



**Comprehensive Analysis *for*  
Service Efficiencies (CASE)  
Overview**



**Final Report**



**San Diego  
Melbourne  
Chicago  
New York  
Montreal**

**March 6, 2008**

# Comprehensive Analysis for Service Efficiencies - Overview

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## 1. Introduction

RTD enjoys a national reputation in its approach to service performance monitoring. The agency has developed a set of design standards to determine the appropriate level of service among the various areas of the District and annually measures the actual performance against the adopted standards. These results are published on the RTD website at rtd-denver.com.

Owing to the extent and complexity of the range of RTD services, the annual analysis is done at a service class and route level. This approach, while very adequate for basic monitoring, may mask low route performance or opportunities for performance improvement in certain geographic sectors or during certain times of the day or days of week.

RTD staff, as part of their annual service review process, chose to look at the entire transit system in more detail to identify those opportunities for improving the effectiveness of the service in meeting the agency's goals or improving the efficiency of the system by achieving these goals at minimum cost.

This project is intended to complement the RTD staff work on performance monitoring by looking at service performance at the route, service day (weekday, Saturday, Sunday), time period (peak, off-peak), and route segment level.

This project consists of two parts. The first is a review of the performance of RTD's bus service by route and time of day. This is documented in this report. A second report reviews each route at the segment and time of day level. These two reviews report on RTD's regular route bus service. However, where appropriate for explaining key findings, data from the rail services and call-n-Ride services will also be offered.

This report assesses readily available RTD ridership data and assesses the productivity and cost-effectiveness of the bus services offered by RTD. It makes no suggestions about service levels or configuration but rather is an objective review of service performance.

## 2. Transit Service Evaluation

Transit service monitoring is intended to assure that the expectations of RTD in producing services of value to riders and taxpayers are being met. Given a budget constraint, the operation of any specific service by RTD has an opportunity cost which is the value of services not being operated elsewhere due to lack of resources. Service evaluation, in which service alterations (increases and decreases) are recommended in response to market conditions, enables RTD to operate a more sustainable system – one in which the amount of service produced is consistent with reasonable long term expectations of public financial support and adaptable to changing conditions.

The mission statement of the RTD is:

*“To meet our constituents’ present and future public transit needs by offering safe, reliable, courteous accessible and cost-effective service throughout the district”*

**The two primary performance measures used by RTD are productivity (boardings per service hour) and cost-effectiveness (subsidy per boardings).**

To achieve this mission, RTD must delicately balance the interests of transit users and regional taxpayers in order to operate a system which can adapt to changes in the market environment. Over the years, RTD staff has developed two important performance measures for the system. The first of

these is *productivity* measured in customer boardings per revenue hour. It is a reflection of utilization per unit of service or an index of service effectiveness. The second measure is subsidy per passenger boarding which is a composite cost-effectiveness measure reflecting service effectiveness, cost efficiency, and average passenger fares in one index. of how cost-effectively the District’s resources are used to produce trips. .

Ideally, RTD would like to have each of its routes trending upward in productivity and cost-effectiveness. However, other considerations such as providing a transportation alternative to those with limited mobility options and equity prevent a strict allocation of resources to maximize these objectives. Further, operating in a regional public environment, equity or “fairness” in the allocation of RTD resources is an important criterion for reviewing service *throughout the district*. For example, RTD could increase the area covered or offer more service in low density areas at the expense of productivity and conversely.

RTD addressed the trade-off between equity and productivity by introducing a range or family of services intended to serve their transit markets appropriately. The market characteristics include trip purpose, customer trip length, and customer characteristics. Service attributes such as frequency, fare structure and collection, service span, stop spacing, vehicle size, and amenities are also tailored to the individual markets. For the purpose of this assessment equity will mean that service throughout the district is appropriate to the market being served.

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RTD has developed a method of allocating transit resources and evaluating their performance through a set of service standards. Each submarket in the district is assigned a target level and type of service depending on underlying service area characteristics such as density and distance from downtown (design standards).

**RTD has a formal process for evaluating service performance and identifying the appropriate service for different parts of the transit district.**

There is considerable variability in the performance expectations for the classes of service. The level of actual performance of each route is measured against standards (performance standards) for similar routes. That

is, routes are compared with other routes within the same class.

The design standards are illustrated in the tables below. Table 1 is a broad description of service for varying areas, while Table 2 describes the service frequency as a function of service performance.

**Table 1 – RTD Service Design Standards**

Minimum and Maximum Service Levels

1. Minimum Service Levels

Areas with 3-12 residents and employees per acre:

- Peak period park-n-Ride service if either the travel time to the Denver CBD by Express bus, or a bus/rail timed connection exceeds 20 minutes.

Areas with 12 or more residents and employees per acre:

- Local service on major arterials with pedestrian access within 0.25 miles
- Peak period, Limited, Express, or Regional service from park-n-Rides if either the travel time to the Denver CBD by Express bus, or a bus/rail timed connection exceeds 20 minutes.

2. Maximum Target Service Levels

Areas with 3-12 residents and employees per acre:

- Local Service along major arterials with pedestrian access within 0.25 miles
- Peak period, Limited, Express, or Regional service from park-n-Rides if either the travel time to the Denver CBD by Express bus, or a bus/rail timed connection exceeds 20 minutes.

Areas with 12 or more residents and employees per acre:

- Local service with 0.5 mile route spacing
- Limited, Express, or Regional service from park-n-Rides if the travel time to the Denver CBD by Express bus exceeds 20 minutes.

**Table 2 – RTD Service Frequency Standards**

Service Type	Time Frame	Minimum Frequency
Local - peak period	Mon-Fri 6:00am to 9:00am and 3:00pm to 6:00pm	30 minutes
Local - Off peak below 25% boardings per hour	Weekday midday	60 minutes
Local - Off peak above 25% boardings per hour	Weekday midday	30 minutes
Local	Evening and weekends	60 minutes
Express and Regional to CBD	3 peak trips Mon.-Fri. Trips should target: 7:00/7:30/8:00 am work shift start times 4:00/4:30/5:00 pm work shift end times	

The method of assessment against the performance standards is as follows:

- All routes are placed into one of several classes depending on the nature of the service (local, express, regional, etc.)
- The two performance measures of productivity and cost-effectiveness are assessed for each route.
- Routes in the lower 10 percent of **either** of the measures or in the lower 25 percent in **both** measures are determined not to meet the standard<sup>1</sup> and are further assessed.

A determination that a route does not meet performance standards is not an automatic warrant for service termination or even reduction. Other remedies such as changes in route alignment and service type to more appropriately serve the intended market can also be introduced. Further, extenuating circumstances such as the economic conditions of the service area (e.g., new development) or the role of the routes in fostering regional economic development are also used in making judicious choices about transit service allocation.

The two performance measures (productivity and cost-effectiveness) incorporate two very important attributes of service. There are several instances where consideration of additional factors is warranted in the application of the standards. These include:

- Urban routes operate as an integrated network with considerable passenger interchange. Certain routes contribute to the overall performance of the network by feeding other routes and serving important regional destinations.
- Some low performing routes, particularly crosstown routes, produce high-value trips for the customers they serve, particularly if they eliminate circuitous alignments on mainline routes or additional transfers through the network.
- Some service, such as late night services, have low productivity but service trip requirements for which there is a counterpart trip at some other time in the opposite direction. Reducing some of this service may disproportionately reduce ridership.
- In highly transit-dependent low density areas, service may be under allocated by strict application of the standards.

### 3. A Family of Services

In meeting the diverse travel requirements of the citizens of the district and maintaining a high-performance sustainable transit system, RTD has developed a range or family of services. Examples of the differentiation of the transit product include the following:

RTD has developed a range or family of services to meet the requirements of the various District market segments.

<sup>1</sup> More precisely, routes in the lower 25% are those whose performance is less than the mean minus .67 times the standard deviation. The lowest 10% are defined as those below the mean minus 1.28 times the standard deviation. This adjustment is to allow for non normal distributions of data.

- In areas where there are a large number of customers with long trip lengths, RTD increases travel speed by the introduction of express and limited stop services.
- In the area close to downtown RTD operates a dense bus network with high frequency service. This reflects both the high density of demand and the relatively high dependence of the residents on RTD’s services.
- On arterial streets in lower density areas with lower frequency service, RTD operates a “timed transfer” system to facilitate interchange of customers between routes by timing route connections.
- Higher quality vehicles are used in some regional routes reflecting longer customer trip duration and the low seat turnover on such routes.
- RTD operates complementary paratransit service (access-a-Ride) to disabled customers who do not have the ability to use RTD services. Also, paratransit for the general public (call-n-Ride) is provided in markets unsuitable for fixed route bus service.
- In downtown Denver, there is a free shuttle along the 16<sup>th</sup> Street Mall. This high frequency service uses low floor, high capacity buses to accommodate commuter collection/distribution and foster mobility in the downtown.

The RTD family of services includes:

- |                       |                        |                         |
|-----------------------|------------------------|-------------------------|
| • Local bus service   | • Regional bus service | • Downtown Mall service |
| • Limited bus service | • Light Rail           | • call-n-Ride service   |
| • Express bus service | • Airport service      | • access-a-Ride service |

**Local bus service** (67 Denver routes, 15 Boulder routes and 8 Longmont routes) is intended to provide basic mobility to residents living near a route network. Owing to the rectilinear grid street network in the area surrounding downtown, the Denver service operates as an interconnected system, where transfers between vehicles are facilitated through schedule coordination and the development of off-street facilities. The local services in Boulder and Longmont operate in a less densely settled environment. Local bus services have high seat turnover and, compared with other services, serve shorter trip lengths.

**Limited bus service** (15 routes) operates along the paths of local bus service but only serve a limited number of high volume stops. Their purpose is to provide a faster ride on corridors with longer trips. They are most effective in corridors where there is a high frequency of bus service and the waiting times of customers will not be too long if limited routes bypass certain stops.

**Regional bus service** (20 routes) connects remote areas to the more developed areas. These are generally services to outlying and mountain areas and do not operate parallel to local services. These routes are characterized by mostly peak hour-only operation and long

customer trips lengths. A major exception is Route B Boulder/Denver, which operates daily, all-day service and represents one-third of all Regional service hours.

**Express service** (37 routes) operates almost exclusively during peak commuter times along heavy travel corridors. They all operate along expressways and usually terminate at a suburban park and ride facility. Route 120X Wagon Road/Thornton Express is an exception to this with midday, evening, and Saturday operation and represents over a quarter of all Express service hours. RTD has 75 park-n-Rides that facilitate these and Regional services, 20 of which are at Light Rail stations. Note that with the introduction of the Southwest Light Rail Line in November 2006, a number of express routes in this corridor were terminated. The hours and boardings of these routes are included in the tables below.

**skyRide** (5 routes) is the brand name for transit to the Denver International Airport. The market for this service is both air travelers and airport employees (about 75 percent). RTD maintains a high average fare on these routes by charging prices comparable to the rest of the services for frequent users such as employees, but a much higher “walk up” fare for those who do not have a monthly pass. This price differentiation enables a higher fare yield from visitors to the area and infrequent local users.

**Mall Shuttle** (one route) is a free service operating along the 16th Street Mall in downtown Denver. Its intent is to improve mobility within the downtown and provide an important feeder/distributor function for the other RTD services from the two major downtown transit hubs. Without this service, additional RTD routes would be needed to circulate within the downtown, congesting the street network. This service has very short trip lengths, high frequency, and high seat turnover. The buses assigned facilitate fast loading and unloading. The introduction of on-board fare collection would greatly impede boarding convenience, reducing bus travel speeds and ironically, increasing operating cost.

**call-n-Ride** is a many-to-many demand responsive service for the general public operating in relatively low density areas of the district that cannot support regular fixed route transit. In most cases, these services connect with regional and express services at a hub such as a rail station or a park-n-Ride facility.

**Access-a-Ride** is the demand responsive ADA service for disabled customers. The minimum service standards for these services are determined by the Federal Transit Administration.

#### **4. Overall Ridership, Productivity and Cost-Effectiveness**

To illustrate how the various RTD services are used, Table 3 provides the number of daily passenger boardings using the various services while Table 4 illustrates the number of service hours. The service supplied data is from current schedules while the ridership data is from

farebox records for the calendar year 2006.<sup>2</sup> Service hours do not include hours to or from the garage but do include layover time at the end of each scheduled trip. The inclusion of the Mall and light rail services, though not the subject of this analysis, are included for the purpose of presenting a more complete picture of the range of RTD services. Table 5 illustrates the proportion of service hours by class of service throughout the day. The accompanying pie charts show the proportion of boardings and service hours in each service class. In these tables, the AM peak period is defined as all service from the start of the service day until 9:00AM. Midday is defined from 9:01 AM until 2:59 PM. The PM peak period is defined as the period between 3:00PM and 5:59PM. The evening period includes all services from 6:00 PM until the end of the service day. The boundaries between periods are the times when farebox boarding recordings are made.

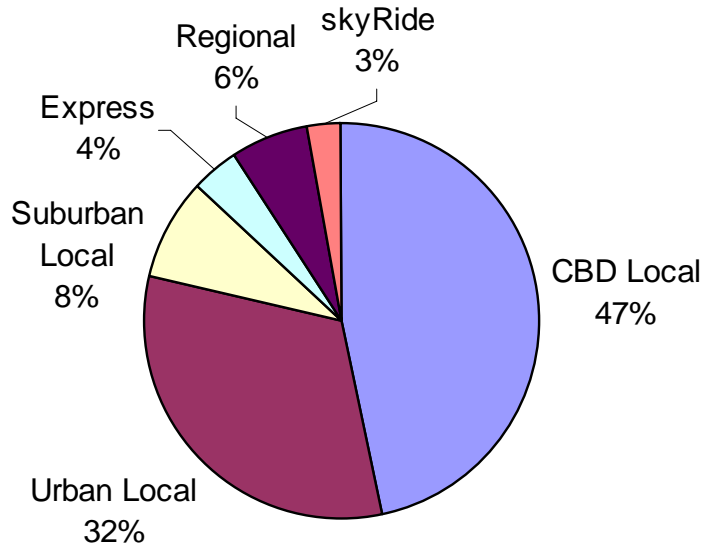
The productivity (passengers per boarding) and cost effectiveness (subsidy per boarding) are summarized in Tables 6 and 7. The Appendix shows this measure by route by time period. The data for all the tables and charts are from calendar year 2006.

**Table 3 – Average Daily Ridership by Time of Day and Route Type**

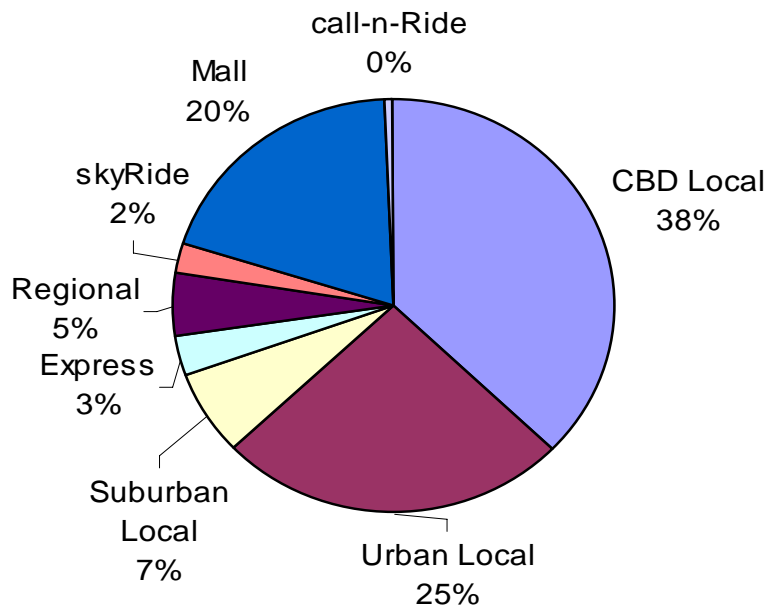
Route Type	Weekday Period				Weekday	Saturday	Sunday
	AM Peak	Midday	PM Peak	Night			
CBD Local	15,633	39,276	13,656	18,068	86,633	48,346	31,973
Urban Local	11,538	27,390	9,275	11,157	59,360	29,404	17,694
Suburban Local	3,202	6,966	2,431	2,808	15,407	5,295	2,506
Express	5,720	1,450	5,418	473	13,061	219	33
Regional	3,327	2,732	3,077	2,510	11,646	2,481	1,696
skyRide	705	1,975	517	2,149	5,346	4,564	4,716
<b>Total Bus</b>	<b>40,125</b>	<b>79,789</b>	<b>34,374</b>	<b>37,165</b>	<b>191,453</b>	<b>90,310</b>	<b>58,618</b>
<i>Mall</i>					46,058	26,314	13,909
<i>call-n-Ride</i>					1,146	295	44
<i>Rail</i>					62,181	33,340	21,002
<i>Total</i>					300,699	149,964	93,529

<sup>2</sup> Total ridership and service on the light rail services are from 2005 since 2006 data includes a period of dramatic growth in the level of service and ridership due to the introduction of the South East LRT.

### Proportion of Weekday Boardings Scheduled Bus Service

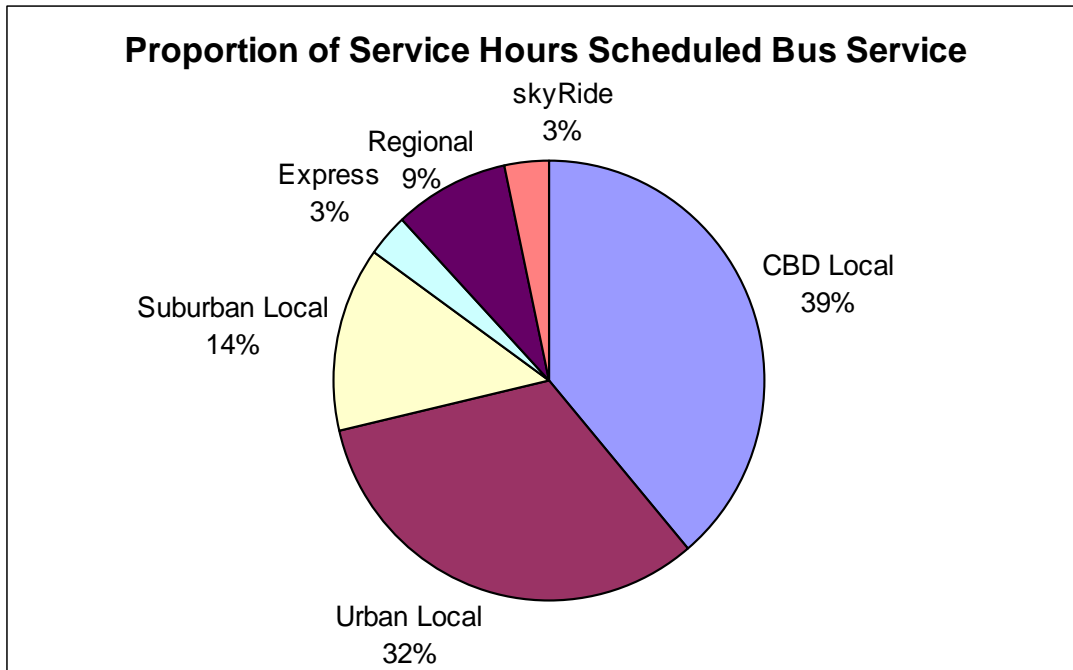


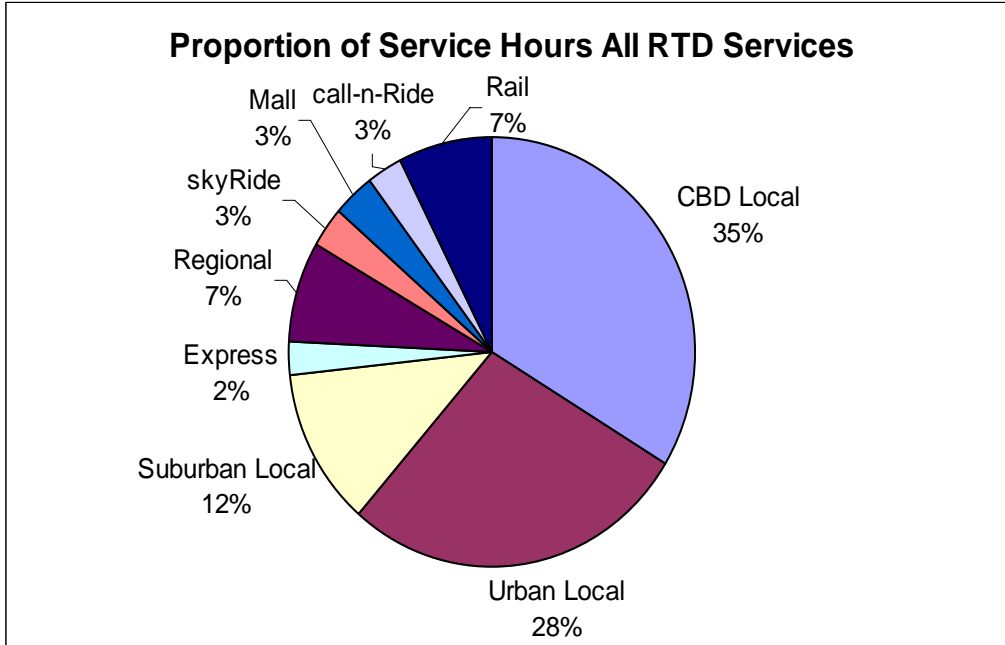
### Proportion of Weekday Boardings All RTD Services



**Table 4 – Service Supplied by Time of Day and Route Type**  
(Revenue hours)

Route Type	Weekday Period				Weekday	Saturday	Sunday
	AM Peak	Midday	PM Peak	Night			
CBD Local	550	1,049	407	650	2,656	1,710	1,284
Urban Local	469	903	349	488	2,209	1,232	816
Suburban Local	226	379	163	175	943	407	214
Express	173	24	162	20	379	21	4
Regional	183	134	149	127	593	132	104
skyRide	40	81	25	82	228	206	208
<b>Total Bus</b>	1,641	2,571	1,255	1,542	7,008	3,707	2,630
<i>Mall</i>					275	128	106
<i>call-n-Ride</i>					226	187	18
<i>Rail</i>					586	423	423
<i>Total</i>					8,096	4,258	3,159





These tables illustrate that the scheduled bus service is the backbone of the RTD system accounting for roughly two-thirds of the ridership and over 85 percent of the service hours.

**Table 5 – Proportion of Weekday Boardings and Hours by Service Type**

Route Type	Boardings		Hours	
	Percent of All Services	Percent of Bus Service	Percent of all Services	Percent of Bus Service
CBD Local	29.4%	46.5%	34.0%	39.3%
Urban Local	19.7%	31.2%	27.3%	31.6%
Suburban Local	4.9%	7.7%	11.1%	12.9%
Express	3.6%	5.7%	4.0%	4.6%
Regional	3.6%	5.7%	6.7%	7.7%
skyRide	2.1%	3.3%	3.2%	3.8%
Mall	15.5%		3.4%	
call-n-Ride	0.3%		2.4%	
Rail	20.9%		7.9%	
Total	100.0%	100.0%	100.0%	100.0%

**Table 6 – Productivity by Time of Day and Route Type**  
(Boardings per service hour)

Route Type	Weekday Period				Weekday	Saturday	Sunday
	AM Peak	Midday	PM Peak	Night			
CBD Local	28	37	34	28	33	28	25
Urban Local	25	30	27	23	27	24	22
Suburban Local	14	18	15	16	16	13	12
Express	34	60	34	24	33	11	9
Regional	18	20	21	20	20	19	16
skyRide	18	24	21	26	24	22	23
<b>Total Bus</b>	25	30	28	24	27	24	22
<i>Mall</i>					167	206	131
<i>call-n-Ride</i>					4	2	2
<i>Rail</i>					106	79	50
<i>Total</i>					37	35	30

**Table 7 – Cost-Effectiveness by Time of Day and Route Type**  
(Subsidy per boarding)

Route Type	Weekday Period				Weekday	Saturday	Sunday
	AM Peak	Midday	PM Peak	Night			
CBD Local	\$ 3.45	\$ 2.48	\$ 2.83	\$ 3.55	\$ 2.93	\$ 3.48	\$ 4.03
Urban Local	\$ 3.95	\$ 3.09	\$ 3.61	\$ 4.31	\$ 3.57	\$ 4.09	\$ 4.57
Suburban Local	\$ 7.87	\$ 5.92	\$ 7.41	\$ 6.85	\$ 6.73	\$ 8.61	\$ 9.62
Express	\$ 6.49	\$ 1.66	\$ 6.38	\$ 6.40	\$ 6.28	\$ 16.57	\$ 14.82
Regional	\$ 7.26	\$ 6.19	\$ 6.12	\$ 6.53	\$ 6.55	\$ 6.93	\$ 8.44
skyRide	\$ 4.43	\$ 2.28	\$ 3.34	\$ 1.85	\$ 2.50	\$ 2.86	\$ 2.70
<b>Total Bus</b>	\$ 4.23	\$ 3.25	\$ 3.64	\$ 4.37	\$ 3.74	\$ 4.28	\$ 4.76
<i>Mall</i>					\$ 0.82	\$ 0.67	\$ 1.05
<i>call-n-Ride</i>					\$ 14.71	N/A	N/A
<i>Rail</i>					\$ 3.11	\$ 3.11	\$ 3.11

## 5 Findings and Conclusions

### Overall Service Supply

- While RTD has a regional mission, the bulk of the service supplied is local routes operating within the core area of the region. This is due to a stronger market near the downtown owing to lower auto ownership, customer density, and the higher proportion

of central city residents working in downtown Denver. As would be expected the regional and express services are focused on downtown Denver.

- Reflecting travel patterns in the region, there is a large amount of midday and evening service on the local routes. On the Metro routes, express and regional, there is substantial service reduction during off-peak hours.

## Productivity

- The average number of weekday boardings per hour is about 27, with slightly diminished productivity on weekend days. It is worth remarking that the midday productivity on nearly all services exceeds the peak hour productivity. At first blush, this is counterintuitive. Some factors which explain this are:
  - In the central cities, lower income service jobs are less likely to have traditional work hours. Thus, there is a healthy ridership level throughout the day.
  - Passengers typically make shorter trips during the midday resulting in higher seat turnover, making each revenue hour more productive. During peak periods, riders travel further for commuting with the result often one passenger per seat per trip.
  - During peak periods additional capacity (revenue hours) is added to meet demand, typically needed in just one direction. The need to run some or all of the additional capacity in the reverse direction for second/third trips is not usually productive, reducing overall service effectiveness.
  - Service typically operates faster in the midday (fewer revenue hours per mile of service) and can often be deployed more efficiently than during peak periods.
- The average productivity of the various services varies widely. This reflects different expectations of the services. While not measured in this report, average trip lengths on Metro routes are longer than those on the Community routes. Using passenger-miles instead of passenger boardings as the metric would eliminate the productivity advantage of short passenger trip, high seat turnover routes.
- The express routes, taken as a whole, appear to exhibit rather high productivity. This is due to the fact that several express vehicle assignments (blocks) have a single productive trip and the time spent traveling to and from the garage is not counted in the service hours. On local routes, time spent traveling in the minor (non-peak) direction of travel is usually operated in revenue service.
- The productivity on weekends is comparable to weekday productivity. This suggests an appropriate adjustment of service levels on weekends to reflect diminished travel.
- Midday productivity on CBD local routes is remarkably high. This reflects a strong demand from customers living in high density, more transit-dependent areas, and reduced off-peak service levels.

- The Mall service, as expected has extremely high productivity, reflecting both the high boarding level, short customer trip length and high seat turnover on this service.
- call-n-Ride productivity is quite low due to the low density service areas, longer trips by individuals, and inherent inefficiencies of a point-to-point operation.
- Table 8 illustrates the relative productivity of each route in each time period. It is the ratio of the route type and time period productivity to the average for that route type. Entries in excess of 1 suggest that the level of service is in excess of what would be warranted by customer activity and conversely. With the exception of the nearly miniscule amount of weekend express service, the patterns illustrate reasonable adjustment of service supply to customer boardings

**Table 8 – Relative Productivity\* By Time of Day and Route Type**

Route Type	Weekday Period				Weekday	Saturday	Sunday
	AM Peak	Midday	PM Peak	Night			
CBD Local	0.90	1.19	1.06	0.88	1.03	0.90	0.79
Urban Local	0.94	1.15	1.01	0.87	1.02	0.91	0.83
Suburban Local	0.89	1.15	0.94	1.01	1.03	0.82	0.74
Express	1.03		1.01		1.02	0.28	0.25
Regional	0.93	1.05	1.06	1.01	1.01	0.97	0.83
skyRide	0.76	1.05	0.89	1.13	1.01	0.95	0.98
<b>Total Bus</b>	0.92	1.14	1.04	0.90	1.02	0.91	0.84
<i>Mall</i>					1.00	1.22	0.78
<i>call-n-Ride</i>					1.00		
<i>Rail</i>					1.10	0.81	0.51
<i>Total</i>					1.02	0.96	0.81

\*This is the ratio of productivity in the time period to the average productivity across all time periods. Entries in excess of 1 have a higher productivity than the average overall productivity for the route type.

### Cost Effectiveness

- The overall weekday subsidy per customer boarding on RTD bus services is \$3.74 with slightly higher subsidies on weekend days. While some subsidies are quite high such as weekend express, the level of service and ridership in this category is very limited on weekend days. Accordingly, this service has very little impact on the overall performance of RTD.
- As expected, due to operation in low density areas, the suburban local and regional services exhibit higher than average subsidies per boarding.
- Despite their high productivity, the subsidy per passenger on express routes is comparable to the other route classes. This reflects higher cost per hour due to higher speeds and deadhead hours (trips to and from the operating base).

- There is a marked difference between midday and peak hour cost-effectiveness on suburban routes. The market for suburban crosstown services is not as heavily skewed to the commuter market, but rather one serving general mobility requirements of the areas they service. In order to attract the discretionary commuter market, increased frequency is provided on these routes during peak hours. This additional peak service leads to higher subsidy per passenger.
- The skyRide service has a relatively low subsidy per boarding despite moderate productivity. This illustrates the value of market-based pricing for this set of routes in which the “walk-up” fare significantly exceeds the monthly pass prices.
- call-n-Ride service exhibits a large subsidy per boarding – not uncommon for such personalized door-to-door services.