be conducted, highlighted the modeling methodology that will be followed, identified a number of options regarding data sources for the modeling effort and discussed a couple of new original data collection efforts (among the possible options) that were recently undertaken. Because the demand modeling work is still at an intermediate stage, many of the detailed methodological issues have not been finalized yet. However, these will inevitably need to be resolved during the model development and application; for this reason, the description of the methodology presented here is at a relatively high level, and some elements described may ultimately change.