Project No: FTA VA-26-7222-2005.1

August 2005

Federal Transit Administration

United States Department of Transportation

Regional Transportation Commission

Las Vegas Metropolitan Area Express

MAX

Bus Rapid Transit (BRT) Demonstration Project

NOTICE:

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE *August 2005*	3. REPORT TYPE AND DATES COVERED BRT Demonstration Initiative Reference Document

4. TITLE AND SUBTITLE Las Vegas Metropolitan Area Express (MAX) BRT Demonstration Project Evaluation	5. FUNDING NUMBERS
6. AUTHOR(S) Eugene J. Kim, Ph.D., Georges Darido, Donald Schneck (Booz Allen Hamilton)	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Booz Allen Hamilton, Inc. 8283 Greensboro Drive McLean, Virginia 22102	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Federal Transit Administration U.S. Department of Transportation Washington, DC 20590	10. SPONSORING/ MONITORING AGENCY REPORT NUMBER FTA-VA-26-7222-2005.2
11. SUPPLEMENTARY NOTE	
12a. DISTRIBUTION/AVAILABILITY STATEMENT **Available From:** National Technical Information Service/NTIS, Springfield, Virginia, 22161. Phone (703) 605-6000, Fax (703) 605-6900, Email [orders@ntis.fedworld.gov]	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This reference was prepared for the Office of Research, Demonstration and Innovation of the Federal Transit Administration (FTA). This case study evaluation of the Metropolitan Area Express (MAX) system is intended to support FTA's ongoing research on bus rapid transit project planning, development and implementation. This report presents a comprehensive assessment of the applications of BRT elements on the MAX system, per the evaluation framework outlined in the Characteristics of Bus Rapid Transit (CBRT) report. Information is presented on a broad range of applications of key elements of BRT – running ways, stations, vehicles, fare collection, intelligent transportation systems (ITS), and service and operating plans. This evaluation also investigates MAX system performance in several key areas, including travel times savings, improving reliability, providing identity and a quality image, improving safety and security, and increasing capacity. The evaluation concludes with an assessment of important system benefits, including transportation system benefits (increasing ridership, and improving capital cost effectiveness and operating efficiency) and community benefits (transit-supportive development and environmental quality).

14. SUBJECT TERMS Bus Rapid Transit, Performance Measurement, Evaluation	15. NUMBER OF PAGES 52
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18298-102

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F	=	y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

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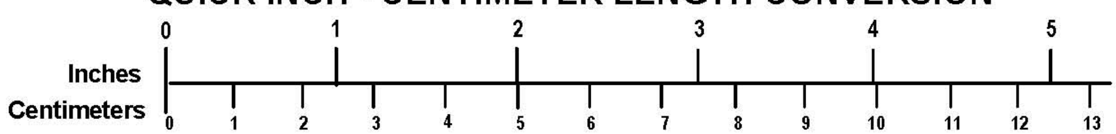
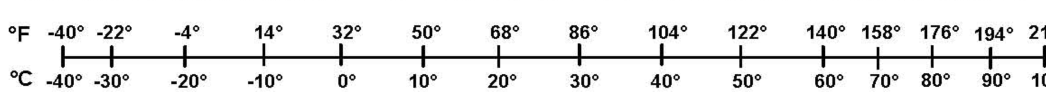
QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

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1.0 INTRODUCTION

This research study is supported through the Federal Transit Administration's Bus Rapid Transit (BRT) Initiative, which investigates the technologies and advanced operational capabilities of BRT systems and facilitates the implementation of successful BRT projects throughout the United States. The specific objectives of FTA's BRT Initiative are to:

- Improve bus speeds and schedule adherence
- Increase ridership as a result of improved quality of service that encompasses bus speeds, schedule adherence and convenience
- Minimize the effect of BRT on other traffic
- Isolate the effect of each BRT feature on bus speed and other traffic
- Assess the benefits of Intelligent Transportation Systems/Automated Public Transportation Systems

Additionally, the BRT Initiative aims to minimize impacts to other traffic and local businesses, determine the benefits of ITS technologies and evaluate the effects of BRT systems on land use and development.

This study presents a detailed evaluation of Regional Transportation Commission of Southern Nevada's (RTC) Metropolitan Area Express (MAX) system, the first major advanced bus rapid transit project to be implemented in the state of Nevada. MAX is a national demonstration project sponsored by the Federal Transit Administration's BRT Initiative. RTC's stated objective in developing the MAX system is to "use an innovative system approach to increase capacity, improve passenger comfort and convenience, reduce dwell times and raise awareness in the community about the benefits of public transportation." (ITE Journal, February 2005)

The data presented in this evaluation was collected according to the Las Vegas MAX Data Collection Plan dated November 11, 2004. This report presents the data collected to date since evaluation activities commenced on June 30, 2004. In accordance with the evaluation framework outlined in the Characteristics of Bus Rapid Transit for Decision-Making (CBRT) report, this evaluation is organized into the following sections:

- Project Context
- Project Description
- System Costs
- Planning, Design and Implementation
- Evaluation of System Performance
- Assessment of System Benefits
- Conclusions

This evaluation finds that MAX is an example of how a comprehensive systems approach to BRT implementation can result in the achievement of a broad array of system performance objectives – including higher ridership, improved travel times, enhanced reliability and system safety and security, among others. These project benefits correspond directly with several of the FTA Strategic Goals. Although the benefits of MAX are still being gained, measured and understood, it is clear that BRT systems like MAX – which are incorporating design and operational characteristics that more and more resemble light rail transit –

enhance the transit experience and can be uniquely and flexibly adapted to a multitude of urban environments. As these systems mature, there is strong evidence that these systems can be incrementally and economically scaled upwards to meet future demand.

1.1 PROJECT CONTEXT

On June 30, 2004, RTC of Southern Nevada introduced Metropolitan Area Express (MAX), a 7.5-mile limited stop rapid transit line serving Las Vegas Boulevard North between the Downtown Transportation Center (DTC) in downtown Las Vegas and Nellis Air Force Base at Craig Road.

MAX was designed to complement Route 113 (**Exhibit 1**) – one of Las Vegas' most heavily patronized bus lines – by offering new express service with enhanced passenger comfort and convenience. Route 113 provides service between the DTC to Nellis Air Force Base via Las Vegas Boulevard North, with 48 stations stop locations throughout the corridor. Prior to the opening of the dedicated transit lane along Las Vegas Boulevard North, Route 113 operated in a mixed traffic environment. Today, MAX and Route 113 operate along the same 7.5-mile corridor and both routes make use of the 4.5-mile dedicated transit lane segment on Las Vegas Boulevard North.

Exhibit 1: Map of CAT Route 113

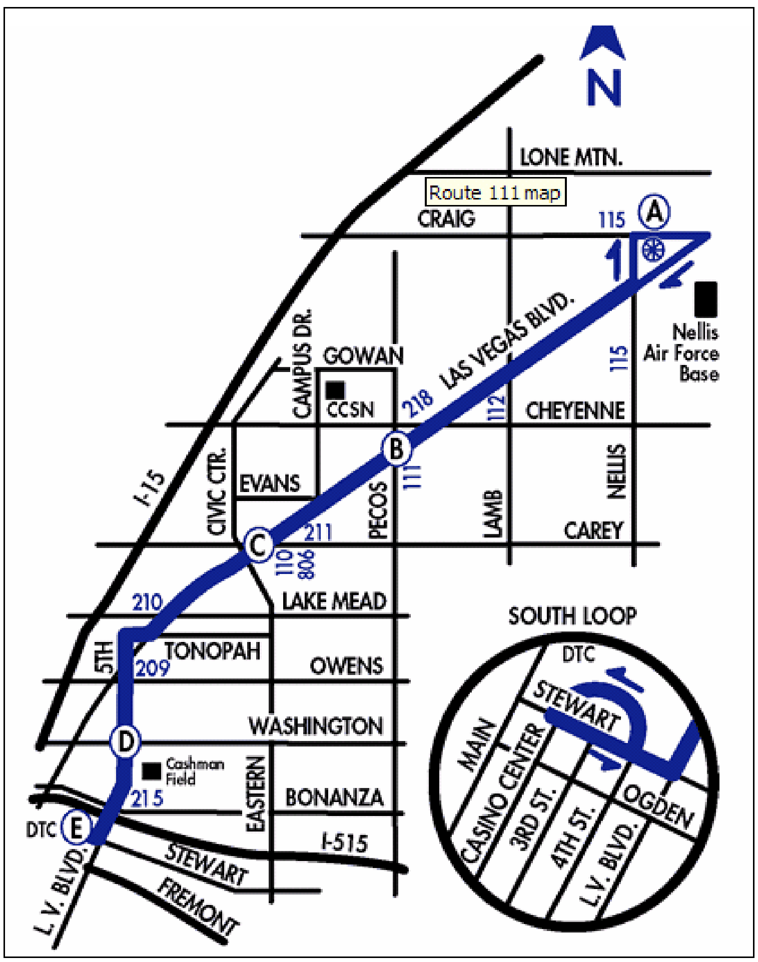


Exhibit 2: CAT Route 113 at the Downtown Transportation Center (DTC)

Route 113 which provides local service along the segment of Las Vegas Boulevard North served by MAX, is the third busiest route in the CAT system.

Las Vegas Boulevard North is one of the region's busiest arterials, connecting residents of North Las Vegas to employment and service centers, including the resort areas along the Las Vegas Strip, Nellis Air Force Base and the City of North Las Vegas' Civic Center.

MAX is an advanced rubber-tire rapid transit system that integrates some design and operational characteristics typically associated with Light Rail Transit (LRT) into a flexible mass transit vehicle. MAX system features include:

- A dedicated transit only lane
- Optical guidance system (OGS)
- 100% low floor vehicles
- In-vehicle bicycle racks
- Enhanced passenger stations, with elevated platforms for level boarding
- Multiple entry boardings
- Traffic signal priority (TSP)
- Automated Passenger Counters (APCs)
- Off-board fare collection
- CAD/AVL system

MAX is part of RTC's Citizens Area Transit (CAT) system, with 48 bus routes serving the Las Vegas Valley and Clark County. In 2004, CAT operated over 1.2 million vehicle service hours and carried 52 million passenger trips. RTC Southern Nevada contracts out all fixed route transit services under CAT to ATC/Vancom, one of the nation's largest transit service providers. As part of the CAT system, ATC Vancom also operates and maintains MAX.

1.2 GENERAL PROJECT OVERVIEW

In Spring 2000, the Nevada Department of Transportation (NDOT) completed a street overlay project along a 5-mile stretch of Las Vegas Boulevard North north of the downtown area. This street overlay project involved both pavement resurfacing and lane reconfiguration, which made available an extra right-hand lane along what was previously the breakdown lane. NDOT, in collaboration with the City of North Las Vegas, proposed re-striping the breakdown lane as a dedicated transit-only lane. NDOT shared these plans with RTC, which subsequently proposed the implementation of an express rapid transit system that could make use of the dedicated transit lane. With both NDOT and the city of North Las Vegas' support, RTC applied for federal funding under FTA's Bus Rapid Transit Initiative for a state-of-the-art advanced express bus service in 2002. The city of North Las Vegas subsequently committed to working with RTC on Traffic Signal Priority (TSP) treatments at major intersections along the planned route.

In defining the MAX concept, RTC Southern Nevada envisioned a modern, sleek vehicle, (**Exhibit 3**) with rail-like appearance that could achieve high peak carrying capacity and some enhanced operational capabilities. After a comprehensive review of advanced bus products manufactured both domestically and internationally, RTC Southern Nevada chose the Civis vehicle as the prototype, manufactured by Irisbus. Early in the process, RTC Southern Nevada identified multiple-entry level boarding as a critical operational design element due to the high passenger volumes carried along this route. The Civis vehicle was chosen in part because of its large carrying capacity and the optical guidance system (OGS) feature, which allows for automated precision docking at station platforms for level boarding at multiple entry points.

Throughout the planning process, RTC launched an aggressive marketing campaign highlighting the innovative aspects of the MAX system. This resulted in strong support from the community and from key decision makers on the plan to introduce advanced rapid bus service in Las Vegas. RTC noted that the receptive response from the community, which is accustomed to risk-taking, technological innovation and timely project delivery, was a key ingredient to successful and timely project delivery. RTC released a detailed feasibility study of the impacts, costs and benefits associated with an advanced BRT alternative along Las Vegas Boulevard North in mid-2003. MAX opened to the public on June 30, 2004.

Exhibit 3: MAX uses a Civis vehicle manufactured by Irisbus

2.0 PROJECT DESCRIPTION

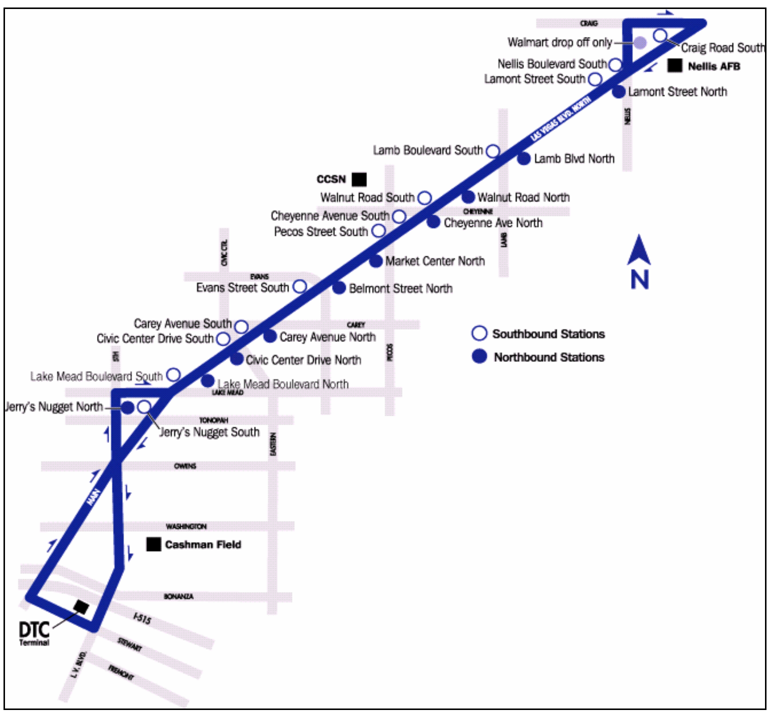
A BRT system is composed of an integrated package of rapid transit elements that, taken together, create a distinct identity and unique brand. The purpose of this section is to offer a detailed description of the following six major BRT elements as presented in the CBRT report:

- Running ways
- Stations
- Vehicles
- Fare Collection
- Intelligent Transportation Systems (ITS)
- Service and Operations Plan

2.1 RUNNING WAYS

MAX functions as a rapid transit overlay onto the local CAT transit services in North Las Vegas and more specifically Route 113, the local bus route operating along Las Vegas Boulevard North. MAX was developed with 22 stations spaced approximately ¾- mile apart along the length of the Main Street/Las Vegas Boulevard North corridor, as illustrated in **Exhibit 4** The northern terminus point for MAX is Craig Road and Las Vegas Boulevard North, adjacent to Nellis Air Force Base. The southern terminus point is the Downtown Transportation Center (DTC) in downtown Las Vegas. The 4.5-mile dedicated transit lane segment runs between Carey Avenue and Craig Road.

Exhibit 4: Map of MAX Alignment and Stations



MAX and Route 113 operate on a 5-mile stretch of dedicated bus lanes along Las Vegas Boulevard North, north of Bruce Street using the former right-hand breakdown lane. Along the alignment, there are ten intersections equipped with Traffic Signal Priority (TSP) for the MAX vehicles and one “queue-jumper”. This queue-jumper provides priority treatment for the MAX vehicles to operate around congested traffic along Las Vegas Boulevard North. South of Civic Center Drive, MAX operates in a mixed traffic environment, with lanes subject to periodic peak period breakdowns.

2.2 STATIONS

With the addition of two new stations at Lake Mead Boulevard in April 2005, there are 22 MAX stations (11 northbound, 11 southbound) spaced approximately 1-mile apart.

Exhibit 4 shows the original 20 stations built at the MAX opening (from south to north):

- Tonopah (E) (W),
- Lake Mead Blvd (S) (N),
- Civic Center Dr (S) (N),
- Carey Avenue (N),
- Evans Ave (S),
- Belmont St (N),
- Las Vegas Boulevard North – Swap Meet (M),
- Pecos Road (M),
- Cheyenne Avenue (M)(S),
- Walnut Street (S),
- Walnut Street (N),
- Lamb Boulevard (S),
- Lamb Boulevard (N),
- Lamont Street (S),
- Lamont Street (N)(Op),
- Nellis Boulevard (S) and
- Craig Road (S).

The two stations at Lake Mead Boulevard were added to improve transfer accessibility to CAT lines serving destinations surrounding the Las Vegas Boulevard North corridor. This integration with the other bus transit services expands the service area and potential travel market for the MAX services. Each MAX station and vehicle is fully ADA compliant, supporting full accessibility for the service area.

Each station, as shown in **Exhibit 5** below, is approximately 220 feet long, and designated separately from Route 113 bus stops along the corridor. The dimensions of the station platform are 65 ft by 10 ft, with 17 inch curbs to allow for level platform boarding, making it ADA compliant and reducing station dwell times.

A ticket vending machine (TVM) and a drink vending machine are housed inside an enclosure between the station platform and the 5-foot wide bypass sidewalk. The sidewalk location to the rear of the station keeps the vehicle boarding and alighting access area clear of through pedestrians; a design aspect contributing to reduced station dwell times. The enclosure sits underneath an aluminum-paneled canopy designed to protect passengers from the elements, particularly direct sunlight. Each station also has indirect ground and panel lighting to illuminate the boarding area at night.

Exhibit 5: MAX station at Civic Center Drive North

The edge of the station platform is a tactile surface designed to cue visually impaired passengers on one's proximity to the platform edge. The height of the curb at passenger loading points is 26 cm (10 ¼ in). While the vehicle floor height is within a small tolerance of the curb height, RTC decided to equip MAX vehicles with ramps in order to facilitate mobility impaired boardings. At the base of the curb, RTC was required to construct a trench in order to maintain a positive flow line for storm water run off. Inside the TVM enclosure, conduits and pull boxes were installed for land-line communications, advertising and a customer information panel that displays CAT transit information. Each station is fully ADA compliant, facilitating passenger movement and minimizing station dwell times.

Each station was constructed at a cost of approximately $175,000 in capital costs. Annual operating and maintenance costs have not yet been determined.

2.3 VEHICLES

MAX uses the Civis vehicle, manufactured by Irisbus based in France. The Civis vehicle is an articulated bus with a rail-like look and ride, and featuring an optical guidance system and dual diesel-electric propulsion system.

The vehicle, as presented in **Exhibit 6**, is 61 feet in length, with a width of 102 inches and a height of 134 inches. MAX has four right-side doors, two in front of the articulated joint and two behind, and can carry up to 120 passengers. The driver's seat is located in an enclosed center cab configuration. A bicycle rack is located at the rear of the vehicle interior, as shown in **Exhibit 7.**

Exhibit 6: MAX vehicle docking at station

Exhibit 7: Onboard Bike Rack

MAX operates in both a mixed traffic and dedicated bus-only setting, with a maximum carrying capacity of 600 passengers per hour per direction (assuming 12 minute headways and 120 passenger capacity). This capacity is comparable to peak load thresholds of some

LRT and other rail-based people mover systems. With a maximum speed of 45 miles per hour at full load, this Civis vehicle model is not suited for limited stop high speed express highway operation. RTC procured ten Civis vehicles, eight for the MAX service design, plus two spares.

In the design phase, RTC targeted several areas for modification to the basic Civis vehicle in order to address federal and state compliance requirements and operating conditions unique to Southern Nevada:

- Wheelchair ramp (consistent with ADA requirement)
- Air conditioning (performance specification based on the Las Vegas Pulldown Test, which requires that a vehicle reduce the interior temperature from 120° to 73° in 30 minutes)
- Engine (consistent with EPA standards)
- Gross Vehicle Weight for Each Axle (because the axel weights were close to 29,500 lbs and the maximum in Nevada is 25,000, RTC requested and was provided a waiver for local street operation)

RTC has two dedicated bays for maintenance of MAX vehicles at the Integrated Bus Maintenance Facility (IBMF). ATC Vancom has trained six technicians and two supervisors for MAX vehicle maintenance and repair, and has set aside 2,800 square feet in storage space for MAX vehicle spare parts and components inventories.

Irisbus provided a six-week training course to three of the six technicians on the Civis vehicle responsible for warranty work. The remaining three technicians were provided with specialty training for vehicle subsystems – specifically air conditioning, drive train, braking and undercarriage.

Each MAX vehicle cost approximately $1 million. This figure does not include additional work efforts, spare parts, and components inventory costs that are included in total vehicle cost figure shown in **Exhibit 9**.

2.4 FARE COLLECTION

MAX employs an off-vehicle, proof-of-payment fare system that requires all passengers to have valid fare media prior to boarding. The purpose of removing the fare collection from the vehicle is to move fare transaction times to the station areas and thereby reduce station dwell times. All 22 MAX stations have Ticket Vending Machines (TVMs), as illustrated in **Exhibit 8**, that enable passengers to purchase a valid fare prior to boarding MAX.

Ticket vending machines accept both cash and credit/debit cards and dispense a variety of fare media. The base adult cash fare to ride CAT buses is $1.25. CAT offers a variety of multi-day fare pass media. Day passes can be purchased for $5.00 at the farebox or TVMs located at stations and the Downtown Transportation Center. CAT also offers a 30-day CAT pass for $30. Transfers between CAT bus routes are free. The same fare structure is applied to MAX as the CAT system as a whole.

Exhibit 8: Ticket Vending Machine (TVM)

TVMs feature audio assistance in both English and Spanish to assist the visually impaired. TVMs are polled every hour to headquarters. A complete TVM audit is performed once a month. A TVM that fails triggers an alarm at headquarters, where a maintenance request is prepared. The standard TVM report package includes 26 summary reports describing sales by fare category, day type and time of day.

2.5 INTELLIGENT TRANSPORTATION SYSTEMS

The MAX service includes several Intelligent Transportation Systems (ITS) to facilitate operations and maintain quality service as scheduled. The systems included in the MAX project include a Traffic Signal Priority (TSP) system along Las Vegas Boulevard North, the Civis vehicle's Optical Guidance System (OGS), the Automated Passenger Counter (APC) sensors and the CAD/AVL communications system (ORBCAD). These combined systems are used to operate at higher speeds and monitor service operations to ensure it meets the scheduled objectives.

Traffic Signal Priority (TSP)

In January 2004, FAST began implementation of Transit Signal Priority (TSP) programming for eleven traffic intersections along the MAX corridor within the jurisdictions of Clark County, the City of Las Vegas, and the City of North Las Vegas. The implementation of the TSP system was designed to allow MAX vehicles to move through the corridor with less red signal delay by extending green times upon approach at major signalized intersections. The additional TSP option of accelerating the green cycle for the approaching MAX vehicle was not included due to the desire to maintain cross street cycles as timed. In addition, Route 113 buses operating along the same route were not equipped with the TSP emitters.

To facilitate emergency vehicle preemption, the city of North Las Vegas installed 2070N controllers and infrared detectors at signalized intersections along the corridor. With this system already in place, RTC equipped MAX vehicles with an infrared emitter that could automatically extend green time at the intersection upon approach. A mutual determination was made between North Las Vegas and RTC to adopt a TSP logic that would not truncate cycle times for east-west road segments approaching the intersection and simply extended green time for oncoming vehicles equipped with TSP emitters. The TSP system is low impact insofar as it allows left turn swaps[2] and extends green time from a central gatekeeping function.

MAX operators cannot manually trigger TSP at intersections. The priority call decision is made at the intersection traffic signal controller based on a site-specific database. RTC did not set up a conditional restriction on the use of the transit signal priority due to relatively low volumes on the corridor and the low number of vehicles with TSP capabilities on the MAX system. To date, there are eleven intersections where low-impact TSP treatments have been programmed. In the future, it is anticipated that TSP costs will be allocated separately to MAX.

As of the completion of this report, TSP has not been integrated into the Orbital system. The TSP system is currently programmed into the controller, which serves as one of two system “gatekeepers.” The controller software is programmed to identify vehicles and assign vehicle priority. The other TSP “gatekeeper” is the TrafficWerks system, which monitors priority calls throughout the larger system.

An integrated regional traffic management system is being developed under RTC’s Freeway and Arterial System of Transportation (FAST) program. FAST will serve as an advanced traffic management control center, capable of adapting the timing of signals throughout the system to optimize vehicular throughput based on real-time traffic conditions. It is anticipated that the TSPs controller will be integrated into the FAST program.

Optical Guidance System (OGS)

The Civis vehicle’s signature feature is the optical guidance system, which is designed to enable precision docking at station platforms. When the vehicle approaches the “guided area,” the system automatically detects and locks onto a trajectory of pavement markings. The operator can disengage the automated guidance by taking control of the steering wheel at any time. The operator remains in control of braking and acceleration throughout.

The level of coordination between RTC and Siemens, the OGS manufacturer, throughout the design and testing phase was extensive, given the complexity of the OGS. There was a steep “learning curve” associated with developing the performance specifications for precision docking. Much of the coordination focused on getting Irisbus to agree to performance standards for precision docking that were considered extremely stringent.

One of the big challenges with precision docking is that the level of precision required was not readily transferable to civil construction and pavement markings. For example, RTC had to develop unique solutions to address the precision required to paint the trajectory read by the optical guidance system to trigger the automated precision docking to desired lateral clearance specifications. RTC reported that there were not many additional civil engineering requirements that had to be considered to accommodate the precision docking technology.

2 *In cases where there are constant vehicle queues in both opposing directions, the signalized intersection may be assigned a left turn “swap” logic, which alternates (or 'swaps') the arrow between each direction every cycle.*

From a civil engineering standard, precision docking became "just another design consideration."

The OGS is currently not in use during revenue service due to extensive maintenance requirements to keep pavement markings clean. The OGS "reads" the contrast between the pavement marking and the underlying pavement. Due to the extreme heat and low annual rainfall, roadway surfaces leach oil and dirt, which is then picked up by vehicles and transferred as accumulated dirt on pavement markings. When trajectory's contrast is degraded, the optical scanning device does not properly read the marker and trigger the automatic guidance system. RTC is currently testing several pavement marking compounds that can better maintain color contrast levels under operating conditions typical of the Las Vegas Valley. Until this is resolved, MAX operates manually dock MAX vehicles at stations.

Radio Communications

All MAX vehicles are equipped with Automated Passenger Counter (APC) sensors and Computer Aided Dispatch/Automated Vehicle Locator (CAD/AVL) system. Final acceptance of Version 3 of the AMDT, radio/data communications and scheduling software components developed by Orbital occurred in March 2003, with an upgrade to Build 5 fully accepted in June 2005. MAX currently shares a radio channel and dispatch functions with CAT fixed route buses. The system requirements originally specified data storage every 30 days, but RTC enhanced the data storage to 90 days, with enough data storage capacity to capture six to ten months of data.

RTC encountered several APC installation issues unique to the MAX vehicle. The standard APC system was designed for a three door vehicle. Because the Civis vehicle has a four door configuration and a wider door than a standard 40-foot bus, the APC sensor had to be placed above all doors and custom mounted. Because of angle and size of the space above the door, the original mounting design would have created a protrusion susceptible to recurring passenger contact. RTC evaluated several awkward mounting configurations before choosing to customize the installation by embedding the sensor device into the overhead door panel. In addition, the manufacturer and Orbital had to modify the software to read the fourth door. This effort took several months and represented a major data collection challenge.

Another major challenge was identifying conduits for internal routing of add-on systems not installed by the manufacturer. An important lesson learned was the importance of sending add-on units to the vehicle manufacturer to be installed as part of the vehicle assembly process.

2.6 SERVICE AND OPERATIONS PLANS

MAX operates every day from 5am to 10pm at headway-based schedules of 12 minutes between 5am and 7pm, and 15 minutes between 7 pm and 10pm. MAX offers several major transfer points to other CAT lines serving North Las Vegas Boulevard. Because service frequencies for MAX are relatively high, to the point where passengers depend more on the consistency of the headway operations rather than an operating schedule, RTC opted for a headway based schedule. To help maintain this headway schedule, MAX was instituted with a policy to skip station stops where there are no stop requests for on board passengers and no waiting passengers in the station.

Between 5am and 7pm, the MAX schedule assumes a northbound end-to-end travel time of 28 minutes and a southbound end-to-end travel time of 31 minutes. After 7pm, the MAX schedule assumes a northbound end-to-end travel time of 23 minutes and southbound end-to-end time of 28 minutes. Southbound travel times on MAX tend to be slightly longer than northbound because of heavy southbound traffic on Main Street and North 5th (south of Lake Mead Boulevard) and the comparatively higher number of southbound alightings at Civic Center Drive and Jerry’s Nugget.

3.0 SYSTEM COSTS

The costs of the MAX project can be broken out by the following project element:

- Vehicles
- Passenger shelters,
- Dynamic message signs,
- Ticket vending machines,
- Radio communications/AVL, and,
- Traffic signal priority equipment

Exhibit 9 provides a capital cost summary of MAX by project element. The total project capital cost was approximately $20.3M (or $2.6M/mile). This total cost per alignment mile (not directional route mile) is on the lower end of the typical project scale for in-street mixed traffic alignments. The main reason the total project cost was comparatively low is because RTC did not incur any right-of-way acquisition or improvement costs. These were covered through the availability of the wide existing alignment profile and the right-of-way ownership by Nevada Department of Transportation (NDOT). The largest project cost was the Civis vehicles, which represented approximately 59 percent of the total project cost.

Exhibit 9: Summary of MAX Project Costs

Project Element	Total Cost	% of Total Cost
Civis Vehicle		
Vehicle & Systems (10 Total) - Irisbus	$11,960,386	58.9%
Vehicle Mfg Inspection - TRC/Semaly	$ 340,760	1.7%
Passenger Shelters		
Engineering Services - Stanley Consultants	$ 1,150,966	5.7%
Construction Bid (West Coast Contractors)	$ 4,152,259	20.5%
Guidance Markings	$ 55,532	0.3%
Miscellaneous	$ 15,530	0.1%
Dynamic Message Signs		
Passenger Information Displays	$ -	0.0%
Ticket Vending Machines		
Production & Installation - GenFare Inc.	$ 1,900,000	9.4%
Fare Collection Design	$ 200,000	1.0%
Radio Communications/AVL		
Radio/AVL/APC Installation - Orbital	$ 298,810	1.5%
Transit Signal Priority		
Implementation Strategy & Analysis	$ 26,026	0.1%
Traffic Signal Equipment - 3M	$ 120,000	0.6%
Vehicle Emitters - 3M	$ 10,945	0.1%
Signal Controller Software Mods - GTS	$ -	0.0%
Data Collection & Mgmt - Econolit/TrafficWerks	$ 59,200	0.3%
TOTAL	$20,290,414	

The next largest project element was the engineering and construction of the MAX stations (20.5 percent), followed by the acquisition and installation of the ticket vending machines (9.4 percent). Much of the traffic signal equipment was in place before the MAX project. Therefore, the cost for the additional TSP, vehicle emitter equipment, and installations was only $216,171. The communications system and the associated vehicle location and passenger counting systems were installed for a combined cost of $298,810. These systems acquisition and installation costs were also relatively low. Soft costs (including administration, agency and consultant costs) were not estimated for the project costs and not included in **Exhibit 9**.

4.0 PLANNING, DESIGN AND IMPLEMENTATION

RTC engaged a comprehensive systems approach in designing the MAX, with the goal of "providing high quality, state-of the-art rubber-tire mass transit." This approach involved systematically planning how design and technological features would map to specific operational objectives, the most ambitious being the design of multiple entry level boardings with lateral clearance equal to light rail transit standards. This would involve three critical design requirements:

- Height of station platforms must be level with low-floor vehicles
- The vehicle must have multiple doors
- Precision docking capability, both in automated and manual modes of operation

The Civis vehicle, manufactured by Irisbus, was among the few technologies worldwide that could meet these design requirements. The vehicle is 100% low floor, has four doors and is equipped with Optical Guidance System (OGS), as illustrated in **Exhibit 10** below. In addition to these specific design requirements, RTC placed high emphasis on a vehicle that boldly conveyed a modern, sleek, rail-like appearance and featured the latest innovations in ITS technology.

Exhibit 10: MAX Vehicle at Station Platform

RTC reports that it invested approximately five times more labor hours on monitoring the Civis vehicle procurement than typically required for a standard bus procurement. RTC estimates that it devoted approximately 4,000 labor hours to monitoring the Civis vehicle procurement. Depending on the inclusion of labor benefits and overhead costs, costs could range between $200,000 and $500,000.

Much of the procurement monitoring effort involved complying with FMVSS requirements and reviewing compatibility with the greater Las Vegas environment with NDOT engineering staff. One of the major accomplishments of the vehicle procurement effort was the hiring of an in-plant inspector, who provided RTC with vehicle inspection and monitoring reports that met or exceeded RTC's expectations.

4.1 PROJECT DEVELOPMENT SCHEDULE

Project delivery for MAX took approximately 26 months, with over twelve months devoted to vehicle design reviews. Below is a schedule of major milestones beginning with the issuance of the vehicle procurement specifications package:

- Technical Specifications for Vehicle Procurement Issued (May 2, 2000)
- Selection of Vehicle Manufacturer (February 8, 2002)
- Vehicle Design Review (April 24, 2001 – October 22, 2002)
- Station Design RFP Issued (April 21, 2002)
- RFP for TVMs Issued (June 2002)
- TVM Bid awarded to GFI (November 2002)
- Traffic Signal Priority Implementation (July 2002 – December 2004)
- ORBCAD Final Acceptance of Version 3 (March 2003)
- Start of MAX station and right-of-way construction (May 15, 2003)
- Civis vehicle testing period (November 16, 2003 – June 29, 2004)
- Upgrade of ORBCAD to Version 5 (December 2004)
- Arrival of first MAX vehicle (August 7, 2003)
- RTC invites public to "Meet MAX" (February 2004)
- TVM installation (February 2004)
- Queue Jump implemented (June 14, 2004)
- RTC opens MAX to the public (June 30, 2004)

This project development schedule reflects a much shorter time period than other comparable projects due to the availability of the right-of-way. This schedule followed the planned project development schedule except for the delays in testing and acceptance of the vehicles. That process introduced about six months of delay to the project.

It is worth noting that RTC Southern Nevada did not have to acquire any right-of-way as part of corridor planning efforts. With very little additional right-of-way needed, MAX advanced relatively quickly through the environmental clearance and planning process. Another major factor that contributed to the successful and expeditious implementation of the MAX project was the Las Vegas community's expectations for timely project delivery and passion for technological innovation.

4.2 STATION PLANNING

RTC staff reviewed the characteristics of each stop along Route 113 and identified 18 candidate locations along the dedicated transit-only lane for MAX stations. In selecting MAX station locations, RTC established a list of station location criteria, including:

- Ridership potential
- Stop location
- Physical configuration of sidewalk
- Sidewalk clearance
- Landscape
- Curb clearance

In addition to these characteristics, RTC tried to limit the number of stations to maintain about an average distance of one mile between stations.

4.3 INSTITUTIONAL SETTING

One of the unique institutional characteristics of the RTC Southern Nevada is its dual role as the Metropolitan Planning Organization (MPO) and transit operator. Because both functions operate in a "collaborative" environment, the MAX project moved through project development on a fast track. Through a comprehensive public outreach effort, RTC Southern Nevada expressed a strong commitment for meeting the community's expectations for a state-of-the-art mass transit project that could be completed on time and within budget. As the project progressed, RTC took advantage of its institutional flexibility to keep the momentum of the project going.

Overall, RTC kept to the planned project development schedule very closely, with the exception of a four-week delay in grand opening from May 1 to June 1. Through the vehicle design and testing period, the project schedule stayed on track. The only major delay occurred with the postponement of opening day, caused by an unanticipated delay in the supply chain for vehicle parts.

Through the project development phase, RTC executed an effective multimedia marketing campaign to familiarize the general public with the MAX project. One of the most effective means of communicating information about future services was a direct mailer to residences and businesses along the corridor in English and Spanish, with invitations to neighborhood outreach meetings where RTC staff introduced MAX and provided instruction on usage of TVMs. Another effective channel of communicating information about MAX were one-on-one media tours, which facilitated in-depth news coverage about the upcoming service.

At every major project milestone, RTC's marketing department also issued press release statements informing the public of project accomplishments. For example, RTC carefully orchestrated the official unveiling of the MAX vehicle upon its first delivery through its online press releases, with RTC media representatives on hand to handle media inquiries. These events were successful in promoting the MAX system to local news media, both TV and radio, and disseminating a distinct new brand of transit service to the public.

4.4 LESSONS LEARNED

This section describes some of the lessons learned in MAX – RTC's first advanced BRT deployment, in addition to being RTC's first overseas vehicle procurement. In a series of focused interviews – both before and after the opening of MAX on June 30, 2004 – RTC staff provided extensive feedback about a wide range of project development, implementation and ongoing operations issues related to the MAX system.

Overseas Vehicle Procurement Challenges

The MAX vehicle design review process was unprecedented insofar as MAX was the first overseas vehicle procurement in RTC's history. Because the manufacturer was based in Europe (France), there were some initial communications breakdowns resulting from the language barrier. RTC scheduled two design reviews per year with the vehicle manufacturer, for a total of six. The design review meetings focused on four main technical areas:

- Wheelchair ramps
- Air conditioning ('Las Vegas' pull-down test)
- Engine selection (vehicle had to conform to EPA standards)
- Tires

These vehicle components were identified by RTC as critical to the success of the Civis vehicle acceptance and operation. One of the most valuable provisions of the vehicle procurement contract was having an in-plant inspector. This facilitated close communications and monitoring throughout the procurement process, especially given the distance to the vehicle plant and the language barrier. After some initial communications issues were resolved, RTC staff felt that the design review process was very effective and well documented.

RTC estimated that there was approximately five times as much inspection and monitoring needed for MAX vehicle procurement than the standard vehicle procurement. This was largely because of complex and time-consuming engineering, Federal Motor Vehicle Safety Standards (FMVSS) and DOT standards. Overall, RTC estimates that it dedicated approximately 4,000 hours to inspection, legal issues and monitoring. Despite the fact that inspection and monitoring efforts took much longer than anticipated, RTC felt that this was one of the best procurements that RTC has ever had, due to the introduction of multiple systems suppliers and successful integration within the vehicle procurement process.

At RTC's direction, ATC Vancom dispatched three technicians to France for six weeks of vehicle maintenance training. Three additional technicians were sent for specialty training, focusing on the air conditioning system, the drive train and braking and undercarriage. ATC Vancom also sent two supervisors to training. These maintenance staff perform both ongoing maintenance and warranty work on the Civis vehicles, with the warranty work under a separate contract.

Supply Chain Issues

One of the biggest challenges of the MAX project was establishing a reliable supply chain of spare parts for the Civis vehicle. This was particularly challenging since this was the first U.S. procurement of an advanced BRT vehicle manufactured overseas. It is an ongoing challenge that RTC continues to face into revenue service.

In pre-revenue testing, RTC encountered a series of minor reliability issues to major vehicle system components. Because the Civis vehicle was manufactured overseas and there were considerable lags in the supply chain for spare parts, RTC discovered that considerable lead time is required to establish a reliable and well-integrated supply chain for spare parts. There were unexpected delays resulting from shipping and customs problems. Taken together, these delivery delays pushed back the MAX opening by four weeks to June 30, 2004.

In the vehicle procurement contract with Irisbus, RTC did not include liquidated damage clauses that would have placed more responsibility on the vehicle manufacturer to meet performance specifications on spare parts delivery and other supply chain issues. Based on this experience, RTC indicated that it would seek to include a liquidated damage clause in future vehicle procurements to lessen exposure to these areas of risk.

Overall, RTC staff reports that the Civis vehicles are generally as reliable as conventional fixed route buses in the CAT fleet. One of the biggest problem areas, however, is the electrical generation and drive system, which was subject to performance requirements that are unique from any other service area where Civis has been deployed. RTC maintenance staff encountered some challenges in fixing electrical problems, given the unanticipated delays in the supply chain for spare parts.

The Southern Nevada desert heat presented significant challenges to many of the electronics-heavy Civis vehicle, which caused some circuit-breakers to fail. RTC noted that the intense heat is unique to Las Vegas, and that the Irisbus representative was very proactive in devising innovative solutions to electrical failures resulting from the summer heat. A major lesson was that having an on-site Irisbus representative for two years was “a really smart thing to do.” The support from the representative has exceeded expectations.

Optical Guidance System

One of the signature technical innovations of the MAX system is the optical guidance system (OGS), which is designed to enable automated precision docking at station platforms. While OGS functioned well in operational acceptance testing, RTC reports that OGS performed irregularly while in service due to the increasingly diminished contrast on the trajectory marker from dirt and oil buildup. In the weeks after the MAX opening, RTC discontinued use of OGS.

The main lesson learned with OGS is that its reliability can be compromised in harsh desert environments where sun, dirt, grease and oil buildup on the road can diminish the trajectory’s contrast. RTC is currently testing several liquid paving markers being developed by 3M, along with other materials.

In the meantime, all MAX operators execute manual station docking. MAX operators have reported that manual docking of MAX vehicles is greatly facilitated by the center configuration of the driver's seat, allowing operators to maneuver the vehicle over the painted trajectory upon approach to the station with great accuracy. Since the discontinuation of OGS in July 2004, there have been no major accidents or incidences related to manual station docking. RTC reports that manual docking does not compromise MAX operations and OGS will be implemented after testing and approval of a new pavement marking solution that can withstand Las Vegas' extreme operating environment.

Advanced Transit Management System (ATMS) Integration Into the Civis Vehicle

RTC encountered several Automated Passenger Counter (APC) installation issues unique to the Civic vehicle. Because the Civic vehicle has multiple doors and a wider door than a standard 40-foot bus, the APC sensor had to be placed above all doors and mounted differently than originally anticipated. With the angle and shape of the space above the door, there was a concern that the original mounting design would have created a protruding object subject to recurring passenger contact.

The standard installation also does not account for a fourth door, so the system had to be custom-installed to provide an accurate count of boardings and alightings at all four doors. In the first eight months of operation, the fourth door of the Civis vehicle was not equipped with APC, so ridership counts uploaded to the Orbital reporting system did not include boardings and alighting through the fourth door.

A major challenge was identifying conduits for internal routing of add-on systems not installed by the manufacturer. Orbital Systems was the vendor chosen to equip the Automated Vehicle Locator (AVL) and Automatic Passenger Counter (APC) system. The units were installed after the vehicles were delivered to RTC. This ended up causing some problems, because the standard equipment was not easy to install on the specialized vehicle. Additionally, running electrical conduit to accommodate the APC equipment took longer than anticipated.

Some of the bugs in the performance reporting system took longer to resolve than anticipated. There is a 28-hour lag in the data transfer from the wireless Local Area Network (LAN) to the Data Information System (DIS). The DIS receives the data and then transmits it via land LAN. The Orbital system creates an APC Correlated Table, which includes door open time, door close time, passengers on, passengers off, and time points. Operators are required to track wheelchair and bicycle boardings manually.

One of the big technical challenges identified during the design review meetings was that conduits for internal routing were extremely important to coordinate before the vehicle was completed. One major lesson learned was to send supplementary units to the manufacturer to be installed during the final assembly process by the manufacturer. RTC's experience is that forethought in systems integration of future system enhancements will greatly reduce some of the challenges associated with custom-installing standard equipment that does not fit into a specialized vehicles like Civis.

Transit Signal Priority (TSP) and Queue-Jump Developments

The TSP system initially conceived as low-impact treatments, with the methods limited to left turn swapping, green extension, and early greens. The desired functionality, however, had to be disabled during certain times of day to avoid creating operational problems at several intersection locations. At locations where lagging left turn phasing were used, for example, FAST was required to disable both the left-turn swapping and green extension functionality. In addition, TSP functionality had to be disabled during times of day when signals ran a 100 second cycle.

Overall, TSP implementation did not result in any traffic disruptions with the exception of the Civic Center and Las Vegas Boulevard, a high traffic intersection located in a closely spaced street network. After several attempts were made too alleviate the traffic disruption caused by the TSP service, RTC disabled TSP at this location during the PM peak period. In general, it appears that TSP implementation along corridor with heavier recurring traffic congestion and inadequate intersection capacity will present a challenge, as there is greater concern that TSP can degrade traffic flow.

One positive development was the successful implementation of a queue jump operation at the Tonopah and Las Vegas Boulevard intersection, originally designated for TSP implementation. The queue jump at this T-intersection involved installation of detection loops at the MAX stop to detect the arrival of the MAX vehicle. The controller programming was modified to provide a short queue jump phase when there is both a detector call from the bus detectors and a TSP call present. This triggers a short queue jump phase in the controller, where all conflicting vehicular and pedestrian indicators are held at red while the MAX vehicle receives a short green indication. The short green time allows the MAX vehicle to clear the intersection before any other traffic movement is allowed to proceed. The protected through movement is conveyed to the MAX operator via a special signal display that uses a vertical white bar indication.

5.0 EVALUATION OF SYSTEM PERFORMANCE

The purpose of this section is to evaluate MAX system performance based on the core elements that comprise BRT system performance, which include: 1) travel time, 2) reliability, 3) image and identity, 4) passenger safety and security, and 5) system capacity. Where data was available, a comparison of transit services pre- and post-MAX conditions is presented.

5.1 TRAVEL TIMES

Travel times are impacted by how key BRT elements (such as running way segregation) are implemented and how these elements relate to one another. The key components of BRT travel time are:

- Running Time
- Station Dwell Time
- Waiting and Transfer Time

Exhibit 11: Average Weekday Travel Times (min) on Route 113 and MAX by Time of Day

	Route 113 (pre-MAX)		MAX		Percentage Reduction	
	NB	SB	NB	SB	NB	SB
AM	38	49	28	31	26.3%	42.8%
Midday	44	49	28	31	36.3%	36.7%
PM	37	39	23	28	37.8%	28.2%

Exhibit 11 shows a comparison of end-to-end average travel time for Route 113 pre-MAX and MAX by time-of-day (in minutes).[3] Average travel times on MAX are significantly shorter than travel times on Route 113 throughout the day. In the midday, for example, pre-MAX travel time on Route 113 in the southbound direction averaged 44 minutes. By contrast, MAX averages 28 minutes northbound in the midday, a 36.3 percent reduction over pre-MAX transit running times. Pre-MAX travel time on southbound Route 113 during the AM period averaged 49 minutes. MAX averaged 31 minutes southbound in the AM period, a 42.8 percent reduction over pre-MAX running times. Travel times on Route 113 are consistently longer than on MAX primarily because Route 113 is a more locally oriented service, with almost twice as many station stops as MAX. Because stops are more tightly spaced, Route 113 vehicles do not reach maximum speeds as high as MAX. Post-MAX travel times on Route 113 appear to be consistent with pre-MAX conditions.

Exhibit 12 shows average speeds for Route 113 and MAX for the AM peak, midday and PM peak hours during a sample week. Average weekday speeds for Route 113 and MAX range between 9 and 18 mph throughout the day, with higher average speeds for MAX.

[3] *Data presented in Exhibits 11, 12 and 13 were calculated based on a sample of pre-MAX Route 113 runs observed between February and May 2004 and a sample of MAX runs observed between July and November 2004.*

Exhibit 12: Average Speed (mph) Route 113 and MAX by Time of Day

	Route 113 (pre-MAX)		MAX	
	NB	SB	NB	SB
AM	11.8	9.2	14.8	15.3
Midday	10.7	9.2	14.8	15.3
PM	12.0	11.4	16.3	18.6

During the AM and midday hours, average speeds on MAX are 25 percent higher in the northbound direction and 66 percent higher than on Route 113 for the southbound direction. MAX achieves higher average speeds than Route 113 for several reasons. Station locations are spaced farther apart, allowing for less travel time delay from the stopping action and less station dwell time throughout the corridor. In addition, MAX bypasses stations where no passengers request a stop and no passengers are waiting at the station.

Another factor impacting the travel time differential between Route 113 and MAX is station dwell times. Route 113 experiences much longer average dwell times than MAX, due in large part to the operational disadvantages associated with single door entry and non-low floor vehicle configuration. The breakdown among these individual effects was not available from RTC.

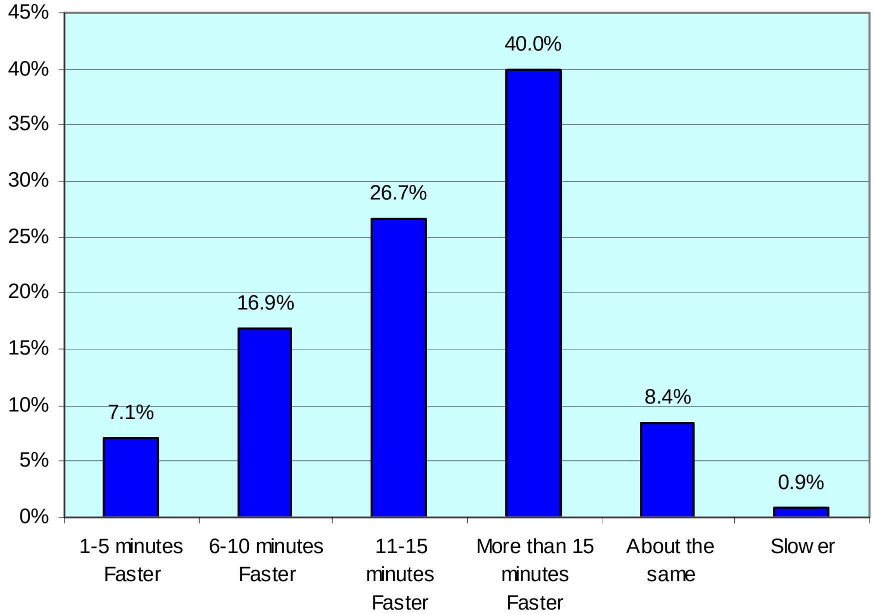
Exhibit 13: Average Weekday Dwell Time (sec) on Route 113 and MAX by Time of Day

	Route 113 (pre-MAX)		MAX	
	NB	SB	NB	SB
AM	24.5	32.1	5.0	8.0
Midday	29.8	35.1	5.0	8.0
PM	27.3	34.2	17.0	12.0

Exhibit 13 shows the average dwell time for Route 113 and MAX for the AM peak, midday and PM peak hours on weekday runs sampled during the first week of October 2004. Overall, station dwell times appear to be longer in the southbound direction, due to relatively higher number of midday and PM boardings in the southbound direction, both for Route 113 and MAX. Throughout the day, station dwell times on MAX are approximately 50 percent shorter than dwell times on Route 113.

MAX facilitates multiple entry boardings, which reduce the likelihood of passenger queues that materialize at high load points on conventional fixed route buses. Although a high proportion of Route 113 riders use multi-day flash passes, the enforcement of validation by the operator resulted in some delays in the dissipation of the passenger queue in the boarding process.

Exhibit 14: Frequencies of MAX Passenger Responses to: "How Has Your Travel Time Changed?"



in the MAX passenger survey conducted in March 2005, riders who reported previously using CAT Route 113 were asked, "How has your travel time changed since riding MAX?" **Exhibit 14** shows the distribution of those responses. Roughly 40 percent of surveyed riders reported that their travel time improved by more than 15 minutes and 26.7 percent reported their travel time improved by 11 to 15 minutes. These results correspond with the travel time differences between MAX and Route 113. One issue not fully investigated in this study is the potential increase in travel time to access the more distant stations. Either the stations were selected extremely well and/or a certain portion of the increased station access time is lost in the perception of the faster in-vehicle travel times.

5.2 SCHEDULE RELIABILITY

Reliability, defined as the variability of travel times, is composed of three dimensions of reliability: 1) running time reliability, 2) station dwell time reliability, and 3) service reliability.

Unlike the CAT system, which relies on a fixed schedule, MAX operates on a headway based schedule, with 12-minute headways from 5 AM to 7 PM and 15-minute headways after 7 PM. RTC has built into the MAX schedule a northbound run time of 28 minutes and a southbound run time of 31 minutes. This run time differential reflects recurring directionally-oriented delays (i.e. heavier traffic delay southbound than northbound).

Prior to the opening of MAX, Route 113 operated on a 24-hour fixed schedule, with 15-minute peak headways and 30-minute off-peak headways. Subsequent to the opening of MAX, RTC adjusted service frequencies on Route 113 to 30-minute headways all day. Between February and May 2004, Route 113 had an average schedule reliability of 95.6%. RTC defines on-time performance as a trip that arrive within one minute of the scheduled timepoint. Since the opening of MAX, schedule reliability on Route 113 has remained at or above this percentage.

Because MAX operates on a dedicated bus lane along a 4.5-mile segment of Las Vegas Boulevard North, MAX experiences less travel time variability than other CAT lines operating in a mixed traffic environment. Between July and December 2004, RTC reported a headway reliability of close to 100 percent for peak and non-peak MAX runs.[4]

The average dwell time for all MAX trips between October 30 and November 11, 2004 was 14.8 seconds per stop, with a standard deviation of 9.3 seconds. Station dwell times and station dwell time variability on MAX are consistently lower than on CAT Route 113 and the CAT systemwide average. CAT stop dwell times generally reflect an average of approximately 11 seconds per person, and have been observed in excess of 5 minutes at high boarding locations.

5.3 IDENTITY AND IMAGE

Identity and image reflect the effectiveness of a BRT system's design in positioning it in the transportation marketplace and establishing a brand niche within the urban environment. In the 18-month period prior to the grand opening of MAX, RTC developed and executed a multimedia marketing campaign that emphasized MAX's modern, sleek rail-like appearance. The MAX features a distinctive blue, white and gold color scheme, with the MAX logo featured prominently on the front and sides of the vehicle. Moreover, the marketing strategy also focused on establishing MAX's identity as an express service wholly unique from the CAT system. By marketing MAX as a new brand of enhanced transit service, RTC was successful in generating positive "buzz" for MAX.

In addition to having four meetings with the community, RTC undertook an advertising campaign through a variety of media, including radio, targeted print, bus advertising and traffic sponsorships. Throughout 2003, RTC invited the media to test ride the MAX vehicle.

In the months prior to its opening on June 30, 2004, RTC promoted MAX on its website. The RTC website has since been redesigned to feature MAX (www.maxride.com) and to highlight several of MAX's innovative system features.

In February 2005, RTC Southern Nevada conducted an on-board customer survey on CAT buses and MAX to better understand the travel patterns of its core ridership market and customer perceptions about CAT service. As shown in **Exhibit 15**, 66 percent of MAX survey respondents characterized the "appearance/design of MAX vehicles" as "excellent." **Exhibit 16** shows that 57 percent of respondents characterized the "appearance/design of MAX stations" as "excellent."

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[4] *RTC tracks on-time performance for MAX by routinely monitoring of station arrival times and the proportion of arrivals at a fixed point in excess of the headway standard for that time of day.*

Exhibit 15: Passenger Ratings of MAX Vehicle Appearance / Design

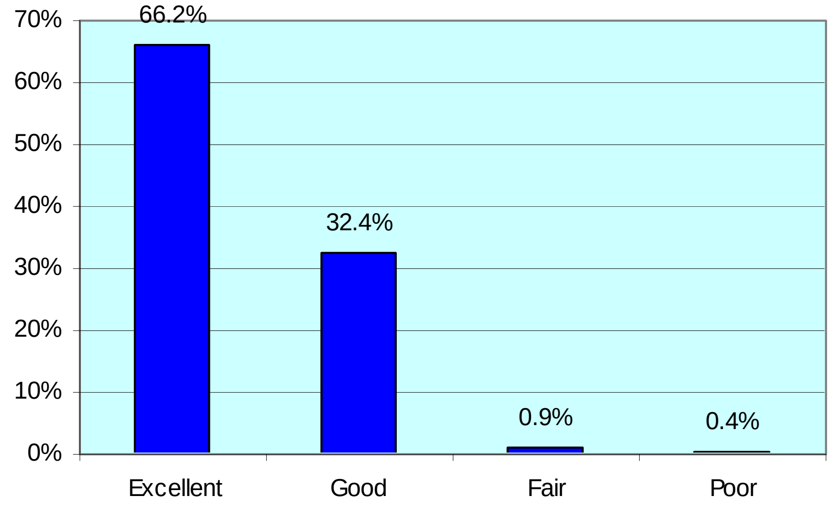
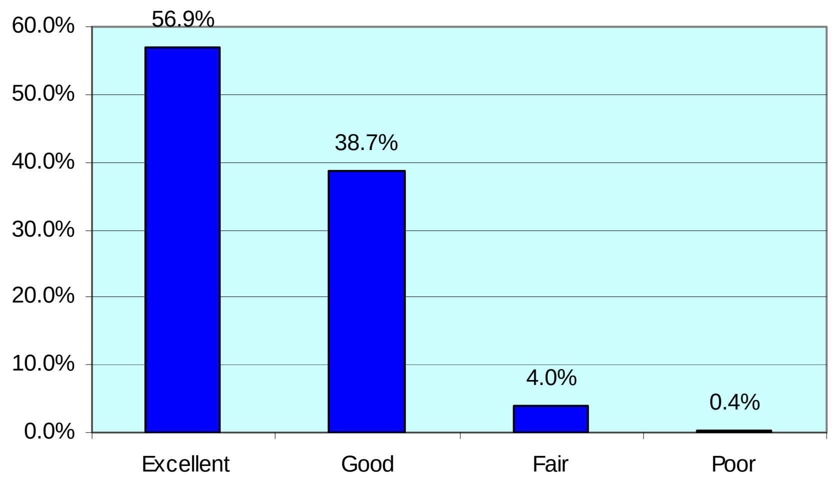


Exhibit 16: Passenger Ratings of MAX Stations



5.4 SAFETY AND SECURITY

RTC contracts fare inspection with Wackenhut of Nevada, a private security company. System security responsibilities reside with ATC. Wackenhut security officers perform routine fare enforcement patrols on MAX vehicles and monitor MAX stations for suspicious or illegal activities. ATC has in place a detailed security and emergency management plan for responding to major incidents on CAT buses and MAX.

The MAX passenger survey suggests that MAX riders feel a high degree of personal safety both at MAX stations and in MAX vehicles. **Exhibit 17** shows that 54 percent of MAX survey respondents characterized safety at MAX stations as “excellent.” **Exhibit 18** shows that 69 percent of MAX survey respondents characterized the safety of MAX vehicles as “excellent” and 30 percent characterized safety on MAX vehicles as “good.”

Exhibit 17: Passenger Ratings of Safety on MAX Stations

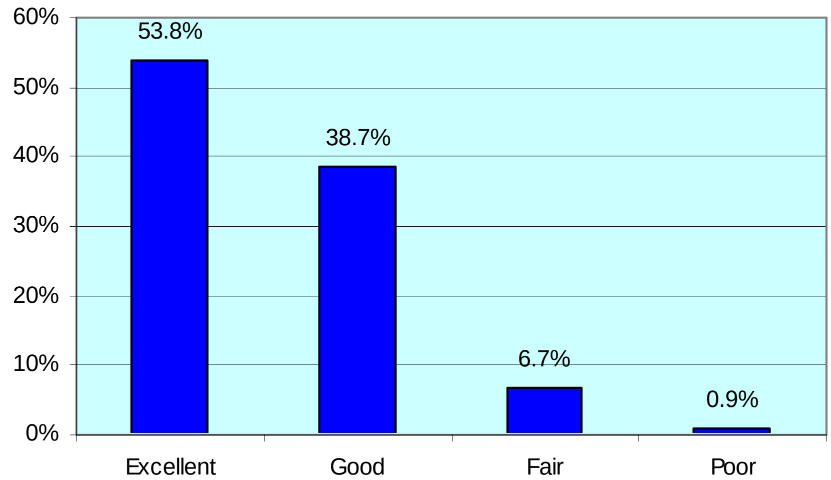
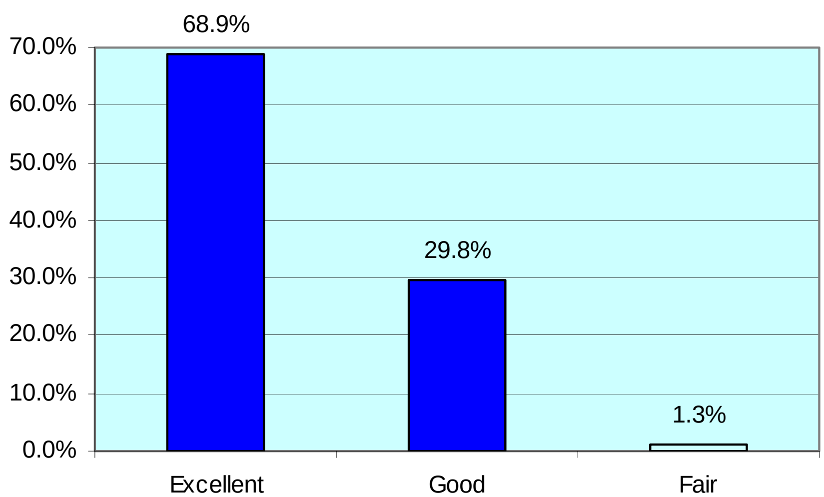


Exhibit 18: Passenger Ratings of Safety on MAX Vehicles



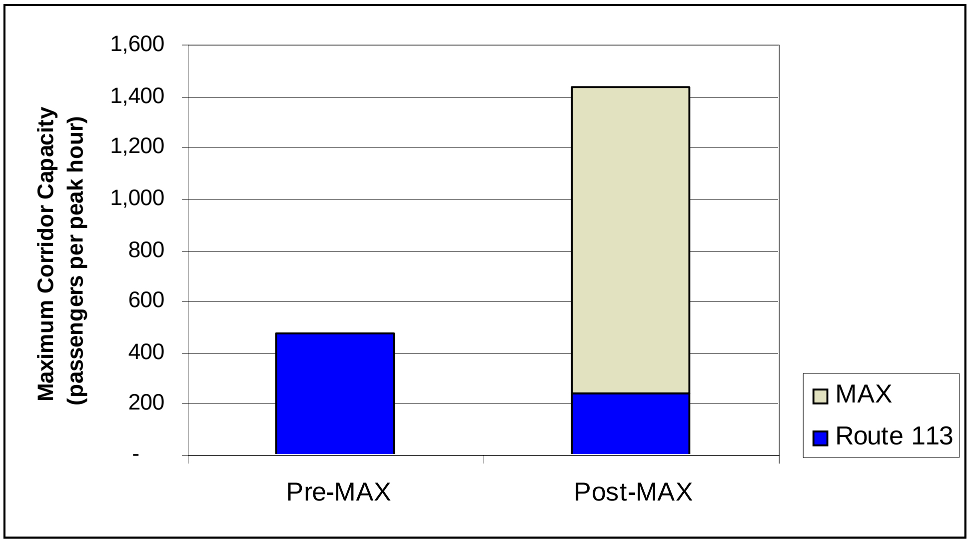
5.5 CAPACITY

Currently, MAX operates at 12 minute headways between 5am and 7pm and 15 minute headways between 7pm and 10pm. Route 113 is a 24-hour service operating at 30 minute headways all day. Before start of operations of MAX in June 2004, Route 113 operated a 15-minute headways between 5am and 7pm and 30 minute headways between 7pm and 5am.

Exhibit 19 shows a comparison of the maximum passenger capacity along the Las Vegas Boulevard North corridor prior to and after the introduction of MAX. Before MAX, Route 113 offered a maximum passenger capacity of 480. With the introduction of MAX, corridor capacity tripled from 480 to 1,440 passengers per peak hour.[5]

[5] *With a maximum passenger capacity of 120 passenger per vehicle, MAX can carry a maximum of approximately 1,200 passengers per hour for both directions based on 12 minute headways.*

Exhibit 19: Maximum Capacity on Las Vegas Boulevard North Corridor



6.0 ASSESSMENT OF SYSTEM BENEFITS

BRT systems provide five major system benefits:

- Higher ridership
- Cost efficiency
- Operating efficiency
- Transit-supportive land development
- Environmental quality

The purpose of this section is to describe the system benefits attributable to the introduction of MAX and assess how BRT system elements and performance characteristics contribute to that system benefit.

6.1 HIGHER RIDERSHIP

Attracting higher ridership is perhaps the most important objectives of any new rapid transit investment. BRT systems attract three types of trips:

- Existing transit trips that divert to the new BRT system from other services
- New or 'induced' trips that were not made before by transit or any other mode
- Trips that were previously made by another, non-transit modes (drive alone, carpool, walk or bicycle) now opting for BRT service.

These increased ridership levels are achieved through the combined effects of travel time savings, service reliability, the identity and image of the service, and the safety and security of the service. The following discussion presents the ridership changes from the existing service to that attracted by MAX. The characteristics of the ridership changes are presented in total and for the boarding and alighting locations. Causes for the increased ridership were not available from the RTC research.

Prior to MAX, the 7.5 mile segment of Las Vegas Boulevard North was served by CAT Route 113, one of RTC's most heavily patronized routes. In the twelve months prior to MAX's opening in July 2004, Route 113 averaged approximately 7,300 passengers per day. In the months after MAX's opening, there was steady and gradually increasing ridership defection from Route 113 to MAX, as the transit customer base gained more familiarity with the MAX system.

Exhibit 20 shows the trend in total monthly boardings on Route 113, MAX and corridor-wide from April to December 2004. Prior to the introduction of MAX service, Route 113 averaged approximately 218,077 monthly boardings between January and June 2004. In the six months after MAX opened, Route 113 boardings declines 22 percent from 189,422 in July 2004 to 147,063 in December 2004.

Ridership on the MAX system showed robust growth over the first six months of operation. Total boardings per month increased 198 percent from 44,431 in July 2004 to 132,718 in December 2004. According to RTC, steady ridership growth resulted from increased awareness of MAX, increased familiarity which its service and new ridership attracted within the corridor. In the first five months after its opening, MAX has contributed to a net 25 percent increase in total ridership along the North Las Vegas Boulevard corridor. It is anticipated that ridership on MAX will soon surpass CAT Route 113.

Exhibit 20: Monthly Trend in Passenger Boardings on Route 113 and MAX

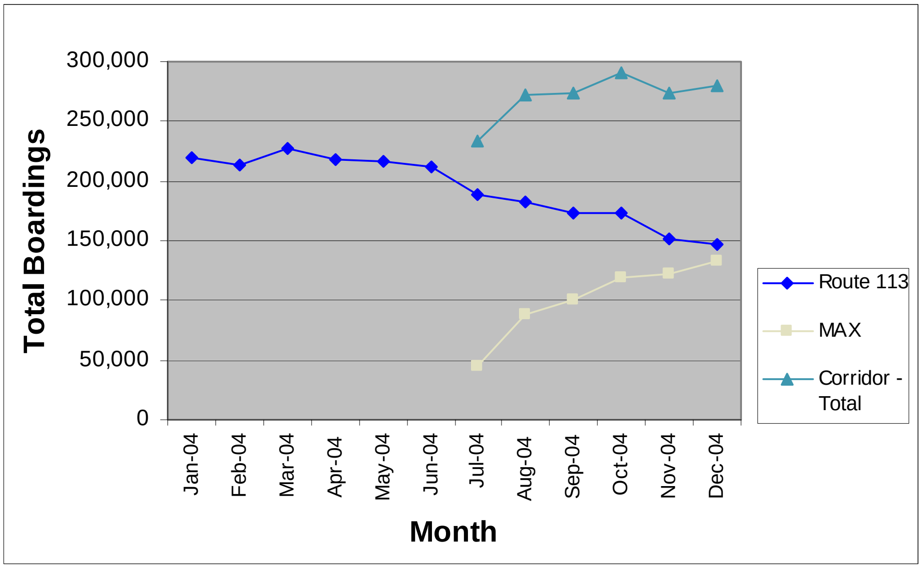


Exhibit 21 and **Exhibit 22** show the distribution of average daily boardings and alightings southbound and northbound during a sample weekday on Route 113 stops prior to the opening of MAX, respectively. In the southbound direction, the stop locations with the highest average boardings were Pecos Road, Lake Mead Boulevard, Foremaster Lane and Hamilton Street. The Pecos Road and Lake Mead Boulevard stops are major transfer points to Route 111 and 210, respectively.

The southbound Route 113 stop locations with the average highest number of alighting passengers is the Las Vegas Boulevard North – Hamilton Street stop (a major transfer point to Route 211) and, not surprisingly, the Downtown Transportation Center, which averaged 590 alightings.

Exhibit 21: Southbound Route 113, Pre-MAX Boardings and Alightings by Stop

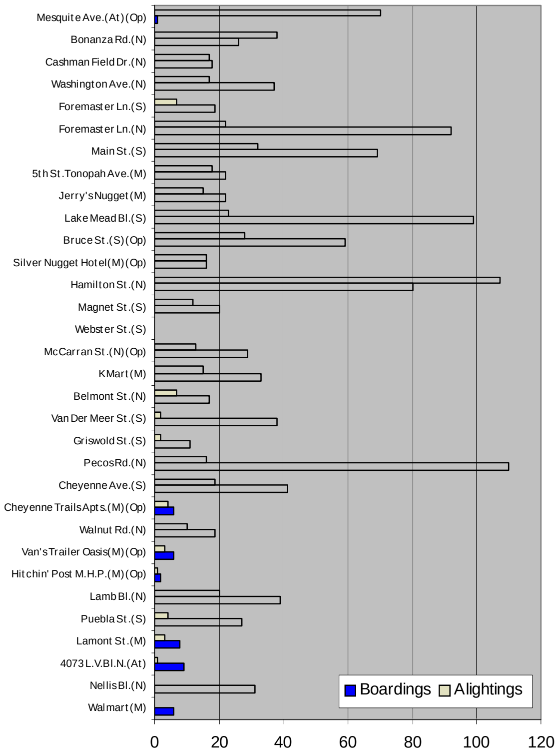
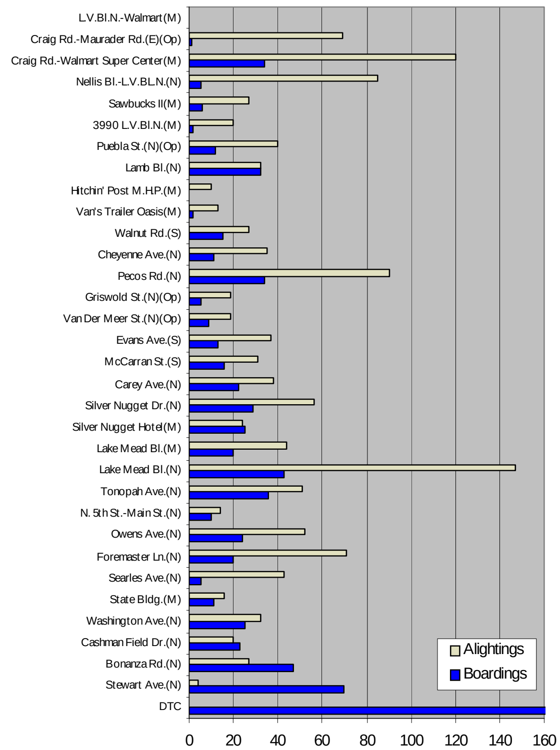


Exhibit 22: Northbound Route 113, Pre-MAX Boardings and Alightings by Stop



In the northbound direction, the highest number of boardings are at the Downtown Transportation Center (DTC), Stewart Ave and Bonanza Road. The average number of daily boardings at the DTC is 787. The northbound Route 113 stop locations with the highest number of alightings are Lake Mead Boulevard, Pecos Road, Nellis Boulevard and Craig Road – Walmart Supercenter.

Exhibit 23 and **Exhibit 24** show the distribution of average boardings and alightings southbound and northbound on Route 113 station stops on a sample weekday after the opening of MAX. Although the post-MAX distribution of southbound and northbound Route 113 boardings remained similar to the pre-MAX distribution, there was a change in the intensity of boardings at popular stop locations.

Exhibit 23: Southbound Route 113, Post-MAX Boardings and Alightings by Stop

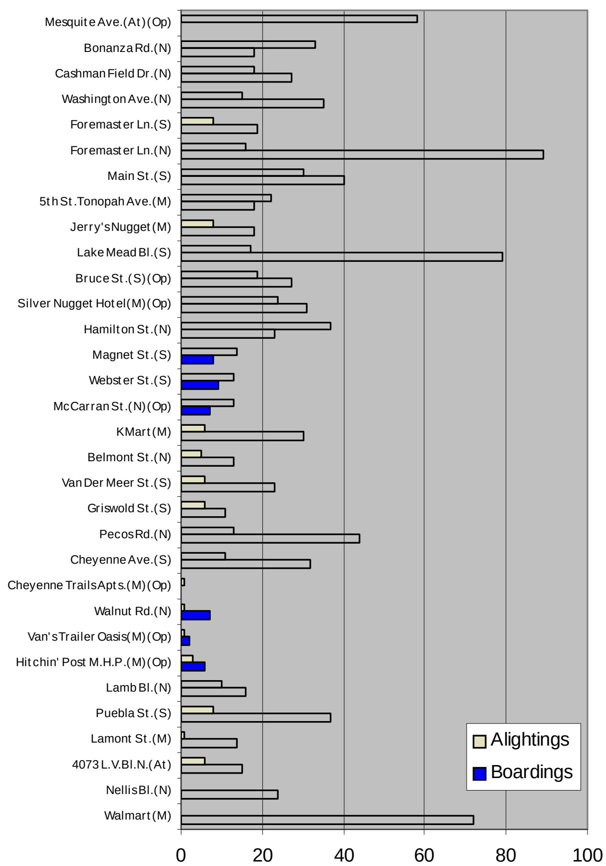
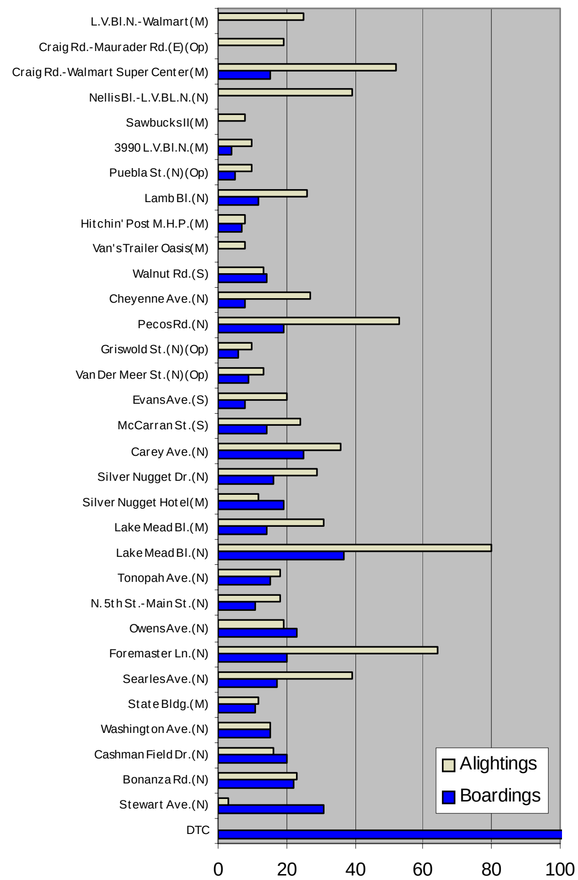


Exhibit 24: Northbound Route 113, Post-MAX Boardings and Alightings by Stop



For example, average boardings at stations adjacent to new MAX stations (Pecos Road, Hamilton St) fell dramatically. Aside from these stations, the average boardings and alightings for most of the Route 113 stops did not change dramatically, which indicates that Route 113 serves a market niche that tends to take linked trips and transfer to and from Route 113 at key transfer locations along the North Las Vegas Boulevard corridor.

MAX appears to serve two travel markets, long-distance and an intermediate-distance. While a large proportion of total boardings and alightings occur at the Downtown Transportation Center, there are several MAX stations that are major transfer points to other CAT routes, particularly at Pecos Road, Civic Center Drive and Nellis Road – Walmart.

Exhibit 25 and **Exhibit 26** show the distribution of southbound and northbound MAX boardings and alightings by station. In the southbound direction, the highest boarding station locations are Craig Road and Pecos. The most popular destination southbound is the Downtown Transportation Center.

Exhibit 25: Southbound MAX Boardings and Alightings by Station

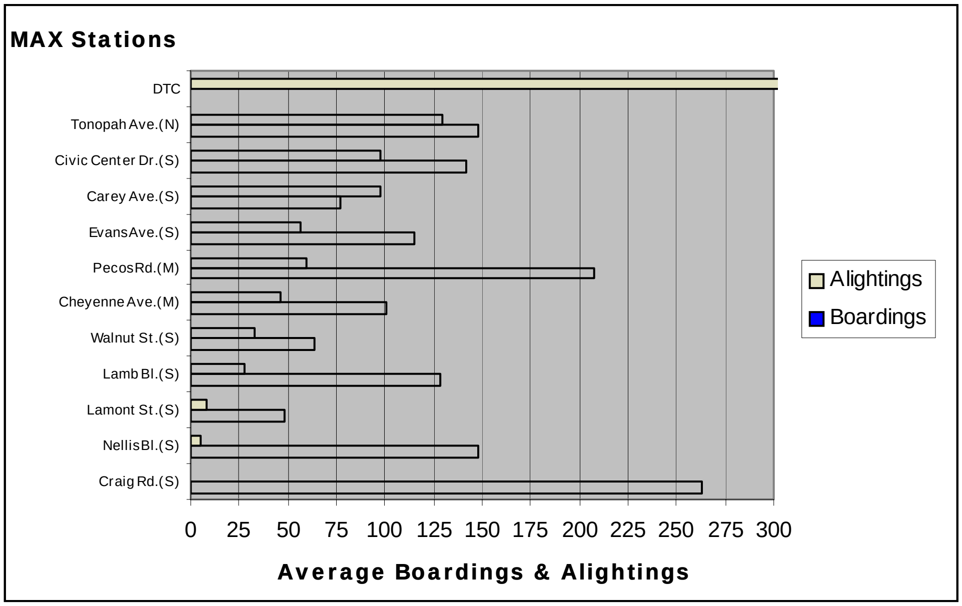
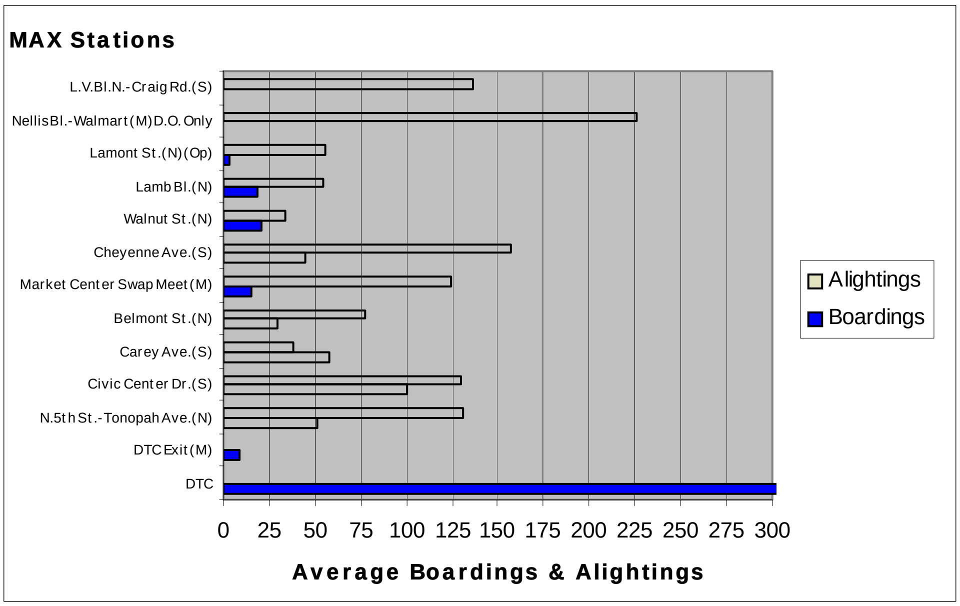


Exhibit 26: Northbound MAX Boardings and Alightings by Station



In the northbound direction, the station with the largest daily boardings is the Downtown Transportation Center (DTC). The stations with the highest alightings are the Nellis Blvd/Walmart and Cheyenne stations.

6.2 CAPITAL COST EFFECTIVENESS

BRT systems possess two principle advantages:

1) Adaptability to diverse operating environments,
2) Scalability of carrying capacity to meet future increases in growth.

In designing a BRT system, planners must select a combination of BRT elements that fit the corridor constraints and opportunities, and whose capital costs can be reasonably justified based on anticipated levels of passenger demand. In the case of MAX, the design of the system was strongly governed by the opportunity made available with the designation of a new dedicated transit lane.

Exhibit 27: MAX Project Costs by Element

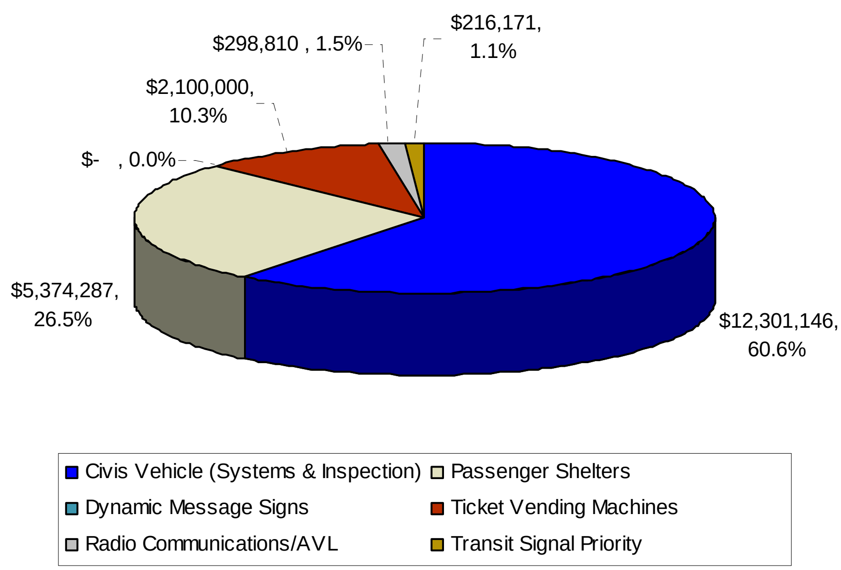


Exhibit 27 shows the component costs of the MAX system, totaling $20.3 million. The largest system cost was vehicles, which comprised 60.6 percent of total system costs. The second largest cost was passenger shelters, which represented 26.5 percent of total costs. The third largest expense was on ticket vending machines (10.4 percent).

The total system cost of approximately $2.8 million per mile is comparatively low even for BRT systems operating at-grade with dedicated bus lanes for some portion of the alignment. This level of the capital cost effectiveness could be achieved because no right-of-way acquisition was required for this project. In addition, right-of-way construction costs for the dedicated lane and the surfacing for the station areas was not included in project costs. The capital cost per mile of $2.8 million is significantly lower than light rail transit systems, which typically range between $20 to $40 million per mile for a comparable service throughput.

6.3 OPERATING COST EFFICIENCY

Operating cost efficiency is defined in this context as the unit cost to produce a unit of service output from a unit of service input. Operating efficiency is assessed according to the following transit performance indicators, typically used throughout the industry to measure service productivity, operating cost efficiency.

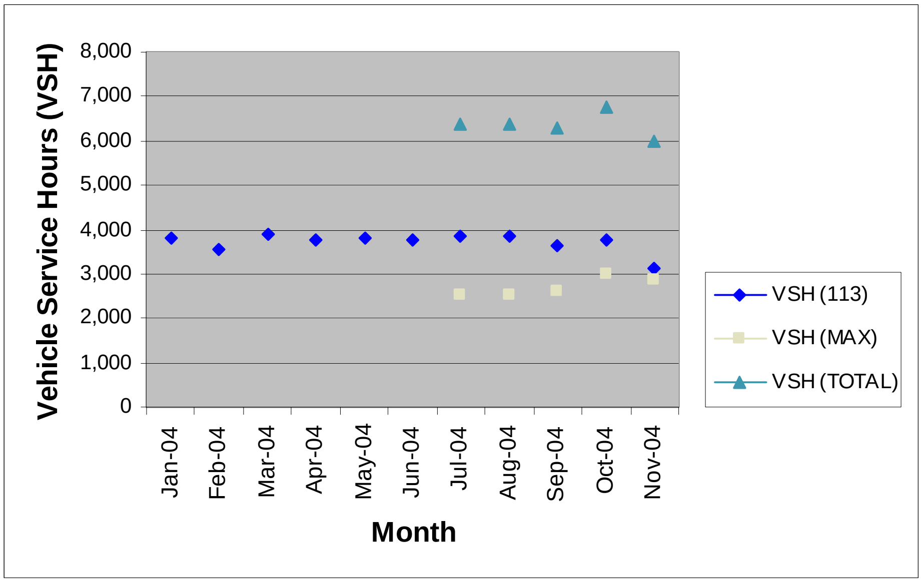
- Operating cost per vehicle service hour
- Farebox recovery ratio
- Operating cost per passenger
- Passengers per vehicle service hour

These performance measures are developed for both the baseline RTC Route 113 service and the completed combination of MAX and the continuing Route 113 operation. These are presented in the following sections.

The initial requirement to the operating efficiency analysis is to establish an understanding of baseline transit services along North Las Vegas Boulevard prior the opening of MAX. Baseline conditions are important to document, in order to assess the net impact of new transit service like MAX on overall performance, cost efficiency, service productivity and corridor ridership. The analysis then compares the post-MAX service environment to that baseline.

Prior to MAX, the North Las Vegas Boulevard corridor was served primarily by CAT Route 113, which operates along Las Vegas Boulevard North over a 24-hour service span, with a AM peak period from 5—9am and PM peak period from 3 – 6:30pm. Weekday headways vary from 30 minutes during non-peak hours to 15 minutes during peak hours. On Saturdays and Sundays, headways are 20 minutes during the peak period and 30 minutes during the off-peak.

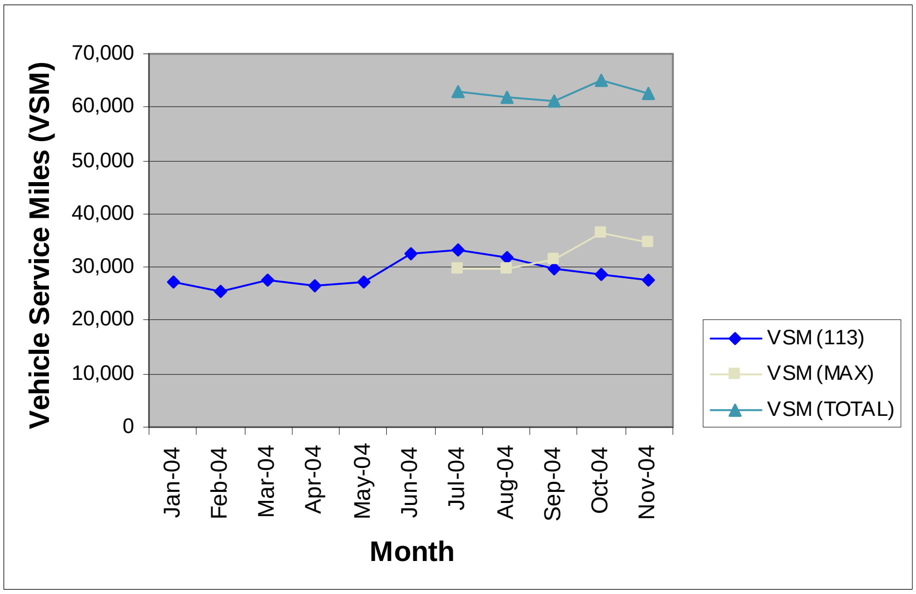
Exhibit 28: Monthly Trend in Vehicle Service Hours on Route 113 and MAX



As shown in **Exhibit 28**, Route 113 averaged 3,711 Vehicle Service Hours (VSH) per month throughout the 2004 calendar year, with minor fluctuations from month to month. With the introduction of MAX service in July 2004, total VSH along the corridor increased 68.8 percent from a monthly average of 3,768 between January and June 2004 to 6,353 between July and December 2004.

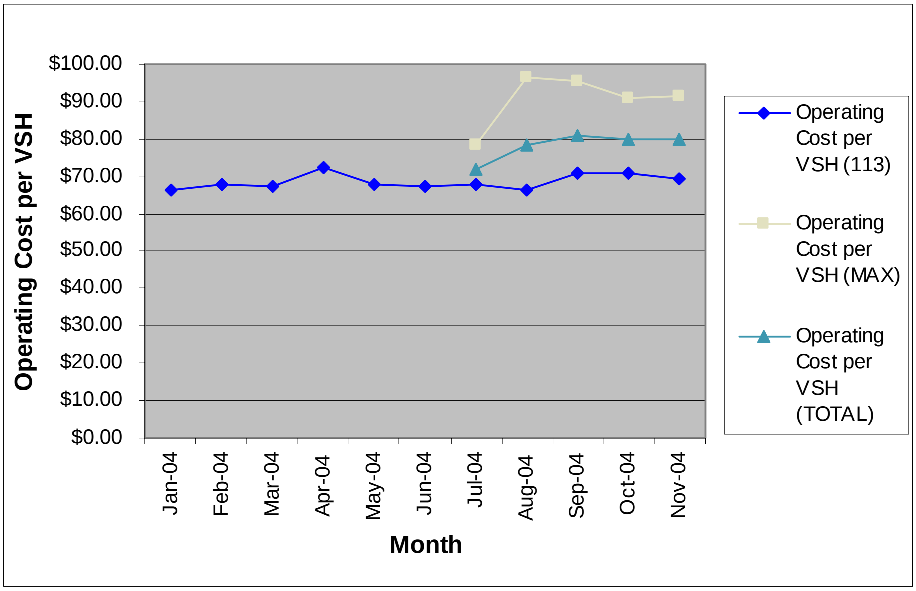
Exhibit 29 shows the monthly trend in vehicle service miles (VSM). Between January and June of 2004, Route 113 averaged 27,814 VSM per month. With the opening of MAX, total VSM along the corridor increased 125 percent from a monthly average of 27,814 between January and June 2004 to 62,674 from July to November 2004.

Exhibit 29: Monthly Trend in Vehicle Service Miles on Route 113 and MAX



Operating costs for MAX increased from $196,192 in its first month of operation, July 2004, to $263,322 in November 2004. While operating costs increased 34.2 percent over this period – due primarily to maintenance issues related to parts inventory problems – cost efficiency over this period, measured by cost per VSM, increased by only 14.0 percent, as shown by **Exhibit 30**. Operating cost per vehicle service hour for MAX has moderated slightly to about $90 per hour. Route 113 has continued to maintain its operating cost per vehicle service hour to slightly less than $70 per hour. The total operating cost per vehicle service hour for both MAX and Route 113 service in the corridor is slightly less than $80 per hour.

Exhibit 30: Monthly Trend in Operating Cost per VSH, Route 113 and MAX



Prior to MAX, Route 113 had a farebox recovery of about 60 percent. This dropped with the introduction of MAX due to its increased operating costs. With the improvement in ridership, MAX experienced a gradual increase in fare revenues, which grew 65.5 percent from $13,345 in July 2004 to $22,084 in January 2005. This resulted in an improvement in the MAX farebox recovery ratio (operating costs/passenger farebox revenues), as shown in **Exhibit 31**. Both Route 113 and MAX are demonstrating increasing trends in farebox recovery. With the steady growth in MAX ridership throughout the first six months of operation, farebox recovery has improved dramatically. By November 2004, MAX farebox recovery increased to 28.8 percent. In combination, the two services are averaging nearly 40 percent.

Exhibit 31: Monthly Trend in Farebox Recovery Ratio, Route 113 and MAX

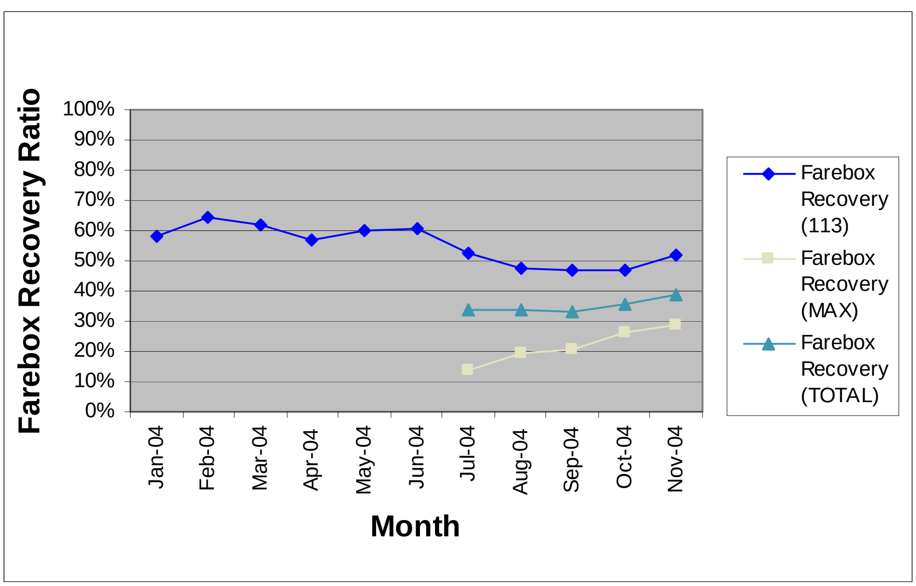
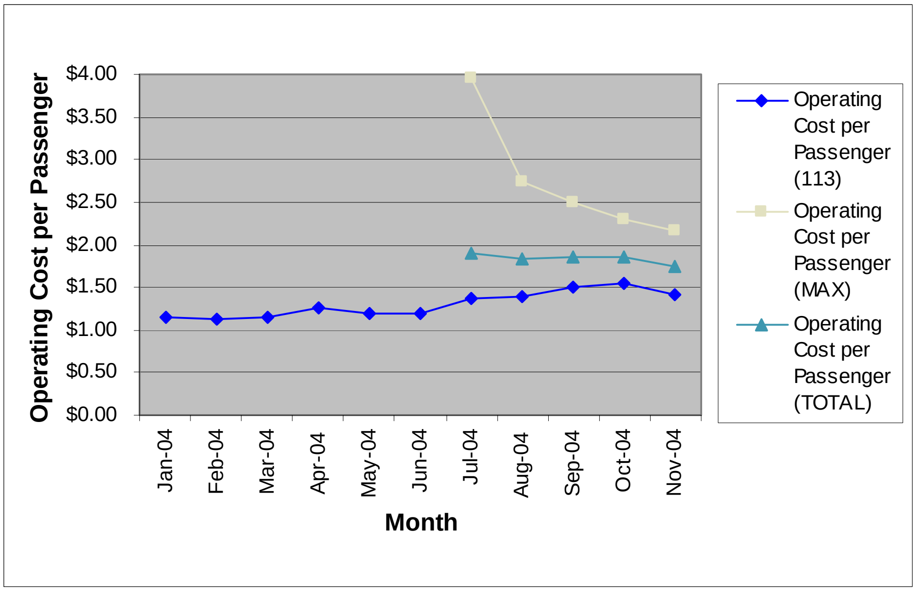


Exhibit 32 shows the trend in the operating cost per passenger on MAX and Route 113. MAX's cost effectiveness improved dramatically, with a decline in the operating cost per passenger from $3.95 in July 2004 to $2.16 in November 2004.

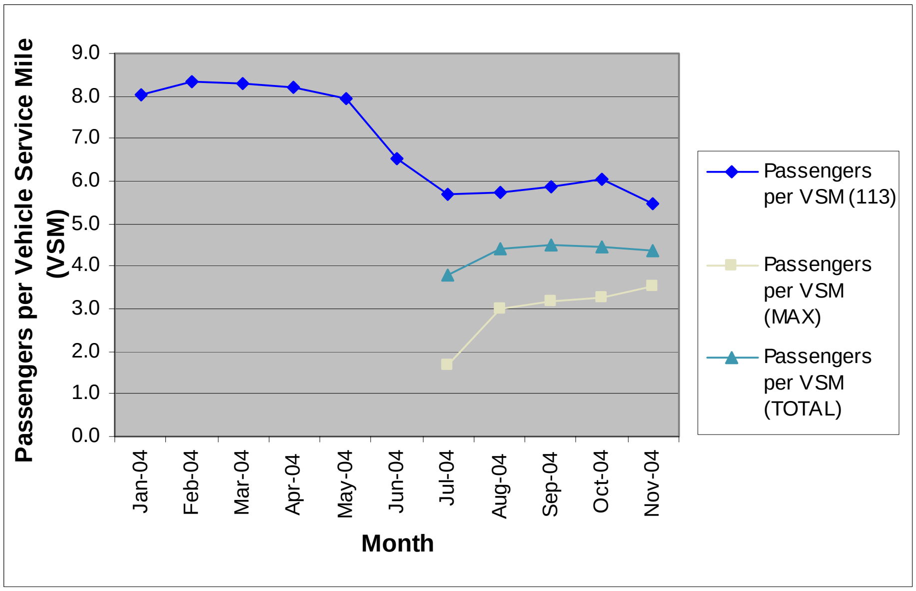
Exhibit 32: Monthly Trend in Operating Cost per Passenger, Route 113 and MAX



On the other hand, operating cost per passenger for Route 113 has increased 19% since the opening of MAX. This is partly because the VSH and VSM levels for Route 113 were maintained for several months after the start of MAX operations. This suggests a slight duplication of service that negatively impacted the operating efficiency and farebox recovery of Route 113. The introduction of MAX impacted Route 113 performance, which is not unusual for services sharing the same right of way during the initial months of operations as the levels of service and ridership have not yet stabilized in the corridor. One possible strategy to mitigate the negative impact on operating efficiency could have been a more timely reduction of Route 113 services commensurate with the reduction in its ridership.

Service productivity on MAX also improved dramatically, as former Route 113 riders gained increasing familiarity and comfort with the MAX system and migrated more permanently onto the MAX service. **Exhibit 33** shows a convergence in passengers per VSH, a measure of service productivity, for Route 113 and MAX. On MAX, passengers per VSH increased 112.8 percent between July and November 2004. The combined measure of passengers per VSH for both 113 and MAX dropped significantly with the opening of MAX but began a steady recovery after July 2004. RTC has now decreased service frequency on Route 113 to 30 minute headways throughout the entire 24-hour service span. This has resulted in lower operating costs, lower vehicle service hours and vehicle service miles – while still offering customers enhanced service in the corridor.

Exhibit 33: Monthly Trend in Passengers per Vehicle Service Mile (VSM) on Route 113 and MAX



The decrease in service productivity on Route 113 reflects some ridership defection onto MAX service, which offers consistently better travel times than Route 113. However, service productivity on Route 113 appears to have reached a stable equilibrium at slightly less than 50 passengers per VSH.

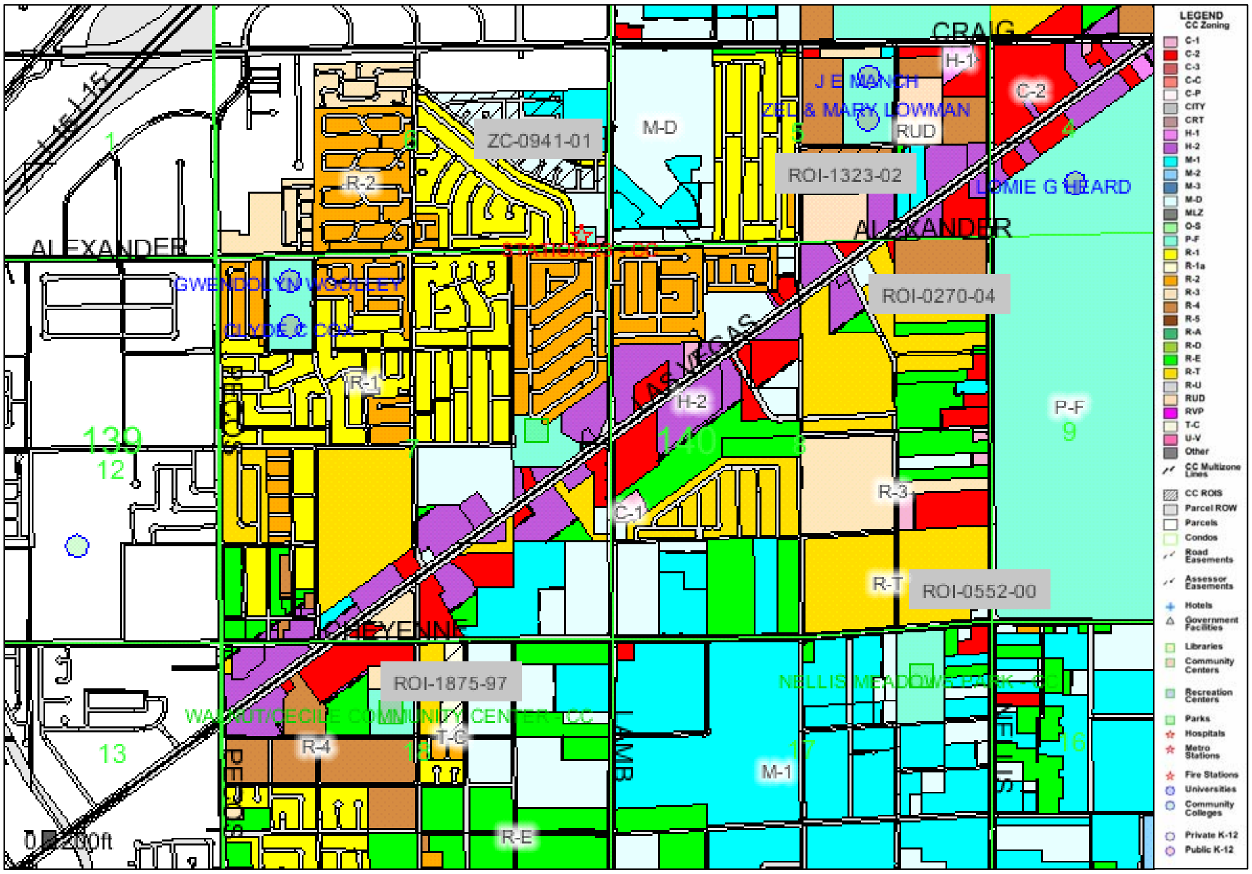
6.4 TRANSIT-SUPPORTIVE LAND DEVELOPMENT

Exhibit 34 provides a color-coded land use plan of the MAX corridor in North Las Vegas. The MAX alignment intersects two jurisdictions: the city of North Las Vegas (between Owens Ave and Pecos Road) and Clark County (north of Pecos Road). This illustration of the project corridor demonstrates a low density development pattern with opportunity for enhancement around the station areas as represented by the zones shaded purple and red. To this point, little has been achieved in redeveloping the corridor with higher density and more transit-supportive land uses. The benefits can be classified into three categories.

- Generative Impacts – Produce net economic growth
- Redistributive Impacts – Account for locational shifts in economic activity
- Transfer Impacts – Redistribution of benefits or revenues

These impacts were not identified in these early stages of the MAX project. The MAX project is still very new and the RTC is conducting outreach efforts to help initiate development projects.

Exhibit 34: Land Use Map of Las Vegas Boulevard North Corridor



The quadrant bordered by Las Vegas Blvd, Owens Ave and Pecos consists largely of low density residential (2 - 4.5 dwelling units per acre) and commercial development (community and business research/development park). To the east of Las Vegas Boulevard within the buffer surrounding I-15, the primary land use is Heavy Industrial.

North of Pecos Road, Las Vegas Boulevard intersects the Sunrise Manor area of Clark County, which includes Nellis Air Force Base. Within 1/8-mile buffer surrounding Las Vegas Boulevard is zoned predominantly H-2, general highway frontage district, and C-2, general commercial district. The northern quadrant bounded by Las Vegas Boulevard, Pecos Road and Craig Road is zoned R-2, medium density residential district, and R-1, single-family residential district.

The southern quadrant bounded by Las Vegas Boulevard, Cheyenne and Nellis consists largely of R-T, manufactured home residential district, C-1, local business district, and R-3, multiple-family residential district. The intensity of land use within these residential districts can be characterized as low-density, averaging approximately 4 dwelling units per acre.

Exhibit 35: Downtown Transportation Center (DTC)

The southern terminus of the MAX line is the Downtown Transportation Center (DTC), one of the region's largest transfer points.

The catchment area near MAX stations consists largely of low-density, low-income residential neighborhoods, with moderate-sized activity generators at several key locations. The biggest single trip attractor on the MAX route is the DTC (**Exhibit 35**), which provides connecting transit service to locations throughout Clark County and the Las Vegas Strip. Currently, the city of North Las Vegas has not formalized plans to develop parcels adjacent to MAX stations.

RTC and the city worked closely on MAX station location and sidewalk access issues. Beyond that, however, the city of North Las Vegas has not taken an active role in pursuing joint development opportunities around MAX stations. Commercial property owners close to planned MAX stations have in some instances become involved in station location and design issues. The owner of Jerry's Nugget Casino, for example, donated right-of-way to RTC to relocate a MAX station closer to the casino's main entrance.

6.5 ENVIRONMENTAL QUALITY

Environmental quality is an indicator of regional quality of life, supporting the health and well-being of the public and the attractiveness and sustainability of the urban and natural environment. The BRT environmental improvement mechanisms include the effects within three general categories.

- Technology Effect – Reduced corridor bus vehicle emissions due to the propulsion technology or fuel efficiency changes
- Ridership Effect – Trips diverted from private vehicles which increase transit ridership

- System Effect – Reduced vehicle emissions from reduced congestion

Overall, MAX has contributed positively toward improving the quality of life for CAT and MAX riders by offering an attractive, fast and convenient service that improves transit accessibility between North Las Vegas, downtown and the resort corridor to the south. Specific results from environmental impacts in the corridor are not yet available.

MAX has been implemented using 10 new diesel vehicles with comparable fuel efficiencies to the existing fleet. While total vehicle miles of travel along the corridor has increased, the additional fleet emissions attributable to MAX is partially offset by the reduction in peak period service for Route 113. The impact of MAX on fleetwide emissions is not known at this time.

The increase in transit ridership in the corridor suggests that there may be an improvement in environmental quality in the corridor as a result of the ridership effect. As much as 7% of the new passengers used private vehicles prior to MAX. However, the reduced emissions from these vehicles has not been quantified.

MAX has not resulted in any noticeable change in the level of traffic congestion along Las Vegas Boulevard North, despite the implementation of TSP at ten signalized intersections along the corridor. As such, there has been no measurable system effect as a result of the MAX project. However, MAX customers and the general public as a whole perceive MAX as contributing to the attractiveness and sustainability of the urban environment.

7.0 CONCLUSIONS

7.1 SUMMARY OF LESSONS LEARNED

RTC's stated objective in developing the MAX system was to "use an innovative system approach to increase capacity, improve passenger comfort and convenience, reduce dwell times and raise awareness in the community about the benefits of public transportation." (ITE Journal, February 2005) In the nine months since its opening, the MAX system has demonstrated achievement toward these project objectives and, more importantly, offer transit agencies nationally an archetype for applying a comprehensive systems approach to the design and implementation of advanced BRT solutions.

RTC embraced a bold and comprehensive systems approach to designing high-quality, fast rapid transit. MAX was the first project in the United States to select an overseas vehicle manufacturer for its advanced rapid transit prototype. The procurement of an advanced transit vehicle from an overseas manufacturer posed several unique challenges:

- **Communications barriers** – Because the manufacturer was based in Europe (France), there were some initial communications breakdowns resulting from both distance and language barriers. *RTC noted that having an in-plant inspector was mission-critical; this greatly facilitated close communication and monitoring throughout the design review process.*

- **Supply chain issues** – Because the vehicle was manufactured overseas, there were some glitches in supply chain for spare parts. RTC discovered that considerable lead time is required to establish a reliable and well-integrated supply chain for spare parts. There were unexpected delays resulting from shipping and customs problems. *RTC indicated that it would seek to include a liquidated damage clause in future vehicle procurements to lessen exposure to these areas of risk.*

- **Optical Guidance System (OGS) Performance** – While OGS functioned reliably in tests, its performance can be compromised in harsh desert environments where dirt, grease and oil buildup on the road can diminish the trajectory's contrast. *Until a more weather-proof method of maintaining the contrast of pavement markings is implemented, MAX operators has placed the OGS off-line and are manually docking at stations. MAX operators have reported that manual docking of MAX vehicles is greatly facilitated by the center configuration of the driver's seat, allowing operators to maneuver the vehicle over the painted trajectory upon approach to the station with great accuracy.*

- **System integration design issues** – After the vehicles were received, RTC faced major challenges in identifying conduits for internal routing of add-on systems not installed by the manufacturer. APC units were installed after the vehicles were delivered to RTC, which caused some problems because the standard equipment were not easy to install on the specialized vehicle. Additionally, running electrical conduit to accommodate the APC equipment took longer than anticipated. *A major lesson learned was the importance of sending add-on units to the vehicle manufacturer to be installed as part of the vehicle prototype.*

- **TSP Functionality** – In future BRT systems operating on a dedicated running way with headway-based service, RTC indicated that it will implement TSP. To minimize impacts on traffic, however, consideration will be given to integrating TSP with the AVL system to maintain vehicle headways or conditionally allow TSP based on schedule adherence performance measures. On corridors where a dedicated running way is not available, RTC would implement a “queue jumper” to reduce impedance along the corridor by minimizing delays caused by intersection queues.

- **Operating costs** - Since the opening of MAX, operating cost per passenger for Route 113 increased 19%. This is partly because the VSH and VSM levels for Route 113 were maintained for several months after the start of MAX operations. This suggests a slight duplication of service that negatively impacted the operating efficiency and farebox recovery of Route 113. This impact of MAX on Route 113, however, is not unusual for services sharing a large portion of the same right of way during the initial months of operations as the levels of service and ridership have not yet stabilized in the corridor. One possible strategy to mitigate the negative impact on operating efficiency could have been a more timely reduction of Route 113 services commensurate with the reduction in its ridership.

7.2 SUMMARY OF SYSTEM PERFORMANCE

The MAX system is among the nation’s most advanced BRT technology in the United States to date. As conceived, the system incorporates numerous features that are designed to enhance system performance and improve operational efficiency. The following are the main highlights of MAX system performance:

- One-way travel times on MAX are approximately 50% lower than travel times of Route 113, the local fixed route service operating along the same route.

- Dwell times on MAX are approximately 60% lower than on Route 113, due to multiple door entry, level boarding at station platforms and off-vehicle fare collection.

- Average speeds on MAX are approximately 25% higher than average speeds on Route 113, due largely to the increased spacing between stations.

- Schedule adherence as measured by headway reliability on MAX is close to 100%; travel time variability is greatly reduced in the corridor since the implementation of MAX due to the presence of a dedicated running way.

- Customers surveyed rate MAX very high for appearance, comfort, convenience and reliability.

7.3 SUMMARY OF SYSTEM BENEFITS

The discussion of MAX system benefits is also informed by a customer survey of MAX and CAT Route 113 riders administered in February 2005. RTC conducted an onboard customer survey of Route 113 and MAX riders to better understand transit usage patterns within the

Las Vegas Boulevard North corridor, gauge customer perceptions of critical features of CAT Route 113 and MAX and identify potential areas of service improvement. A follow-up survey will be administered again in late Summer 2005 to measure changes in travel patterns and customer perceptions.

The MAX system yielded a wide range of benefits:

MAX resulted in a 25% increase in corridor transit ridership – From MAX's opening in July 2004 to December 2004, ridership along the Las Vegas Boulevard North corridor grew from 7,800 passengers per day to 9,800 passengers per day, a 25 percent increase. While a sizeable proportion of Route 113's customers transitioned to MAX, the increase in total corridor ridership indicates that the implementation of an attractive, comfortable and faster bus system – which integrated into a favorable operating environment – has the potential to generate new ridership.

One in four MAX survey respondents reported being new to transit, having previously drove, walked or bicycled to their final destination or avoided the trip altogether. The other three-quarters are former CAT Route 113 riders. MAX supports the concept that adding rapid transit service can attract new riders to transit.

MAX cut transit travel times in half – Transit travel time along the Las Vegas Boulevard corridor decreased by approximately 50 percent, from 50 minutes with Route 113 services before MAX to 25 minutes with MAX. This benefit is the result of implementing Transit Signal Priority, an off-board proof-of-payment fare collection system, and nearly doubling the distance between stops. About 40 percent of MAX survey respondents reported that their travel times were 15 minutes faster; 27 percent reported that there travel times were between 11 and 15 minutes faster than their previous CAT trip. Of the MAX respondents who favor riding MAX to Route 113, 72 percent reported they preferred riding MAX because of "faster travel time."

MAX is one of CAT's most reliable and dependable services – Schedule reliability on MAX is close to 100 percent, earning MAX a reputation for dependability. MAX customers felt that MAX offered a high degree of overall peak service reliability. 60 percent of MAX survey respondents rated MAX service reliability as "excellent" and 37 percent rated MAX service reliability as "good."

MAX offers among CAT's shortest wait times – MAX station wait times are significantly lower than on Route 113, due to shorter headways throughout the service day. 60 percent of MAX survey respondents rated wait times at MAX stations as "excellent" and 37 percent rated wait times as "good." By comparison, 2.7 percent of CAT Route 113 respondents rated wait times at Route 113 stops as "excellent,"33 percent rated wait times as "good," and 35 percent rated wait times as "fair."

Customers give MAX high marks for convenience – Customers expressed that MAX offered fast, convenient and comfortable service that was qualitatively better than CAT fixed route bus service. 62 percent of MAX survey respondents rated the convenience of MAX as "excellent" and 34 percent rated convenience of MAX as "good."

MAX customers overwhelmingly support off-vehicle fare purchase – Customers overwhelmingly support the installation of TVMs, which allow passengers to pre-pay a variety of fare media that can be used throughout the CAT system. 93 percent of MAX survey respondents rated the convenience of off-board fare purchase as “excellent” and “good.”

Customers give the MAX experience high marks – 97 percent of MAX riders rated their experience riding MAX as “good” or “excellent.” By comparison, 62 percent of Route 113 riders rated their experience as “good” or “excellent.” Overall, MAX riders indicated a high degree of satisfaction with MAX.