Review & Evaluation

Submitted by:

Transportation Management & Design, Inc.
Shuttles and Circulators Review

1. What is a Shuttle or Circulator?
RTD currently classifies its transit service into seven categories, including CBD Local, Urban Local, Suburban Local, Limited, Express, Regional, and skyRide services. Shuttle and circulator routes are not currently defined as a separate class of service (most are considered Urban Local routes), but RTD is considering separating these services as a category.

Shuttle and circulator routes are generally defined by the following characteristics:
- They are usually shorter than regular line-haul routes, usually less than 10 miles long.
- They run on local streets as well as arterial roadways.
- They may serve special destinations or areas, such as universities, employment centers, or shopping districts.
- Passenger trip lengths are usually shorter than on Urban or Suburban Local routes.
- Circulators especially serve local trips within a single community, and are often loop routes connecting key destinations.
- Shuttles especially provide connecting services between major activity centers. They often serve as the initial (“first mile”) or final (“last mile”) link in the transit network, providing the station-to-home or station-to-work linkage.

The shuttles and circulators studied here involve routes which comply with most, if not all, of the above characteristics. Their widely differing performance relates to differences in the areas and destinations the routes serve, as well as their service spans and headways.

2. Methodology
This review presents analysis of various factors that influence the performance of shuttles and circulators in the RTD system. The review objective is to identify market conditions and service design variables related to successful shuttles and circulators through evaluation of existing RTD service as well as industry best practices. The attributes associated with successful routes can then be applied to new-route proposals, in order to estimate likely performance before funding and implementation. The variables considered in the analysis are readily available, allowing them to be applied in a wide variety of circumstances.

Industry review indicates that key service performance metrics include both ridership per mile of route (independent of length, speed, and frequencies) and a basic productivity measure like boardings per revenue hour (or in-service hour for RTD). As a result, market performance was evaluated using boardings per route mile, while service productivity was measured using boardings per in-service hour.

The key market variables identified as possible predictors of route performance include population and employment densities, senior and youth population densities, concentrations of zero-vehicle households, and median income. These attributes are often associated with
transit ridership. They also tend to demonstrate collinearity – i.e., not only are they associated with route performance, they are also associated with each other. Areas of high population density, for example, are likely to have more zero-vehicle households and lower income levels than less dense areas.

**Service characteristics** evaluated for their effect on performance include peak headways, service spans, and fares. These factors, however, are not only predictors of good performance, they may come as a result of good performance. For example, high ridership may be a product of short headways, but short headways may be implemented due to crowding on high-performing lines. Service characteristics may therefore be viewed as both a cause and effect of service performance.

Routes reviewed include RTD shuttles and circulators running today, as well as two that have been discontinued. These include:

- **Hop.** The Hop, Skip, and Stampede are part of the City of Boulder’s Community Transit Network. The Hop is a circulator that loops around downtown Boulder.
- **Skip.** This route runs along Broadway St, a major north-south thoroughfare through Boulder. While the Skip is 10 miles long, the major destinations of downtown Boulder and the University of Colorado are in the middle of the route, effectively making it two 5-mile shuttles joined together. A passenger’s trip length would rarely be longer than 5 miles.
- **Stampede.** The Stampede mainly serves the University of Colorado, Boulder campus area.
- **ART Shuttle.** Running within the City of Englewood south of Denver, the ART shuttle connects many local destinations.
- **ZIP Shuttle.** The ZIP runs exclusively within the Flatirons Crossing development, which includes many shopping and dining destinations.
- **Link.** No longer in service, the Link connected areas in southern Denver including the Denver Tech Center and the Greenwood Plaza developments. Like the Skip, the Link is a 10-mile route that functions as two 5-mile routes joined together, serving both sides of I-25.
- **Gus.** The Gus bus ran within the City of Golden on Denver’s eastern edge, and ceased operation in 1997. The Gus is included in this analysis as the City of Golden is proposing to develop a new shuttle service.

Maps of each route are included as Appendix C.

Two shuttle routes, the 16th St. Mall Shuttle and the B-Line, were studied but not included in the following statistical analysis. Their structures and market roles place them in substantially different categories than the routes discussed above. These routes will be discussed in the context of the statistical analysis further along in the report.
• **16th St Mall Shuttle**: This is a short, very high-frequency route (every 75 seconds) providing both “last mile” and internal circulation to thousands of riders per day in downtown Denver. While its length (just over a mile) makes it appropriate to class as shuttle, its very high volume of service and very specialized role places it in a unique classification in terms of comparative analysis to the other shuttles and circulators.

• **B-Line.** The B-Line ran from downtown Denver to Southmoor, and operated between 1999 and 2006. It is among the longer routes in the study, along with the Skip and the Link. The B-Line, however, which ends in downtown Denver, is a true 10-mile route, and not a combination of two shorter routes. The B-Line essentially filled the role of a local overlay to the core urban route network rather than a shuttle.

3. **Markets and Service Performance**
The following matrices show the values for each variable across all routes. Routes are listed in order or descending performance, based on both boardings per route mile and boardings per in-service hour. Densities are given on a per-acre basis.

<table>
<thead>
<tr>
<th>Route</th>
<th>Population Density</th>
<th>Zero Vehicle Household Density</th>
<th>Median Income</th>
<th>Employment Density</th>
<th>Senior Density</th>
<th>Youth Density</th>
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<td>SKIP</td>
<td>10</td>
<td>0.6</td>
<td>$56,000</td>
<td>13</td>
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<td>10</td>
<td>0.6</td>
<td>0.5</td>
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<td>ART</td>
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<td>1.5</td>
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<td>ZIP</td>
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<td>23</td>
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<td>1</td>
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<table>
<thead>
<tr>
<th>Route</th>
<th>Boardings Per Route Mile</th>
<th>Boardings Per In-Service Hour</th>
<th>Route Length (miles)</th>
<th>Peak Headway (minutes)</th>
<th>Weekday Service Span</th>
<th>Weekend Service</th>
<th>Fare</th>
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<td>60</td>
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<td>40</td>
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<td>7</td>
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<tr>
<td>LINK*</td>
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<td>15</td>
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<td>Saturday</td>
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*Discontinued
Each demographic variable was plotted against both boardings per route mile and boardings per revenue hour, to determine the level of correlation between each variable and route performance. These graphs are shown in Appendix A. The R squared value represents the amount of variation in the route performance which can be explained by the demographic characteristic studied. An R squared value of around 0.5 or higher shows some significant correlation between the variables. The Mall Shuttle and B-Line are not included in the analysis as they are substantially different from the other routes, as discussed above.

The strongest correlation appears between population density and performance, and prevalence of zero-vehicle households and performance. There is strong relationship between these two variables, in that it is usually more possible to complete trips without using cars in dense areas.

**All routes showing over 10 boardings per in-service hour correlated with a population density of over 10 people per acre.**

A weaker correlation exists between median income and performance, with routes serving moderate-income areas more successfully than high-income areas. Variables of employment density, senior density, and youth density appear to have little effect on shuttle and circulator productivity. Areas of high employment concentration were somewhat inversely correlated and may be the result of lower density “office park” type environments, which include little in the way of residential development or other destinations such as shopping or entertainment.

Peak headways and fares for each route were also plotted against route performance. These graphs are shown in Appendix B. Peak headways showed a strong negative correlation with route productivity, with the most successful shuttles running at sub-10 minute headways during some portion of the day. Low headways are needed to generate spontaneous, short “walk-up” trips, where passengers do not need to plan ahead in order to use transit. Industry studies show that at intervals between buses of 13 minutes or longer, most passengers consult a published schedule.

The days of the week when the routes run varied little among the routes surveyed, but the two most successful routes run all week, and until at least midnight. Fare seemed to have no effect on ridership, with the high-performing routes charging more than the low-performing routes.

**4. On-Route Destinations**

The differing performance of routes with similar land use and demographic characteristics shows that other factors contribute to route success. Each route serves a different type of role within its community, and includes various destinations. The matrix below shows the types of destinations served along each route.

The most productive route, the Skip, includes a wide variety of destinations, such as downtown Boulder including the shopping district, the University of Colorado at Boulder, a high school, and a hospital. Combined with higher residential population densities, this allows the route to
serve many different roles within the community and attract a wide ridership market which can complete many types of trips without transfer. The successful Hop and Art shuttles also include a variety of destination types. The Stampede boasts among the highest population density of the routes studied, but runs mainly within the University area and does not serve downtown Boulder or other destinations and as a result performs less successfully.

The Gus shuttle in Golden, which demonstrated the lowest productivity level in the group, served as many different types of destinations as the top performers. Its population density, however, is the lowest in the group, while the Skip, Hop, and Art routes all run in areas with over 10 residents per acre. This finding suggests that population density is a primary factor in route success – *only when density is established, do the destinations along the line begin to affect route performance*.

<table>
<thead>
<tr>
<th>Route</th>
<th>Productivity</th>
<th>Regional Bus Transportation Connections</th>
<th>Shopping</th>
<th>Town Center</th>
<th>Universities</th>
<th>Other Entertainment</th>
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</tr>
<tr>
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<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>LINK*</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>GUS*</td>
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<tr>
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<td>●</td>
<td>●</td>
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<td>●</td>
</tr>
<tr>
<td>B-LINE*</td>
<td>Low</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<thead>
<tr>
<th>Route</th>
<th>Retirement Communities</th>
<th>Hospitals</th>
<th>Light Rail Connections</th>
<th>Office Parks</th>
<th>Schools</th>
<th>Malls</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>HOP</td>
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<tr>
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<td>●</td>
<td></td>
<td></td>
<td></td>
<td>●</td>
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<tr>
<td>STAMPEDE</td>
<td>●</td>
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</tr>
<tr>
<td>ZIP</td>
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<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

* Discontinued
5. Regional Connections
One of the key design roles of shuttles and circulators is to provide “first-mile” from home and “last-mile” to destination connections to the regional network. Regional routes may serve 90 percent of a passenger’s trip, but completing that extra mile to a residence or place of work often requires supplemental service, especially in the suburbs. All of the RTD shuttles evaluated connect with regional routes at at least one location. While these transfers play a part in generating ridership, the data shows that successful shuttles are built on strong local trip-making first, with regional connections playing a support role in overall success.

Passenger boarding data for the Skip, for example, shows strong activity at the Broadway/27th St. Park n Ride, a hub connecting many RTD services. However, boarding activity is as strong or stronger around downtown Boulder and the University of Colorado. The line is well-used along its entire length. The largest boarding location along the Link line, a poor performer, was the Arapahoe Park n Ride lot at Caley Avenue and Yosemite St., with little activity along the rest of the line. This suggests that the Link was mainly used as a first-mile or last-mile connection for long-distance transit riders, and not as a way to make internal community trips, again indicating that the regional connection role is secondary in generating success.

6. Related RTD Services
While all of RTD’s current shuttles and circulators are included in this study, several of the discontinued lines are not included. These include the Cultural Connection Trolley, the Ranch Rider, and community circulators in Aurora, Arvada, and Broomfield.

The Cultural Connection Trolley ran only during the summer months, and provided tourist access to venues such as museums, amphitheaters, and other attractions. It did not provide the type of daily trip-making capabilities of the other routes. The local area circulators mainly connected local destinations and ran infrequently (such as every 60 minutes). They tended to perform poorly and were converted into demand-responsive call-n-Ride service.

In many ways, the performance of the 16th St. Mall Shuttle confirms many of the findings in this study. With the highest population density, large amounts of zero-vehicle households, low to moderate income levels, and very frequent service, its high productivity seems appropriate to its surroundings.

The B-Line also ran through areas of high population density and many zero-vehicle households, and served many popular destinations. On those measures alone, the route had every chance for success. The main downside of the B-Line is that it did not fill a unique market niche. Its length, and the fact that much of the route was covered by other RTD services, made it more of a local route overlay than a shuttle filling a unique role. Additionally, while it served many highly populated areas, a significant portion of its service area was low-density.

The B-Line could be considered a shuttle with a particular market niche, if it had served the portion of the route from Colorado Station to the Cherry Creek Shopping District. This three-
mile section includes high-density areas, and B-Line rider surveys indicated that the majority of passengers used the route to access shopping destinations.

7. Industry Research
While few transit systems include specific shuttle and circulator information within their service standards, some TCRP reports provide case studies of high and low-performing routes and their associated characteristics. TCRP Report 55, Guidelines for Enhancing Suburban Mobility Using Public Transportation, dedicates several chapters to shuttle and circulator services. This report finds certain factors linked to success: operating environment, markets, cost control measures, vehicle types, linked services, small innovations, and public-private partnerships.

The findings stress the importance of serving “hub” areas, either for people (such as employment centers) or for transit (such as transfer centers). Aside from hubs, however, high-performing suburban routes also operated along moderately dense corridors with a mix of uses. TCRP Report 116, Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services, finds that shuttles and circulators are most effective when serving more “urban,” mixed-use areas where residents do not require cars to reach many destinations. This report describes an area’s transit affinity in terms of the “four D’s”: density, diversity, design, and deterrents to driving.

TCRP Report 55 states that shuttles and circulators can be successful either in serving transit’s more traditional markets, such as lower income and transit-dependent riders, or by attracting “choice” customers with high-quality, frequent service. This study of RTD routes reinforces these findings, by showing a strong correlation between density and performance, but only a moderate correlation between performance and income.

Other elements of success outlined in the studies involve fitting the transit product to the market. Each shuttle or circulator’s service area is unique, and may require a different service approach. In lower-density areas, flexible service types which allow route deviations provide a way of competing with car travel. Routes which fill a specific service niche, such as running solely within an entertainment complex, require special branding and high-quality connections to regional service. Within dense, mixed-use areas, routes can run at high frequencies and perform many different roles. This is also confirmed for RTD’s shuttles and circulators.

8. Recommended Service Warrants
The results of the analysis suggest that several factors are critical to shuttle and circulator success. While this study does not show that a statistical model can be used to specifically predict route performance, general correlations exist which allow transit agencies and Board members to make informed decisions on shuttle and circulator implementation. The following characteristics are listed in order of importance in determining route success.

- **Step 1 – Population Density.** A sustained average population density of at least 10 people per acre along the length of the route is a key determinant of success. The shuttles running in areas of at least this density – many of them in Boulder – perform significantly better
than those running in less dense environments. This finding suggests that shuttle and circulator service require a critical mass of potential riders in order to succeed. This is not surprising because compact communities are a key ingredient for successful sustainable mobility (walking, bicycling, and transit). As a result, many smaller communities like Golden can begin to support transit shuttles and circulators as new Smart Growth or New Urbanism densification initiatives are introduced. There may be opportunities to lead committed and funded development by introducing externally-funded transit shuttle and circulator initiatives during the land use buildout in order to have the mobility options in place as the market matures.

- **Step 2 – On-Route Destinations.** The analysis also indicates that shuttles and circulators that provide one-seat trips between community residences and community destinations are significantly more successful than those that do not. This suggests that when higher densities are present, the route design should provide direct connections with many varied community destinations. Serving locations such as schools (universities, colleges, high schools, middle schools), shopping districts (but not auto-centric malls), medical centers, and downtowns (central business district) helps to create routes that appeal to all market segments (youth, families, seniors) and can serve a wide variety of trips. Routes that cater to more limited market segments (e.g. the Stampede, running largely within the University of Colorado) tend not to perform as well as others such as the Skip and Hop, even with high population density.

- **Step 3 – Transit Friendly Area Characteristics.** Shuttle and circulator service areas with the minimum population density and multi-use destinations must still be “transit friendly” in order for a fully successful operation. Pedestrian friendly environments (walkable streets) are a minimum. Other associated sustainable mobility characteristics, such as mixed land uses, areas of clustered shopping or employment, public “exchange space” with available seating, and bicycle rights-of-way, help ensure a successful shuttle and circulator service. People are more likely not to own cars in such areas, and thus use transit and other sustainable modes more frequently. University areas such as Boulder are also particularly conducive to transit usage, with their relatively high densities and lower student income levels. They are also more likely to attract pedestrians on short trips.

- **Step 4 – Service Characteristics.** Steps 1-3 ensure a strong market and service environment for shuttle and circulator success. The last critical element in success is the transit service itself. Attributes such as frequency, span, and fare all significantly affect the attractiveness of the shuttle or circulator. These transit modes will work best as part of an overall sustainable mobility initiative that also includes walking and bicycling. As a result, transit needs to operate frequently enough over a full service span to attract spontaneous walk up use. Successful shuttles and circulators in the RTD system run at least 15 minute headways, and the high-performing Boulder routes run headways under 10 minutes. In order to generate spontaneous, short “walk-up” trips, minimum headways of 12 minutes are required with headways of 10 minutes or less highly desirable.
Fare levels seem to have little effect on ridership, as the most successful routes charge full fares (although students can ride Boulder routes at discounted rates). Regular use for all kinds of community trip-making makes the “per-use” pass cost very low.
Appendix A – Demographics

![Graph 1: Population Density vs. Boardings Per Route Mile](image1)

- Population Density (Pers/Acre)
- Boardings Per Route Mile
- Points labeled: Zip, Gus, Link, Art, Stampede, Hop, Skip
- R² = 0.4124

![Graph 2: Zero Vehicle Household Density vs. Boardings Per Route Mile](image2)

- Zero Vehicle Household Density (HH/Acre)
- Boardings Per Route Mile
- Points labeled: Zip, Gus, Link, Art, Stampede, Hop, Skip
- R² = 0.4194
R² = 0.0294

R² = 0.0718
Elderly Population Density (65+) (Pers/Acre)

Youth Population Density (18 and under) (Pers/Acre)
Appendix B – Service Characteristics

![Graph 1: Boardings Per Route Mile vs. Peak Headway (Minutes)]

- **Peak Headway (Minutes)**
  - X-axis: Peak Headway (Minutes)

- **Boardings Per Route Mile**
  - Y-axis: Boardings Per Route Mile

- **Lines and Data Points**
  - Data points for different routes:
    - Skip
    - Hop
    - Art
    - Stampede
    - Zip
    - Link
    - Gus

- **Statistics**
  - R² = 0.4713

![Graph 2: Boardings Per Route Mile vs. Fare](image2)

- **Fare**
  - X-axis: Fare

- **Boardings Per Route Mile**
  - Y-axis: Boardings Per Route Mile

- **Lines and Data Points**
  - Data points for different routes:
    - Skip
    - Hop
    - Art
    - Stamped
    - Zip
    - Link
    - Gus

- **Statistics**
  - R² = 0.6235
Appendix C – Route Maps
Art Shuttle  
City of Englewood

Legend

Population Density (by TAZ)
Residents per Acre

- 0-2
- 2-5
- 5-10
- 10-15
- 15+

- Shuttle/Circulator Route
- Destination
- Connecting RTD Route

Art Shuttle
City of Englewood

RTD Connections
C, D, 0, 12, 27, 36, 61, U
Stampede
Boulder Community
Transit Network

Legend

Population Density (by TAZ)
Residents per Acre

- 0-2
- 2-5
- 5-10
- 10-15
- 15+

- Shuttle/Circulator Route
- Destination
- Connecting RTD Route

New Vista High School
University of Colorado East Campus
University of Colorado Campus
Boulder High School
Village Boulder Shopping Center
Boulder Community Transit Network

Legend

- 0
- 0.25
- 0.5

Miles

0
0.25
0.5

Stampede Boulder Community Transit Network

COLORADO AVE
ARAPAHOE AVE
COLORADO AVE
BROADWAY ST
Boulder Community Transit Network

204, AB, B, DASH, DD, DM, GS, SKIP
Shuttle/Circulator Route
Connecting RTD Route