AN ABSTRACT OF THE THESIS OF

Ian M. Roholt for the degree of Master of Science in Civil Engineering presented on March 6, 2013.

Title: Developing an Analysis Framework to Compare Commuter Rail Service and Bus Service in the Mid-Willamette Valley in Oregon

Abstract approved:

Katharine Hunter-Zaworski

This thesis develops a framework for analyzing the application of commuter rail and bus services between several small urban centers to enhance overall connectivity. The study includes analyzing specific performance criteria for commuter rail service and express bus service based on data from existing systems around the U.S. The study then compares these findings to the theoretical performance of commuter rail and express bus service in the U.S. Highway 20 corridor from Corvallis, OR to Lebanon, OR via Albany, OR. The study concludes that commuter rail rated higher in six of eight analysis criteria and would be the preferred mode to bus service in terms of the performance criteria used in the study. Further cost and operational analysis is necessary to analyze implementation of future commuter rail or express bus service in the Mid-Willamette Valley in Oregon.

Developing an Analysis Framework to Compare Commuter Rail Service and Bus Service in the Mid-Willamette Valley in Oregon

by
Ian M. Roholt

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Ian M. Roholt, Author

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

Page

Figure

LIST OF TABLES

Page

Table

Chapter 1 - Introduction

There is a growing demand and enthusiasm to create better public transportation options in the Willamette Valley in Oregon. The Willamette Valley, from Eugene, Oregon to Portland, Oregon has been designated by the federal government as part of the Northwest High-Speed Rail Corridor. As seen in Figure 1, this corridor connects Vancouver, B.C., Seattle, WA, Portland, OR, Eugene OR and cities between them via railways (1). Currently, studies are being performed by the Oregon Department of Transportation (ODOT) to determine appropriate routes to meet this mandate from the federal government.

Higher-Speed Rail will likely be established in Oregon in the near future, creating a need to transport passengers from cities located east and west of the Northwest High-Speed Rail Corridor (NWHSRC) in the Willamette Valley to stations along the corridor. This will allow passengers to travel north and south through the region by higher-speed rail. Though there are modes of public transportation serving towns along the Highway 20 corridor (Philomath,

Figure 1: Pacific NW High-Speed Rail Corridor (38)

Corvallis, Albany, Lebanon, and Sweet Home), few studies have been performed to compare passenger rail service to other transportation modes such as bus transportation. The Oregon Department of Transportation performed a rail study in 2010 to analyze potential high-speed rail corridors as well as the current conditions of all of the rail lines in Oregon. The report mentioned a line called the "Corvallis Option" (the segment of railway connecting Corvallis and Albany) which was modeled by ODOT through computer simulation. The "Corvallis Option" was modeled to determine the feasibility of connecting Corvallis to the main Willamette Valley corridor. ODOT determined that further analysis was necessary to estimate the feasibility of the route since the modeling techniques they used were only accurate for lines of 50 miles and longer (1).

ODOT has not been the only entity to explore this transportation option. The "*Benton County Comprehensive Plan*" mentions that one of the goals they should aim for is to "actively plan for and promote the idea of commuter rail service between Albany and Philomath at the earliest possible time" (2). Similarly, the "*Linn County Comprehensive Plan*" states "A transit opportunity that needs to be explored is institution of passenger service on the Burlington Northern and Southern Pacific line between Sweet Home, Lebanon, Albany and Corvallis" (3).

Essentially, it has been determined by planning groups from both county and state agencies that there is interest in exploring a potential passenger rail line that extends across the Willamette Valley from Philomath to Sweet Home via Corvallis, Albany and Lebanon. That interest helped develop the following thesis questions:

1. Is passenger rail a viable option for this corridor?
2. Is bus transportation that follows a route similar to the rail alignment more viable than passenger rail?
3. When is the best time to implement commuter rail as a transportation mode?

This thesis aims to answer those questions. The purpose of the thesis is to develop a high-level framework analysis to analyze two transportation modes between the cities of Corvallis in Benton County and Albany and Lebanon in Linn County. The two modes explored are commuter rail service and a bus service. For the purpose of the study, the locations of the stations are assumed to be the same for both modes due to the ease of comparison and that most stations currently act as multimodal hubs which feature both modes of transportation. The thesis compares these two modes on the following criteria:

- Travel Time
- Vehicle Service Life
- Fuel Efficiency
- Capital Costs and Operational Costs

- Person Capacity
- Line Capacity
- Safety
- Service Reliability

Data from these criteria was gathered from academic articles, interviews with industry professionals, GIS data, transportation agencies and public records. Quality of Service was also the primary measure of these criteria and was determined using the "*Transit Capacity and Quality of Service Manual*" (4).

Chapter 2 - Literature Review

2.1 Rail Transportation

2.1.1 Rail Characteristics

Passenger Rail service can be described in many different terms. Four characteristics used to describe the difference between rail transportation from other modes of transit include: external guidance, rail technology, electric propulsion and right-of-way (ROW) separation. Of these criteria, the two that define rail transportation the most are external guidance and rail technology (5). External guidance means that rail vehicles are physically steered by their tracks instead of steered from within the vehicle. This characteristic is distinctly different from roadway vehicles. Rail technology refers to the flanged steel wheels running on two steel rails. This technology is unique to rail transportation which is commonly referred to as “steel-tire” as opposed to roadway transportation being called “rubber-tire” (6). Electric propulsion refers to the form of power that propels most passenger rail transportation systems. This is not a definitive characteristic, but is true for most systems around the world. ROW separation designates that passenger rail vehicles operate on a ROW that is separate from the ROW that other modes of transportation use, such as automobiles (7). This is another rule that is not definitive as exampled by streetcars and trolleys, but it is a characteristic of most rail systems around the world.

The passenger rail system analyzed in this study is similar to the definition developed by Vukan Vuchic in "*Urban Transit Systems and Technology*", but has minor variations (5). The vehicle in this study will assume to operate on an external guidance system and will use rail technology. However, the analysis will assume that a diesel-electric multiple unit (DMU) is the vehicle of choice for this study area. This assumption is made because freight locomotives use the existing infrastructure at the present time without any electrical propulsion infrastructure. Constructing systems to electrically propel passenger trains on a freight line is very capital intensive and would likely interfere with the existing freight operations. The study corridor also meets the definition of right-of-way separation because trains are the only vehicles that can access and use the ROW.

2.1.2 Rail Modes

Vuchic describes four categories of passenger rail: Streetcars/Tramways (SCR/TW), Light Rail Transit (LRT), Rapid Rail Transit (RRT), and Regional Rail Transit (RGR).

SCR/TW and LRT are lighter modes which typically travel slower, carry fewer passengers and offer more frequent service (8). This mode also often shares its ROW with other transportation modes, such as cars and buses, and predominantly uses electrical propulsion. Neither of these modes were considered in this study because they are most frequently used in dense urban areas with electric power. Local examples of this mode include the Portland Streetcar or the Metropolitan Area Express (MAX) in Portland, Oregon.

Regional Rapid Transit (RRT) is a heavier form of rail transport which carries more passengers and has a much more separated ROW than SCR/TW and LRT. This mode is typically used in very dense urban settings and predominantly uses electric propulsion by a third rail. This mode was also not considered in the study. Some examples of RRT in the U.S. include the New York Subway, the Washington D.C. Metro, and the Bay-Area Rapid Transit in San Francisco, California (8).

Regional Rail Transit (RGR) is different from the previous three types of rail transport. RGR is similar to RRT in that it has multiple cars that carry between 140 to 210 passengers per train, but the average operating speeds are typically higher due to station spacing being further apart and average corridor length being longer. Another common term for this regional service is commuter rail, which refers to travelers typically using the service to commute into and out of dense urban areas such as downtown or a central business district (8). The terms regional rail and commuter rail are very similar with slight differences in the operations of the service. For the study the term “commuter rail” is used

Commuter rail is a mode that has the highest operational and technical standards of transit. This is due to the service being offered by railroad agencies and passenger services often sharing lines with freight services. The regulations of the Federal Railroad Administration (FRA) instead of the Federal Transit Administration (FTA) govern this mode because lines are shared with freight railroads. Most commuter rail systems around the world operate with electric power, however some use diesel-electric engines. This mode is fully grade separated which means that only rail vehicles operate on tracks and no other vehicles share the ROW (8).

The code of federal regulations also describes "commuter rail passenger transportation" as “short-haul rail passenger transportation in metropolitan and suburban areas usually having reduced fare, multiple-ride, and commuter tickets and morning and evening peak period operations” (9).

After examining Vuchic’s definitions of rail transit in general, and commuter rail transportation in particular, the mode that will be studied in this analysis is a form of commuter rail. The assumed vehicle will be a diesel-electric multiple unit similar to the Westside Express Service (WES) that currently operates in Portland, Oregon. The system will be analyzed using the existing freight structure.

2.2 Bus Transportation

2.2.1 Bus Characteristics

The characteristics of bus transportation are different from rail transportation. Although there are many small variations that make defining different bus transport modes complicated, there are a few fundamental differences that separate bus transportation from rail transportation. Buses travel on wheels with rubber tires, contrary to the "steel-tires" of trains. Also, buses are steered from within the vehicle by an operator instead of guided by an external element such as a track. Additionally, buses are able to mix with street traffic due to the previously mentioned criteria (7). Though there are bus modes that have characteristics differing from these mentioned, the bus mode that is analyzed in this study operates with these characteristics.

2.2.2 Bus Modes

There are several different modes of buses having varying sizes (15 passengers to 140 passengers), shapes, propulsion systems (diesel, electric and hybrid), and access to exclusive ROWs (busway, bus rapid transit (BRT), and conventional bus) (4). The bus mode analyzed in this study models a bus type that already exists in the Linn-Benton Loop fleet. This type of bus is a standard bus, ranging 33 feet to 40 feet in length and can carry up to 85 passengers (35 seating/55 standing). Analyzing this type of bus is logical because using buses that already exist in the Linn-Benton Loop fleet would be the most economical and realistic option.

2.3 Rail and Bus Comparison

There are advantages and disadvantages when comparing the guided system of rail transportation to the steered system of bus transportation. Below is a table showing the typical differences in operations of both modes and criterion regarding the advantages and disadvantages of guided transportation systems.

Table 1: Technical, Operational, and System Characteristics of Urban Transport Modes (5)

Technical, Operational, and System Characteristics of Urban Transport Modes (For RB & CR)			
Characteristics	**Unit**	**Regular Bus**	**Commuter Rail**
Vehicle Capacity	sps/veh	40-120	140-210
Vehicles/TU	veh/TU	1	1-10
TU Capacity	sps/TU	40-120	140-2,400
Maximum Technical Speed	mph	25-50	50-80
Maximum Frequency	TU/h	60-180	10-30
Line Capacity	sps/h	240-8,000	8,000-60,000
Normal Operating Speed	mph	9-16	25-50
Operating Speed at Capacity	mph	5-9	24-46
Lane Width	ft	10-12	13-16
Reliability	-	low-med	very high
Safety	-	med	very high
Station Spacing	mi	0.12-0.31	0.75-2.8
Investment cost per pairs of lines	10M$/mi	0.8-9.6	80-192

Advantages of Guided Systems

The advantages of a guided system are:

- Guided systems have the ability to use larger vehicles and to operate those vehicles in trains. This greatly increases line capacity, provides lower operating costs and allows easy adjustments to increasing passenger volumes.

- The mode has higher overall performance in speed, capacity and reliability.
- Automation of signaling systems provides fail-safe operations and prevents potential accidents due to operator error.
- Require a narrower ROW.
- Reduces air pollution in pedestrian areas (electric systems).
- Operations in tunnels are feasible (electric systems).

Disadvantages of Guided Systems

- Require a fully separate ROW which necessitates larger investment costs.
- Requires construction of stations which increases investment costs.
- Has a much more limited network making route choice much more rigid and necessitating travelers transfer more.

2.4 Framework Criteria Development

2.4.1 Previous Studies

The "*Southeast King County Commuter Rail Feasibility Study*" included an analysis of the projected ridership, the capital and operational costs, and the institutional issues associated with beginning commuter rail operations between Auburn, Covington and Maple Valley, Washington. The study conducted analysis to compare express bus operations to commuter rail operations along the corridor, but because it was a feasibility study, the authors thoroughly analyzed the costs associated with beginning commuter rail service along the corridor and how the costs fluctuate given different ridership projections. This study was more focused on the financial analysis of operations than the performance of operations along the corridor. The comparison of the two modes for projected ridership levels was useful but there was a lack of performance criteria to accurately compare the operational performance of both modes along a single corridor (10).

A study that developed criteria for comparing rail operations is the "*Draft Final Alternatives Selection Report: Identification of Reasonable and Feasible Passenger Rail Alternatives*" prepared for the departments of transportation in Minnesota and Wisconsin by Quandel Consultants LLC. Nine criteria were developed in the study: route characteristics, travel time, market size, capital costs, operating costs, safety, reliability, system connectivity, and environmental features to determine the best route for high-speed rail from the Twin Cities region of Minnesota to Milwaukee, Wisconsin. The purpose of the study was different from the research reported in this thesis, as the goal was to find the best route for high-speed rail and not to compare rail transportation to bus transportation (11). Categories such as route characteristics, market size, system connectivity and environmental features are important when considering corridors but were not used in analysis of the highway 20 corridor because the route was approximately the same for both modes. The remaining criteria (travel time, capital costs, operating costs, safety, reliability) were chosen to analyze because they were used in this study, they are criteria suggested by Vuchic, and the criteria compares both rail and bus transportation effectively.

2.4.2 Developing Analysis Criteria

Vuchic identifies four broad categories that must be considered when evaluating transit systems: 1. Performance, 2. Level of Service (LOS), 3. Impacts, and 4. Cost of the system (5). In the Performance category, he lists eight features:

1. Service Frequency: the number of Transportation Unit (TU) departures every hour
2. Operating Speed: the speed of travel on the line of the TU
3. Reliability: the percentage of vehicles arriving "on time"
4. Safety: the number of fatalities or injuries per 100 million passenger-mi or similar unit
5. Line Capacity: the maximum number of spaces or passengers that a TU can carry past a given point in an hour
6. Productive Capacity: the product of operating speed and line capacity (a convenient composite measure of mode performance)
7. Productivity: the quantity of an output per another unit such as vehicle-mi per operating cost, fuel, etc.
8. Utilization: the ratio of output to input such as person-km/space-km offered (5).

Productive Capacity, Productivity and Utilization were not analyzed in the study because they are abstract ratios which are more important to consider when analyzing complex transit systems, not single corridors. They are also easier to calculate for services that are existing; this study is analyzing proposed systems which do not currently exist.

Service Frequency, Operating Speed, Reliability, Line Capacity and Safety were examined because these parameters were more easily measured and estimated. These parameters also relate directly to the needs of the riders who continually look for transit service that is on time, frequent and has adequate carrying capacity. Four of these five criteria are also included in the criteria considered for Oregon High-Speed Rail: Reliability, Frequency of Service, Journey Time, Accessibility, and Cultural Acceptance (12).

2.5 Level of Service and Quality of Service

The "*Transit Capacity and Quality of Service Manual*" (TCQSM) defines LOS as "Designated ranges of values for a particular service measure... based on a transit passenger's perception of a particular aspect of transit service" (4). This is not to be confused with the TCQSM's definition of Quality of Service (QOS): "The overall measured or perceived quality of transportation service from the user's or passenger's point of view, rather than from the operating agency's point of view" (4). The main difference between the two is that LOS is based on the perception of the authority that provides the transit service while QOS is based on the perception of the passenger. Both perceptions have important roles in rating transportation systems.

2.6 Framework Criteria Definitions

2.6.1 Travel Time

The travel time classification used in this study is Station-to-Station travel time. This type of travel time is defined as "the time interval between a Transit Unit's departure from two adjacent stations" (13). Essentially, it includes the sum of the amount of time required for the TU to travel from one station to another and the dwell time at either station (13).

2.6.2 Vehicle Service Life

There are three elements to consider for determining the length of vehicle life: the economic life, the physical life and the functional life (13). The economic life of the vehicle defines the lowest life-cycle costs of the vehicle such as the average cost per year over the entire life of the vehicle. The physical life defines the time span in which the vehicle operates with acceptable maintenance and reliability requirements. The functional life of the vehicle is defined by the length of time until the technology used by the vehicle becomes obsolete or replaced by better technology (13). A vehicle could easily have many years left in its economic or physical life yet overrun its functional life. This study will analyze the average physical life of the modes because it is simpler to analyze and it is the largest contributing factor to determining when to purchase new vehicles. Functional life is also referred to as "vehicle service life".

2.6.3 Fuel Efficiency

Fuel efficiency is important to consider for transportation. Though neither of the modes in this study use electric propulsion, it is necessary to compare which mode transports passengers with the least amount of fuel consumed to keep operation costs and environmental impacts low.

The amount of energy used to generate an output is called energy consumption. The inverse of this, measured output by a consumed energy amount is called energy efficiency. There are multiple ways to quantify the amount of output based on energy consumption, four common ones include: kilowatt-hours/vehicle-mile, kilowatt-hours/ton-mile, kilowatt-hours/space-mile and kilowatt-hours/person-mile (5). The fourth unit, kilowatt-hour/person-mile, will be the value analyzed in the study because it quantifies the amount of energy used per passenger and is easily compared across modes.

Bus and rail modes utilize energy for processes other than propelling the vehicle. The energy that is used in auxiliary functions such as fixed-facilities (stations, yards, signals, etc.) and support functions (maintenance, cleaning, inspection, etc.) were not considered in this study.

2.6.4 Capital and Operational Costs

Capital Costs refer to "expenses related to the purchase of equipment" (14). Equipment is defined as "an article of non-expendable tangible personal property having a useful life of more than one year…" (14). Operational costs refer to "expenses associated with the operation of transit agency and good s and service purchased for system operation" (14). It is the sum of the costs associated with vehicle operations, vehicle maintenance, non-vehicle maintenance and general administration.

2.6.5 Line Capacity

Line capacity defines the number of transit units (TUs) that can operate on a section of track over a given period of time (4). Factors that can affect the line capacity of a system include: signaling systems, track geometry, line crossings or grade crossings, station activity such as dwell time and redirection time, and other mode specific issues such as mixing with traffic (4).

A line capacity issue very common to commuter rail service is the shared use of track with freight rail service. Many small commuter rail lines do not own the tracks that they operate on and therefore must negotiate operations with the freight company that own the right-of-way (4). Because of the variation in commuter rail operations from location to location and the other minor factors that affect capacity, computer simulation is the most highly recommended tool for accurately calculating line capacity (4). Because of the high-level of analysis, this study will utilize techniques to estimate line capacity in the corridor other than computer simulation.

2.6.6 Safety

Safety is commonly "measured by the number of fatalities, injuries, and property damage per 100 million passenger-km or a similar unit" (5). Safety was measured in this unit because it shows the rate at which incidents happen per a passenger-mi. Comparing the safety of the modes in the study will simply be analyzing and comparing the number of incidents the two modes experience nationally.

2.6.7 Person Capacity

The person capacity of a vehicle is how many passengers can be transported in the vehicle. For services where distances between stops or total trip travel time is short, it is common for passengers to stand during the trip. The modes analyzed in this study provide a service that is longer in distance than typical urban transit (4). Therefore, it is assumed that all passengers will sit during the trip and the number of seats in the vehicle will determine the person capacity. The equation to calculate person capacity is simple: (number of TUs per hour) x (number of seats per TU) x (0.90). The 0.90 is a peak hour percentage that allows for varying demand in passenger boarding (4).

2.6.8 Service Reliability

Service Reliability refers to how well a transit mode remains on schedule and is "expressed as a percentage of TU arrivals with less than a fixed time deviation from schedule" (5). For example, if the fixed time deviation from the scheduled arrival time is 4 minutes, then a vehicle that arrives within 4 minutes after the scheduled arrival time is considered on time. If it arrives after the 4 minute interval, then the vehicle is considered late.

The modes in this study are proposed and do not currently exist. It is therefore impossible to measure the service reliability of the modes along this corridor. To analyze service reliability, the service reliability of similar transit services in the region were analyzed to estimate the service reliability of this corridor.

2.7 Analysis Area

The area of the study includes the Oregon Highway 20 corridor connecting the cities of Corvallis, Albany and Lebanon. Portland and Western Railroad operates on the ROW from Toledo through Corvallis and into Albany. Albany and Eastern Railroad Co. operates on the tracks from Albany to Lebanon. These track corridors will be the line analyzed for commuter rail service.

Lebanon, Albany and Corvallis are connected via US 20 which travels through the downtown areas of all three towns. Corvallis and Lebanon are also connected via OR 34 with a connection to Albany in between via OR 99E. These highway segments will be the routes used to analyze the bus transportation. Figure 2, below, shows a map of the analysis area.

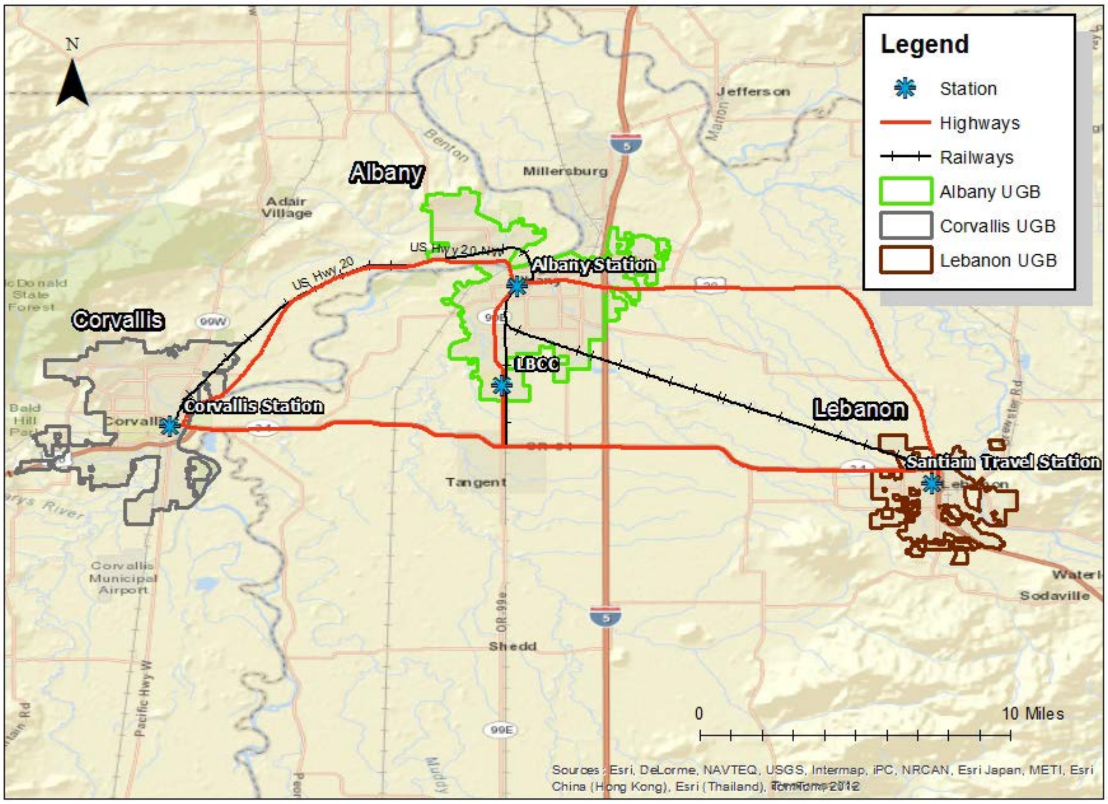

Figure 2: Corridor Map (source: *TIGER GIS data, ESRI background map*)

2.7.1 Corvallis

Corvallis is the county seat of Benton County located in the central part of the Willamette Valley (15). It has an estimated 2012 population of 55,055 making it the 10th largest city in Oregon with a total area of 13.8 square miles. Corvallis is the largest city in the Albany-Corvallis-Lebanon combined statistical area (CSA) and the largest city in Benton County (15). Major employers in the city include Oregon State University, Hewlett-Packard, Good Samaritan Hospital, the Corvallis Clinic and

CH2M Hill (16). Figure 3, below, shows a map of the city with the highway and railway connections.

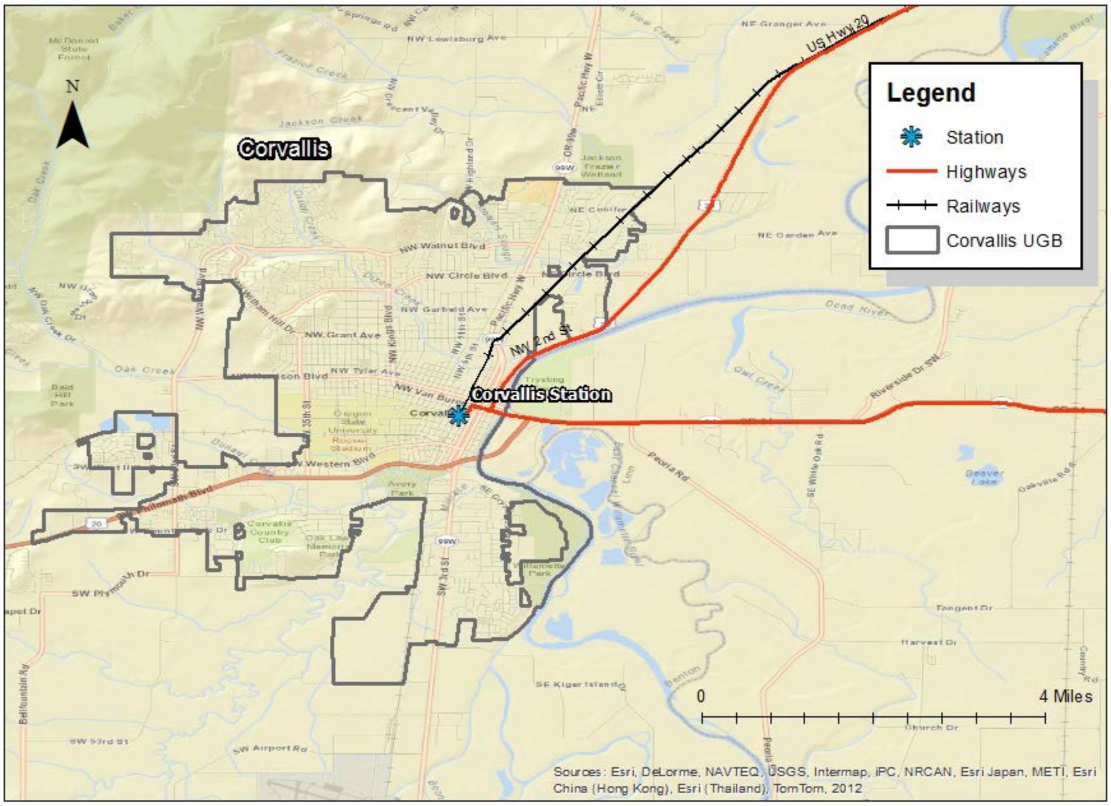

Figure 3: Corvallis City Limits (source: *TIGER GIS data*, *ESRI background map*)

2.7.2 Albany

Albany is the county seat of Linn County and is the largest city in Linn County (17). It has an estimated 2011 population of 50,520 making it the 11th largest city in Oregon with a total area of 17.7 square miles. The city is home to major employers such as ATI Wah Chang, National Frozen Foods Corporation, Golden West Homes and

Weyerhaeuser Inc. (18). Albany is also home to Linn-Benton Community College which is a large draw for dual-enrolled students from Oregon State University (19). Figure 4, below, shows a map of the city with the highway and railway connections.

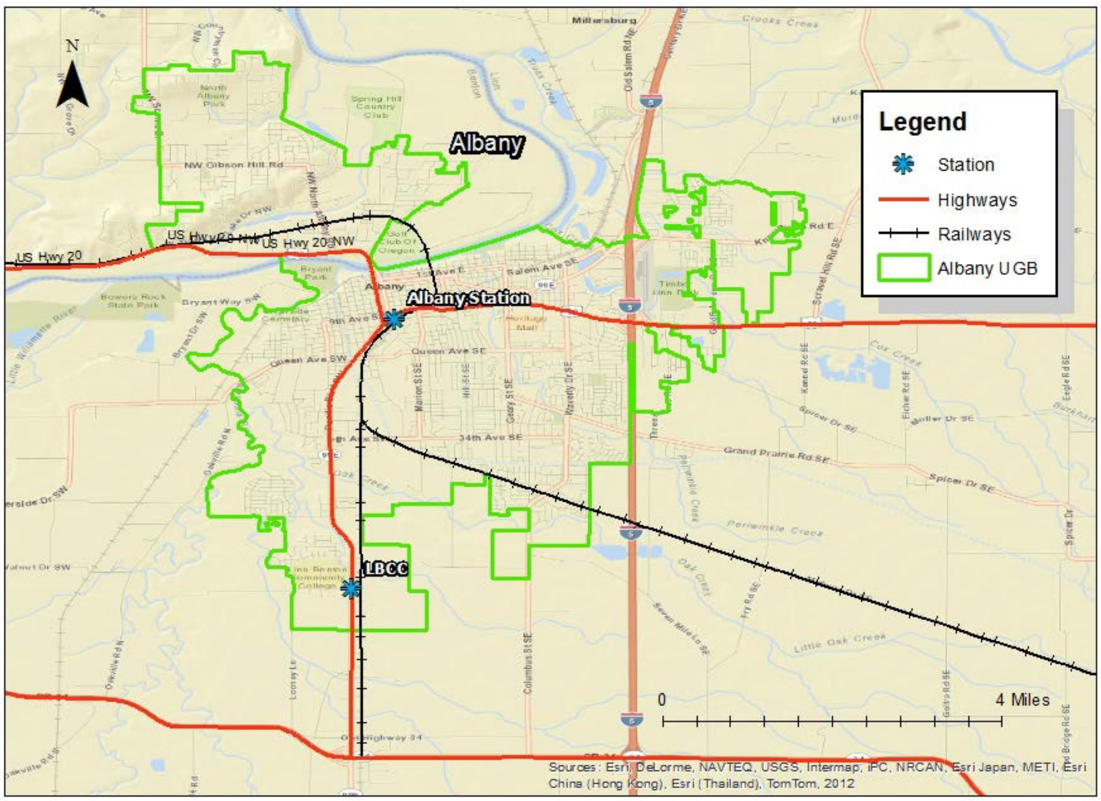

Figure 4: Albany City Limits (source: *TIGER GIS data, ESRI background map*)

2.7.3 Lebanon

Lebanon is located in Linn County and is the 34th largest city in Oregon. It has a 2011 population of 15,565 with a total area of 6.78 square miles (20). The largest employers, as of 2003, in the town include the Lebanon Community Hospital, Weyerhaeuser, Entek Manufacturing, Georgia Pacific and the Willamette Valley Rehabilitation Center (21). Lebanon is also home to the recently built College of Osteopathic Medicine of the Pacific Northwest (22). Figure 3, below, shows a map of the city with the highway and railway connections.

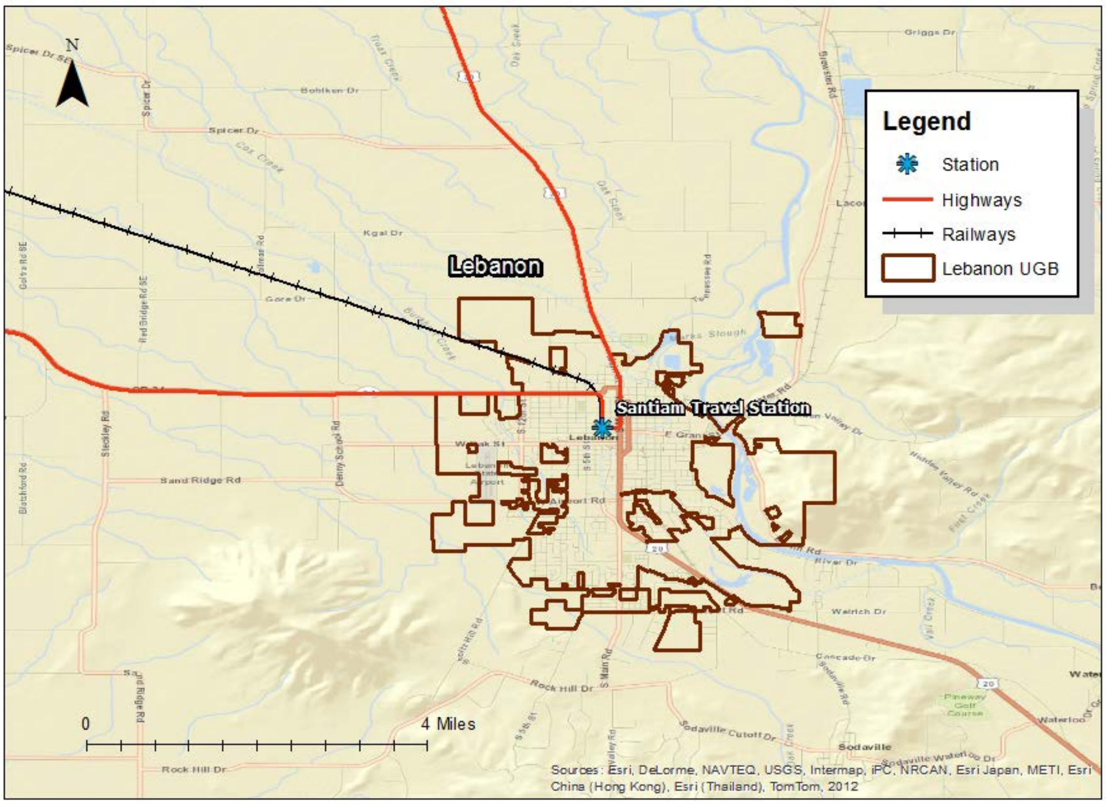

Figure 5: Lebanon City Limits (source: *TIGER GIS data, ESRI background map*)

2.7.4 Stations

This study does not aim to determine the optimum location of stations. Simply, the locations of the stations for this study will be the existing stations at the Corvallis

Transit Center (CTC), the Albany Station (AS), and the Santiam Travel Station (STS). The CTC is located one block from downtown Corvallis where highways 20, 34 and 99W meet. It is also where the Corvallis bus system begins and ends their routes, the Linn-Benton Loop currently stops and the Philomath Connection transports passengers from Philomath to CTC. The station is about two blocks from the Corvallis Greyhound Station. Similarly, the AS is a stop for the Albany Transit System, the Linn-Benton Loop, the Valley Retriever, Amtrak and Greyhound. The third station location will be the Santiam Travel Station in Lebanon. The building used to be owned by the Southern Pacific Railroad and was used as a passenger and freight station in previous years. The building was renovated in 1998 and is now owned by the City of Lebanon (23). The City of Lebanon intends for the building to be used as a multi-modal facility in the future, which further warrants the location for analysis (24). The station is also two blocks from US 20 making the comparison with bus transportation ideal.

2.7.5 Highway 20

Highway US 20 is classified as a regional highway by ODOT and is mainly a rural minor arterial with sections that are classified as rural principle arterial and urban principle arterial (25). The highway is mostly two lanes with more lanes added in divided sections in urban areas. There are two sections of the highway that were analyzed. The first section is designated as ODOT Hwy #31 and it begins on 2nd Street in Corvallis and ends at the junction with Hwy 99E in downtown Albany. The second section begins at the diverging of Hwy 20 and Hwy 99E and ends at E. Oak Street in downtown Lebanon (25).

2.7.6 Highway 34

Highway OR 34 is classified as a regional highway by ODOT and is mostly a rural principle arterial, but is classified as an urban principle arterial in both Corvallis and Lebanon. The highway is a four-lane road from Corvallis to Denny School Road west of Lebanon. From that point it is a two-lane road with a two-way-left-turn lane until becoming a two-lane road just after Langmack Road. The volume data for this roadway begins on Van Buren Street in downtown Corvallis and ends on Morgan Street in downtown Lebanon just before the highway connects to US 20.

2.7.7 Highway 99E

Highway OR 99E is classified as a regional highway by ODOT and is mostly a rural minor arterial except in Albany where it is classified as an urban principle arterial. Through downtown Albany the highway is divided with two to three lanes in both directions. South of the Albany Station the highway becomes a four-lane roadway until it connects with Highway OR 34. Volume data will be analyzed from the automatic traffic classifier Sta. 22-022 to the point right before the Highway 34 on-ramp.

Chapter 3 – Analysis Methods & Materials

3.1 Introduction

The analysis for this study is high-level due to the lack of data from existing commuter services currently operating in the corridor. Because of this constraint, the analysis was done using operational and performance data from other existing commuter rail and bus systems in the United States. General performance for the criteria was analyzed for existing transit modes and systems. The proposed commuter service and the existing bus service were then analyzed using these criteria and the available operational and performance data.

3.2 Data Collection

The data for this study came from various sources. Most of the operational and performance data came from the "*American Public Transportation Association (APTA) 2012 Fact Book*" (26). This data was used to calculate vehicle fuel efficiency and capital and operational costs. Safety was calculated using data from the Federal Transit Administration (FTA) (27). Reliability data was collected from the Tri-County Metropolitan Transportation District (TriMet) of Portland, OR (28) and the Central Puget Sound Regional Transit Authority (Sound Transit) of Seattle, WA (29). The on-time performance data was collected for bus and rail service at these transit agencies due to the availability of the data and the geographical proximity to the analysis area.

3.3 Methods for Criteria

3.3.1 Travel Time

As seen in Figure 6, there are two possible equations used to calculate station-to-station travel time: one where the distance from one station to the next is too short for the TU to reach full speed and the other is when there is enough distance for the TU to reach full speed. In the first scenario only acceleration, braking, and standing times are considered while the second scenario includes time traveled at full speed (13). This research will deal with the latter scenario due to the distance between proposed stations.

Due to the complex nature of a bus intermixing with traffic and being subject to traffic signals and intersections, the station-to-station travel time of the bus will use a travel time estimation from GPS software such as Google Maps. This travel time estimation will then be added to the station dwell time to calculate the station-to-station travel time. The expression for station-to-station travel time is:

$$T_{si} = t_{ri} + t_{si} \tag{1}$$

Where: T_{si} = Station-to-station travel time

t_{ri} = Running travel time

t_{si} = station standing/dwell time

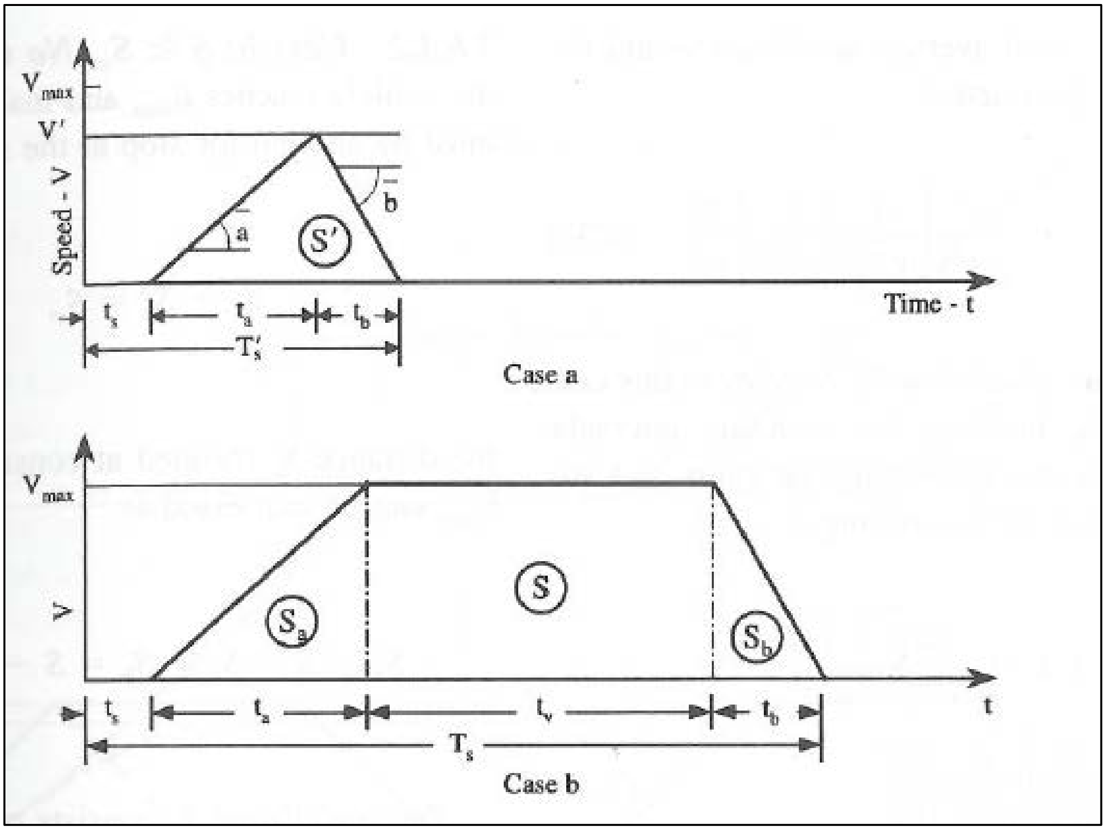

Figure 6: Travel Time Regimes (5)

3.3.2 Vehicle Service Life

To determine the service life of the modes, typical life span information was collected from Vuchic (13). This collection of information helped to approximate the average life span of a typical vehicle in each mode. Table 2, below, shows typical physical service lives of public transportation vehicles.

Table 2: Typical Life Lengths for Rolling Stock of Different Transit Modes (13)

Transit Mode	**Typical Life (Years)**	**Maximum Life (Years)**
Minibus, van	4-6	7-10
Bus	10-12	15-20
Trolleybus	15-18	20-30
Rail: Tramways, LRT, Metro, Regional Rail	25-30	40-50

3.3.3 Fuel Efficiency

The standard unit of measure for fuel efficiency is *passenger-distance/energy output*. For this study, U.S. customary units were followed and therefore, the fuel efficiency for the two modes was calculated in *passenger-miles/kWh*. This calculation was performed by finding the total passenger-miles travelled by mode in the United States. The most recent data available is from 2010 so the calculations cover the years 2001 to 2010. The other data necessary for this calculation was the energy consumed to propel the rail and bus modes. The bus consumption of energy was measured in gallons of diesel. To convert this unit to kWh, a conversion of 1 gallon of diesel fuel = 13.891 kWh of electricity was used. The passenger-miles were then divided by the kWh of electricity to determine the fuel efficiency. The same method was used to calculate the fuel efficiency of diesel-electric commuter rail systems in the U.S. The total energy consumed for commuter rail included diesel propulsion and electric propulsion energy added together.

3.3.4 Capital and Operational Costs

The capital and operational cost calculations were similar to the fuel efficiency calculations. The typical unit of measure is *cost/passenger-distance*, which for this study is *dollars/passenger-miles*. To calculate this unit, the same values for total passengers miles in the U.S. from 2001 to 2010 were used. In addition, the total capital expenses and the total operational expenses for each year were collected for each mode. These expenses were then simply divided by the passenger-miles for the year and then added together to get the total capital and operational costs in dollars/passenger-mile per year.

3.3.5 Person Capacity

The person capacity of both modes was analyzed by simply examining the specifications of different vehicle manufacturers for each mode to determine the number of passengers that can be carried, while seated, in a vehicle. Public transportation vehicles typically allow room for passengers to stand during travel, but due to the longer distances in the analysis corridor, it was assumed that a vehicle with more seating would be preferred to one with more standing room. This value was then included in an equation to allow for variation in passenger size.

Also considered for this criterion is the capacity for bicycles. There is no equation to account for the variability in bicycles on a vehicle, so this capacity will simply be counted by looking at vehicle specifications.

3.3.6 Line Capacity

The ideal line capacity for each mode was collected from Vuchic, because line capacity is difficult to estimate without the use of computer simulation, (13). These optimum capacities were compared to potential real-world capacity levels. However, it should be noted that the potential operations of both modes in this analysis corridor will not come near to the optimum capacity described in the literature.

3.3.7 Safety

The typical unit of measuring injuries and fatalities for each mode is *incidents/passenger-distance*. For this study, they were measured in *injuries/100 million passenger-mile* and *fatalities/100 million passenger-miles*. Data was collected from the U.S. Department of Transportation Federal Transit Administration (FTA) for both modes (27).

3.3.8 Service Reliability

Service reliability was calculated by collecting the percent of on-time performance for bus and commuter rail modes for TriMet and Sound Transit. TriMet's commuter rail service began in 2009 so the data collected for analysis includes 2010, 2011, and 2012 through November. Sound Transit's commuter rail began operation in 2000, but data was available only as early as 2004 resulting in on-time performance data ranging from 2004 to 2011. These on-time percentages were then averaged to determine which mode was more reliable.

TriMet classifies their on-time performance for buses as “departs no more than 1 minute early and no more than 5 minutes late” and for WES (commuter rail) as “trains that arrive at the scheduled station within 4 minutes of the scheduled time” (30). Sound Transit defines on-time bus performance as “no later than 10 minutes of scheduled departure time” and on-time commuter rail performance as the “monthly average of all trains arriving at terminus within seven minutes of schedule at least 19 out of 20 trips” (31).

Chapter 4 – Results

4.1 Analysis Results

Table 3: Analysis Results

Final Analysis Results				
Criteria	**Regular Bus (RB)**	**Commuter Rail (CR)**	**RB**	**CR**
Station-to-Station Travel Time	Corvallis to Albany: 22 min Albany to Lebanon: 22 min	Corvallis to Albany: 30 min Albany to Lebanon: 32 min	X	
Optimal Line Capacity	3,800-5,400 sps/hr	30,000-36,000 sps/hr		X
Vehicle Service Life	Avg. = 10-12 years Max. = 15-20 years	Avg. = 25-30 years Max. = 40-50 years		X
Capital Cost and Operational Cost	Op.: 0.77$/prs-mil Cap.: 0.17 $/prs-mil Total: 0.94 $/prs-mil	Op.: 0.36 $/prs-mil Cap.: 0.25 $/prs-mil Total: 0.61 $/prs-mil		X
Fuel Efficiency	42.03 prs-mi/gal diesel fuel	53.72 prs-mi/gal diesel fuel		X
Average 10-year Safety	0.51 deaths/100 Mil prs-mi 132.4 injuries/100 Mil prs-mi	1.10 deaths/100 Mil prs-mi 18.67 injuries/100 Mil prs-mi	X	
Person Capacity	New Flyer = 39 seats Gillig Phantom = 42 seats	US Railcar = 116 Seats Stadler (MP) = 104		X
Service Reliability	TriMet Bus = 81.9% ST Express= 92.4%	TriMet WES = 98.1% ST Sounder = 97.5%		X

4.1.1 Travel Time

To estimate the travel time for rail, a conservative speed of 25 mph was used. This speed was used due to the rail infrastructure necessitating slowdowns such as the corridor through Corvallis, the bridge between Benton and Linn counties, and the current operating standards of Willamette and Pacific Railroad (WPRR). A 2005 corridor study performed by HDR rated the track as FRA class 3, allowing maximum speeds for freight trains to operate at 40 mph and passenger trains to operate at 60 mph (32). However, for safety, WPRR currently operates the line as a FRA class 2 classification, limiting maximum train speeds to 25 mph for freight and 30 mph for passenger trains (12). Upgrading to a faster allowable speed in the future is possible, but uncertain at this time. By assuming an average travel speed of 25 mph the estimated travel time from Corvallis to Albany is 30 minutes. This average speed also estimates a travel time of 32 minutes from Albany to Lebanon. These two segment times result in a total estimated corridor travel time of 62 minutes.

The bus travel time is slightly different due to the multiple options of routes. The three main station locations (nodes) in the network are the Downtown Transit Center in Corvallis, the Albany Station in Albany and the Santiam Travel Station in Lebanon. Between Corvallis and Albany there are two routes: Hwy 20 and Hwy 34 - Hwy 99E. Each of these routes have an estimated travel time of 22 minutes, but the Hwy 20 route is shorter in distance and was therefore selected as the preferred route. Similarly, the two routes from Albany to Lebanon require the same amount of travel time, 22 minutes, and the two routes are Hwy 20 and Hwy 34 – Hwy 99E. Again, Hwy 20 is shorter in mileage and is therefore the selected route. These two route segments result in an estimated corridor travel time of 44 minutes. Analysis results for travel time can be seen in Figure 7, below.

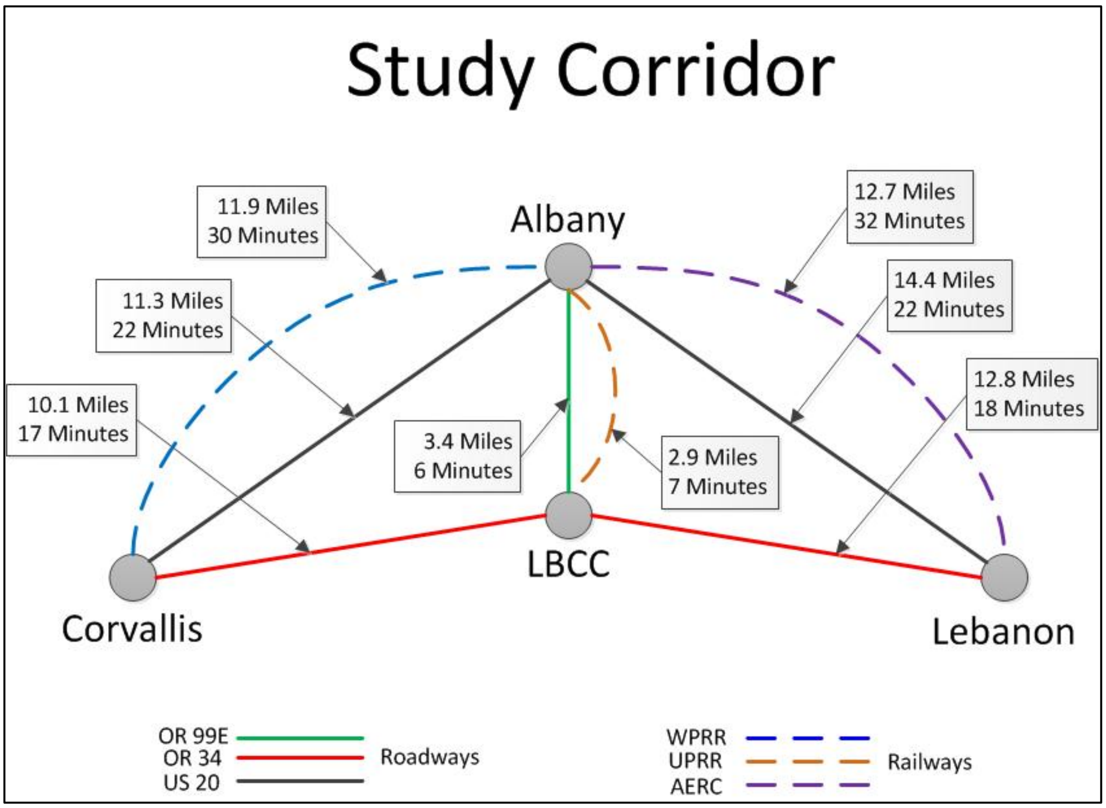

Figure 7: Corridor Travel Time Diagram

4.1.2 Vehicle Service Life

The Federal Transit Administration established a required retirement age for buses purchased using federal dollars to be a minimum of 12 years (33). This legislation has led to many bus models having a physical life similar to the required life of the FTA. FTA performed a study to examine whether the minimum age selected for retirement was appropriate for the actual life of the vehicles. The study found that the average of a bus transit vehicle was 15.1 years before the vehicle was retired (33).

The average service life of rail vehicles is more difficult to determine due to the fact there is no federal requirement for a minimum retirement age. Vuchic estimates the typical useful life range for rail vehicles is 25 to 30 years and the maximum useful life range is 40 to 50 years (13). This useful life expectancy is possible with overhauls of the vehicle. The diesel multiple units (DMUs) manufactured by US Railcar are estimated to have a useful life of 50 years (34)[1] and TriMet verifies this estimate through the operation of such vehicles. To improve service reliability, TriMet purchased two diesel cars from the Alaska Railroad (35). The cars were built by the Budd Company in 1953 and were the inspiration for designing the modern DMUs manufactured by U.S. Railcar. These cars are 60 years-old and with a complete rebuild in 2000 they are still used in service today (35)

4.1.3 Fuel Efficiency

After collecting the passenger-mile data and calculating the energy consumed for each mode, the fuel efficiency was calculated. The national average for commuter rail service from 2001 to 2010 equated to 53.72 passenger-miles per gallon of diesel-equivalent. The national average for bus service from 2001 to 2010 equated to 42.03 passenger-miles per gallon of diesel-equivalent. These calculations conclude that

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[1] The vehicles mentioned in the report were manufactured by Colorado Railcar Co., which has since been purchased by U.S. Railcar.

commuter rail is more fuel efficient by being able to transport more passenger-miles per gallon of diesel-equivalent then the bus mode, though both modes are separated by a small difference. The results are shown in Table 4 and Figure 8, below.

Table 4: Passenger-miles per Gallon of Diesel (26)

Passenger-mi/Gal. of Diesel		
Year	**Regular Bus**	**Commuter Rail**
2001	37.503	56.273
2002	39.072	56.292
2003	39.469	55.621
2004	38.832	55.124
2005	40.886	51.615
2006	42.521	56.005
2007	42.453	53.719
2008	44.105	53.331
2009	47.150	50.336
2010	48.261	48.858
10-year Avg. =	42.025	53.717

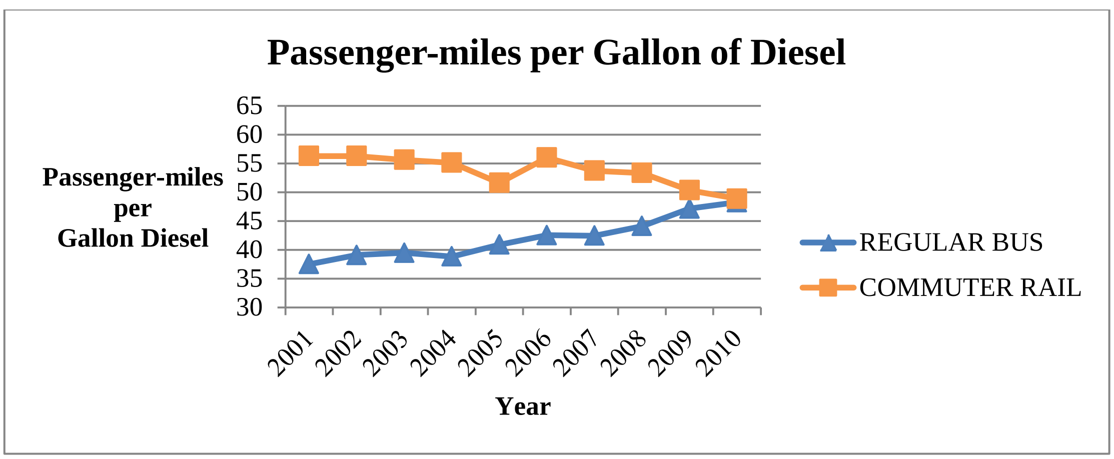

Figure 8: Passenger-Miles per Gallon of Diesel-equivalent (26)

4.1.4 Capital and Operational Costs

After collecting the passenger-mile data and the capital and operational cost data, the dollars per passenger-mile totals were calculated. From 2001 to 2010 the average operational cost per passenger-mile for bus service was $0.77/passenger-mile and the average capital cost was $0.17/passenger-mile (26). This results in a total cost of $0.94/passenger-mi for bus service. In the same time period the operational cost for commuter rail service was $0.36/passenger-mile and the capital cost was $0.25/passenger-mile (26). These capital and operational costs result in a total of $0.61/passenger-mile. These findings show that the total capital and operational costs per passenger-mile for bus mode, nationally, are about 1.5 times greater than the commuter rail mode. The data for capital costs is shown in Table 5 and Figure 9, the data for operational costs is shown in Table 6 and Figure 10 and the total combined cost is shown in Table 7 and Figure 11.

Table 5: Capital Costs (26)

Capital Costs Per Mode ($/prs-mi)		
Year	**Regular Bus**	**Commuter Rail**
2001	$0.17	$0.24
2002	$0.16	$0.25
2003	$0.15	$0.26
2004	$0.18	$0.27
2005	$0.15	$0.26
2006	$0.16	$0.24
2007	$0.16	$0.22
2008	$0.19	$0.25
2009	$0.19	$0.24
2010	$0.21	$0.28
10-year Avg. =	$0.17	$0.25

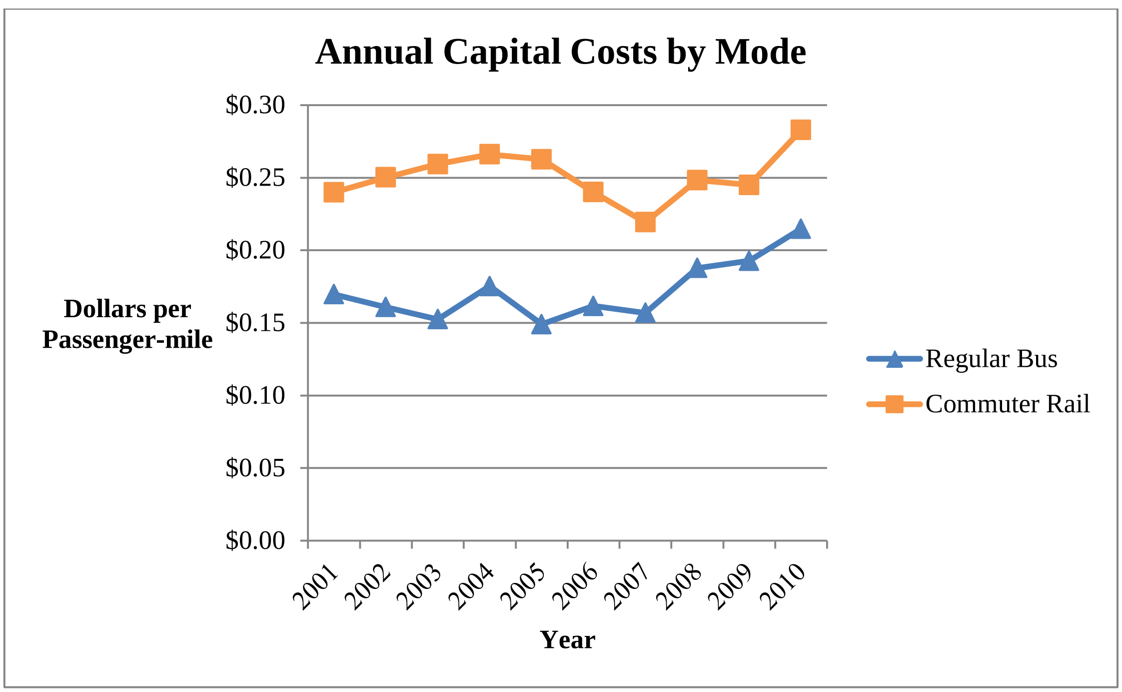

Figure 9: Capital Costs (26)

Table 6: Operational Costs (26)

Operational Costs Per Mode ($/prs-mi)		
Year	**Regular Bus**	**Commuter Rail**
2001	$0.61	$0.30
2002	$0.64	$0.32
2003	$0.72	$0.33
2004	$0.75	$0.35
2005	$0.77	$0.39
2006	$0.78	$0.36
2007	$0.83	$0.36
2008	$0.86	$0.39
2009	$0.87	$0.41
2010	$0.90	$0.43
10-year Avg. =	$0.77	$0.36

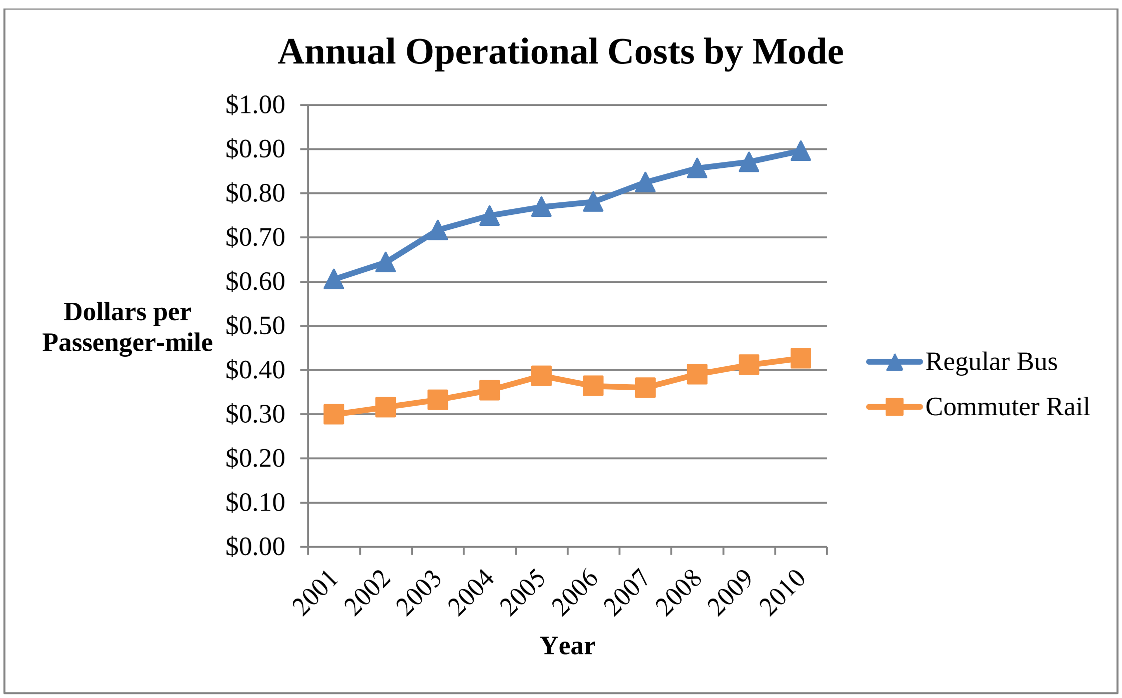

Figure 10: Operational Costs (26)

Table 7: Combined Capital and Operational Costs (26)

Total Cost Per Mode ($/prs-mi)		
Year	**Regular Bus**	**Commuter Rail**
2001	$0.78	$0.54
2002	$0.80	$0.57
2003	$0.87	$0.59
2004	$0.92	$0.62
2005	$0.92	$0.65
2006	$0.94	$0.60
2007	$0.98	$0.58
2008	$1.04	$0.64
2009	$1.06	$0.66
2010	$1.11	$0.71
10-year Avg. =	$0.86	$0.56

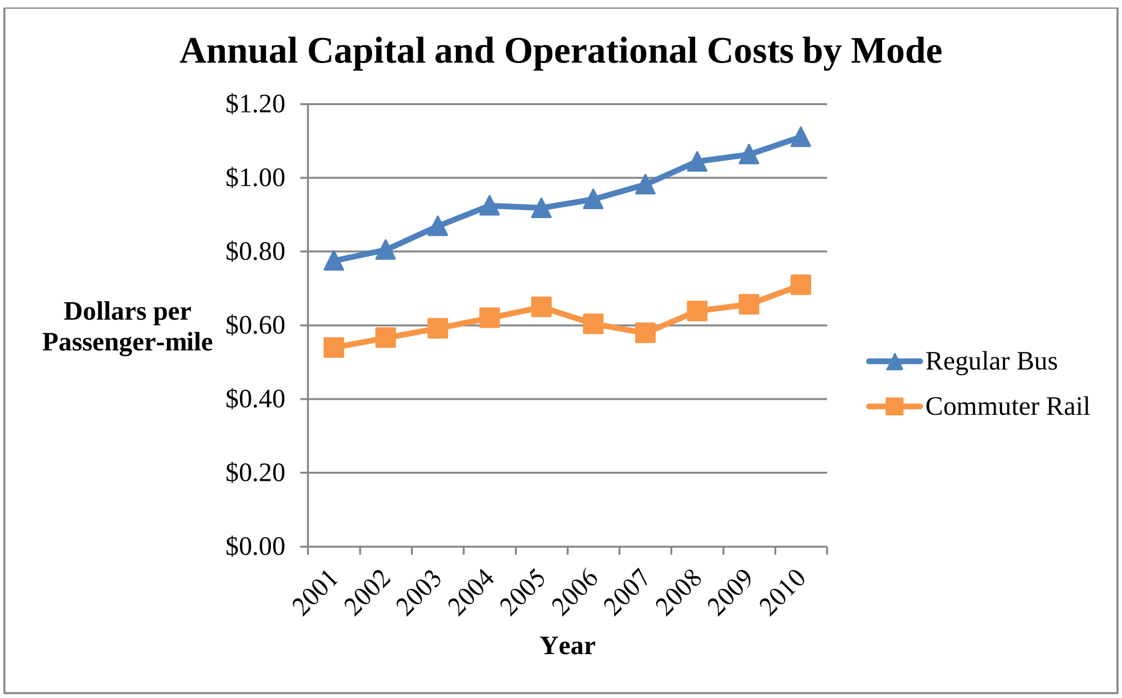

Figure 11: Combined Capital and Operational Costs

4.1.5 Person Capacity

After examining the specifications for multiple vehicles for each mode, the highest seating capacity was selected. For the commuter rail mode, the DMU vehicle manufacturer selected was U.S. Railcar with their single-level DMU holding 116 passengers with 2x3 seating arrangement. This vehicle also allows for storage of two bicycles. For the bus mode, the vehicle manufacturer chosen was Gillig-Phantom with their city buses having 42 seats. The bicycle racks on the front of the buses allow for a bus to carry two bicycles as well. In Figure 12 below is a DMU vehicle manufactured by Stadler and shows the typical layout of DMU rail vehicles

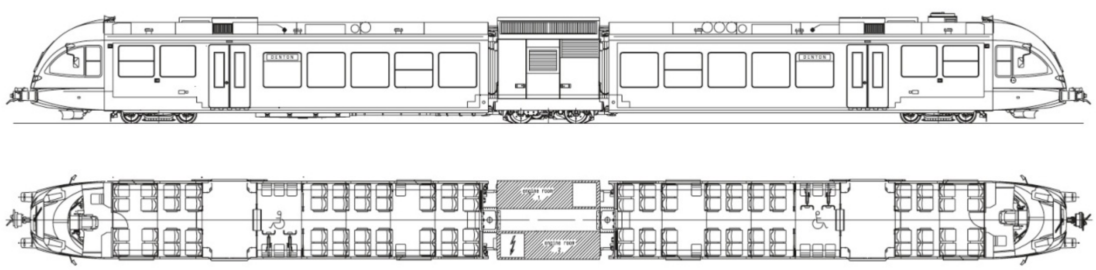

Figure 12: Stadler DMU Plan (36)

4.1.6 Line Capacity

Vuchic estimates the range for maximum line capacity for regular bus service to be 3,800 to 5,400 spaces/hr (13). He also estimates the range for maximum line capacity for commuter rail to be 30,000 to 36,000 spaces/hr (13). Clearly commuter rail has the potential for more line capacity due to its ability to have longer trains of cars with higher capacities than buses. However, if commuter service were introduced to the analysis area the frequencies and vehicle capacity would be much lower than the maximum potential service. Similarly, current bus service along the corridor has a frequency of one TU/hr which would likely remain constant unless ridership increased.

4.1.7 Safety

The safety of both modes was analyzed by collecting fatality and injury data and the passenger-miles travelled. The fatality and injury were both divided by the passenger-miles travelled to find the fatalities/100 million passenger miles and the injuries/100 million passenger-miles for both modes.

The national data showed that bus transportation averaged 0.51 fatalities/100 million passenger-miles and 132.44 injuries/100 million passenger-miles. Commuter rail transportation averaged 1.10 fatalities/100 million passenger-miles and 18.67 injuries/100 million passenger-miles. These findings show that commuter rail averages 2.18 times the fatalities of buses, but buses average 7.09 times the injuries of commuter rail. The fatality data is shown, below, in Table 8 and Figure 13 and the injury data is shown in Table 9 and Figure 14. It should also be noted that in 2002 the definitions for injuries and fatalities changed causing significant changes in quantities to both categories.

Table 8: Fatalities (27)

Fatalities per 100 Million Passenger-Miles		
Year	**Regular Bus**	**Commuter Rail**
1997	0.65	1.13
1998	0.64	1.16
1999	0.57	1.16
2000	0.51	0.99
2001	0.52	0.99
2002	0.43	1.36
2003	0.50	0.90
2004	0.46	1.00
2005	0.38	1.27
2006	0.53	0.93
2007	0.51	1.27
10-year Avg. =	0.51	1.10

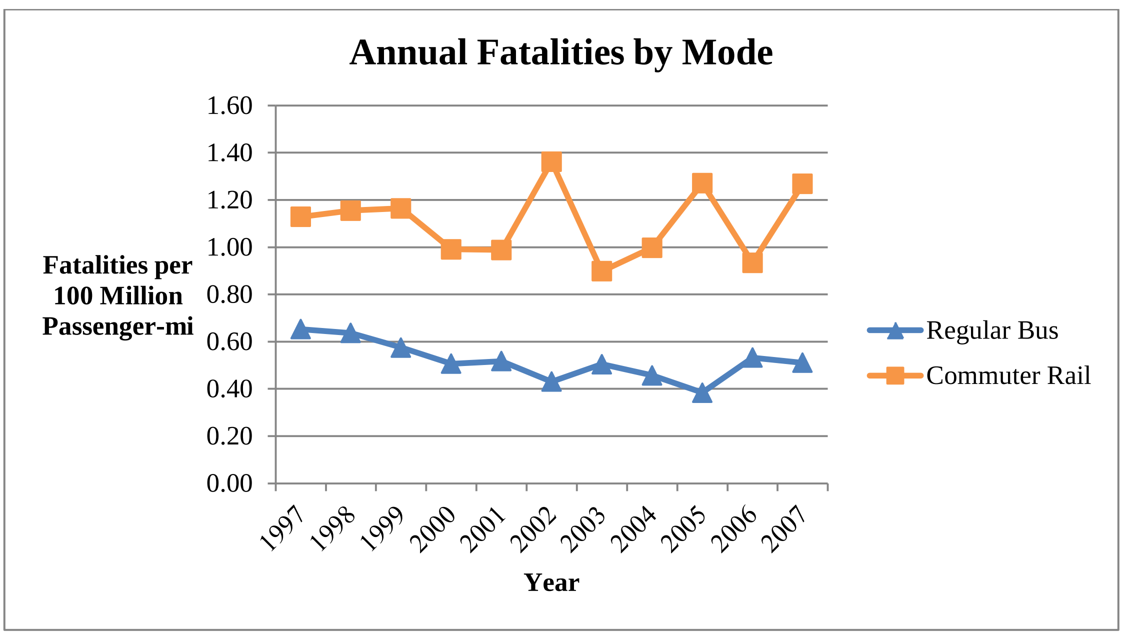

Figure 13: Fatalities (27)

Table 9: Injuries (27)

Injuries per 100 Million Passenger-Miles		
Year	**Regular Bus**	**Commuter Rail**
1997	234.67	34.11
1998	239.79	20.61
1999	232.32	21.59
2000	230.40	20.32
2001	211.44	20.60
2002	66.20	17.41
2003	66.66	18.63
2004	70.59	15.82
2005	67.18	20.24
2006	66.91	15.67
2007	72.92	15.83
10-year Avg. =	132.44	18.67

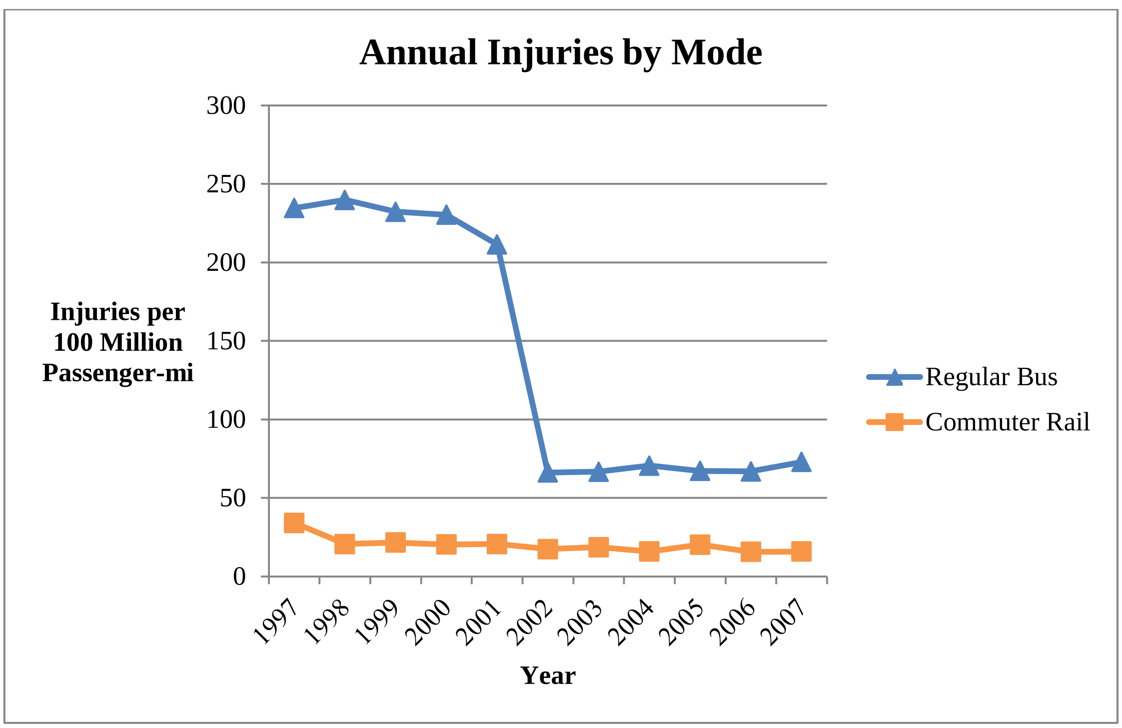

Figure 14: Injuries (27)

4.1.8 Service Reliability

After collecting the on-time performance data for Sound Transit and TriMet, the potential service reliability was calculated. For both transit agencies, the commuter rail mode had more reliable service than the bus mode. TriMet's WES was, on average, on-time 98.1% of the time from 2010 through the third quarter of 2012. Sound Transit's Sounder service was, on average, on-time 97.5% from 2004 to 2011. TriMet's bus service was on-time an average of 81.9% in the same time period as analyzed for WES and the Sound Transit Express service was on-time an average of 92.4%. The reliability data for Sound Transit and TriMet is shown in Figures 15 and 16 respectively

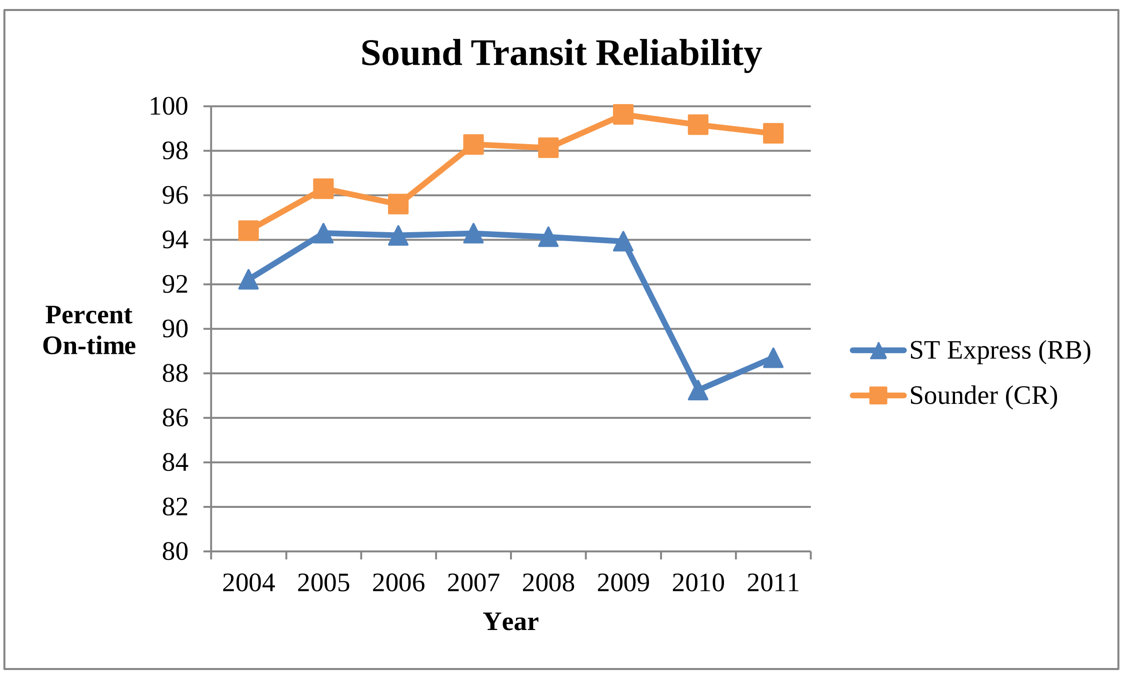

Figure 15: Sound Transit Reliability (29)

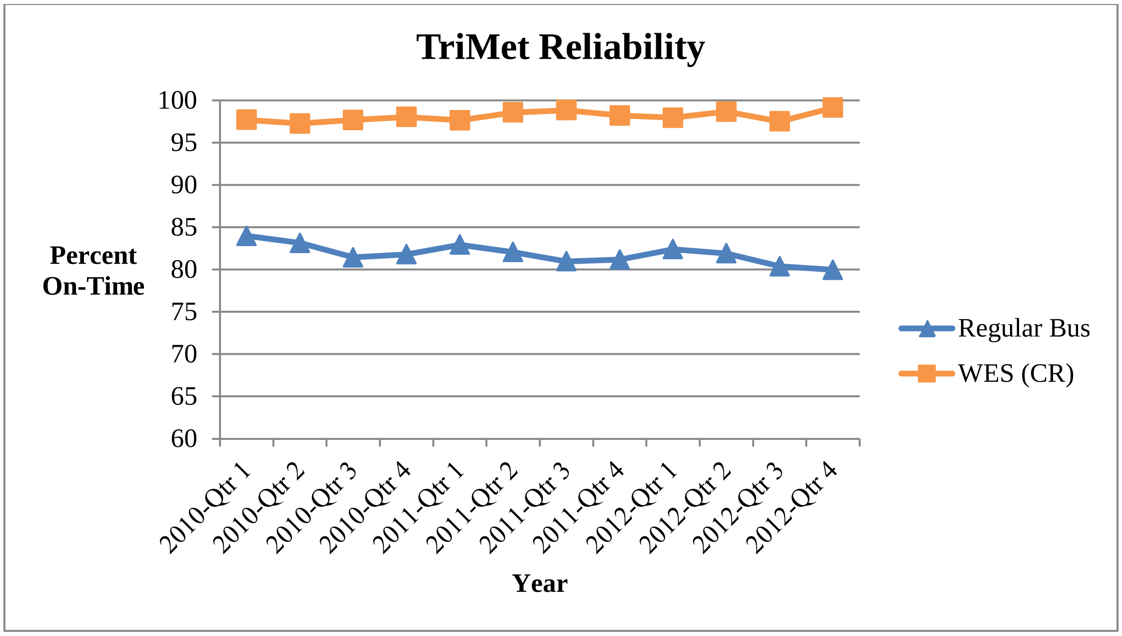

Figure 16: TriMet Reliability (28)

Chapter 5 – Discussion

5.1 Results

5.1.1 Summary

From the criteria analyzed, it was concluded that commuter rail was the better transportation mode in terms of operational performance. The mode offered more line capacity with the ability to transport more passengers with a more efficient vehicle usage.

The travel time for the commuter rail service is a criterion that would need to see improvement if the mode were ever to be put into service. For the commuter rail travel time to be equal to the express bus travel time, the train would need to maintain an average speed of 35 mph. This speed would only be attainable with upgrades to the track to warrant a class 3 FRA track classification.

The data shows that the service life of commuter rail vehicles is much longer than buses. Though it is necessary to have overhauls of the vehicle to maintain that service life, maintenance is cheaper than purchasing a new vehicle. A typical bus service life is about half of a train service life.

Average capital costs and average operational costs have advantages and disadvantages for both modes and would require further analysis for specific operating conditions. Nationally, capital costs are slightly higher for commuter rail than they are for buses (about 1.5 times the amount). However, the operational costs for buses are higher (averaging about 2 times that of commuter rail). This results in the combined cost per a passenger-mile being about 1.4 times higher for bus transportation than for commuter rail transportation. This result could conclude that rail is the cheaper choice overall among the two modes, but the result more likely explains the operations of the mode. Commuter rail typically operates over longer distances with fewer stops than inner-city bus service. This condition is likely reflected in the analysis results. The operational costs include the necessary staffing of the vehicle. Staffing typically requires one operator for buses but two operators (engineer and conductor) for commuter rail.

The fuel efficiency for commuter rail service was found to be better than the fuel efficiency for bus service by calculating the passenger-miles per gallon of diesel fuel equivalent. This was another area where having a better separation of data would more clearly explain the fuel efficiency of each mode. This result is not surprising since commuter rail carries more passengers per a transit unit than bus service and would therefore use fuel more efficiently.

The results of the safety data were surprising. It was found that commuter rail averaged about twice as many deaths per passenger-mile as bus service did. Though bus service injuries were about seven times higher than commuter rail injuries, bus service was determined to be safer than commuter rail due to its lower fatality rates.

The person capacity results were not surprising since DMUs are obviously larger vehicles and can therefore carry more passengers. Some articulated buses are capable of carrying over 100 passengers, but those were not considered for this study.

It was expected that commuter rail had better reliability than bus service, however the level of reliability in bus service was surprising. The Sound Transit Express bus service averaged 92.4% on-time performance compared to the 97.5% on-time performance of the Sounder commuter rail. It is unknown what factors contribute to these percentages being close in value, but it is evidence that express bus service can perform similarly to commuter rail service in reliability if given the right circumstances.

5.2 Possible Biases

It should be noted that there are possible biases in the study and that it is difficult to compare the two modes as if they were equal. The bus statistics were collected from APTA data, which segregates data only into the categories of demand-responsive service and fixed-route service. Therefore, the bus data in the study includes inner-city bus service grouped together with commuter, or express, bus service.

Also in the APTA Factbook, commuter rail passenger-miles are reported as the total amount for the mode and are not separated by fuel type. Additionally, the fuel type data for commuter rail was reported in gallons of diesel and in kWh of electricity. It would have been beneficial to compare just the performance of diesel commuter rail systems with that of buses, but that data was not available for this study.

The station-to-station travel time is just an approximation. To have a thoroughly accurate travel time more track structure analysis would be necessary and the speed at grade crossings and bridges would need to be examined.

The optimal line capacity is only an estimation and does not explain the capacity of the line in real-life operations.

The 10-year safety statistics were not examined for any anomalies. It is unknown whether there were unusual events or incidents that led to the data used in this analysis.

Person capacity was picked based on the largest capacity offered by typical vehicle models. The actual capacity of any vehicle will depend upon the desire of agencies and the needs of the public.

Service reliability was collected from only a couple agencies due to limited data being available to the public. A larger sample size of reliability data would give a better description of the performance of both modes on a national level.

5.3 Other Considerations

This study shows that the operational characteristics of commuter rail and bus transportation are very similar. On a national and regional level, the performance criteria had similar results in most categories. However, this study did not examine certain factors that may be crucial to consider when choosing a public transportation mode.

5.3.1 Right-of-Way Ownership

A major advantage of bus transportation is being able to utilize roadways that are available to the public. Operating commuter rail service on freight railways creates many challenges with negotiating contracts and permission to use the right-of-way. In Albany, sections of the railways are owned and operated by different freight railroad companies. Below is a map (Figure 17) illustrating the different companies that have right-of-way ownership. Also shown are the companies which are allowed access to the right-of-ways by means of negotiation. Negotiating access to these right-of-ways can be challenging and expensive.

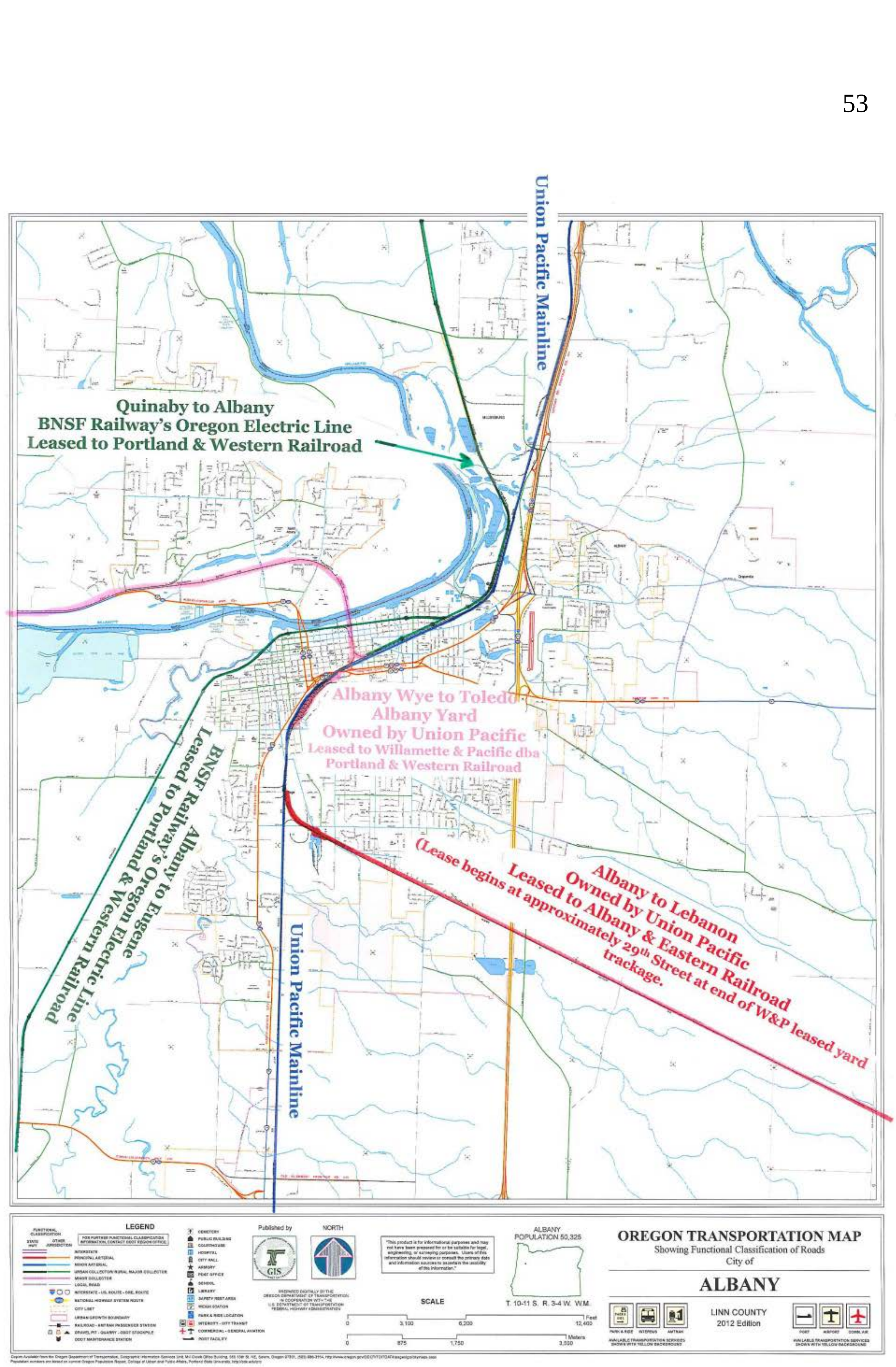

Figure 17: Right-of-Way Ownership Map (12)

Another expensive item to consider is the liability insurance required by the commuter agency. The Amtrak Reform and Accountability Act of 1997 limits the claims of all passengers resulting from a single incident to be no higher than $200 million, which in turn requires all passenger rail providers to have, at a minimum, $200 million of liability insurance (37).

5.3.2 Initial Capital Investments

This study did not examine what capital investments would be necessary for the start-up operations. These investments could include stations, platforms, signal improvements, grade separation, grade crossing improvements, bridge and structural crossing improvements, possible double tracking and other possibilities. Meanwhile, bus operations currently exist with stops and stations available, which would require minimal initial investment to begin an express service between cities.

5.4 Future Research Topics

Performing this research has generated multiple questions and topics for future research. One topic that would be interesting to research is whether there is software that can model operations for a short corridor such as Corvallis to Lebanon. The ODOT Rail Study did not mention what software was used for analysis, but the report mentioned it was inadequate. It would be much more beneficial to measure the true capacity of the rail corridor and not just estimate it with approximate data.

Analysis of whether there is an advantage of rider catchment based on the routes of commuter rail and bus service would be an additional area of research. Researching ridership catchment and land use could lead to considerations for land development in the future and helping decide which areas are more suitable for specific zoning types.

The identification of more evaluation criteria is another area that should be considered in future studies. One example would be which mode provides better connectivity to areas and other transportation modes in the cities. This study assumed that both modes would start and end at the same locations, but it would be interesting to research whether there were better locations that would maximize the connectivity of the community and its transportation options.

Chapter 6 – Conclusion

This study used evaluation criteria suggested by Vuchic to develop a framework for analysis of commuter rail transportation and bus transportation. This framework was then used to analyze potential commuter rail service between the towns of Corvallis, Albany and Lebanon. The analysis showed that the operational performance of both modes were similar; however, commuter rail had an advantage in six of the eight criteria examined. This study concludes that for the operational criteria considered, commuter rail operations rated better than bus in the majority of the categories under consideration. Factors such as initial investment cost, mode attractiveness and connectivity were not analyzed and require further analysis. These are three items that should be analyzed in future consideration. The study does show that commuter rail could be a viable option and should be considered in any future analysis. Commuter rail could be the preferred mode choice if the population density of the cities continue to increase and the economic development of the region continues to grow.

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