This section describes transit service concepts—types of service—and descriptions of various transit technologies and vehicles for modern transit systems. It also includes information on the kinds of places and trips that each can most effectively serve.

In making specific recommendations for transit investments, there are many considerations that come into play. Just as people make different kinds of trips, there are different ways of serving those trips. In making recommendations about various transit investments, careful thought must be given to balancing current and future needs of our growing region, while ensuring that the investments meet the goals for a Regional Transit Vision Plan. This requires consideration not only of initial, shorter-term costs, but the overall cost structure of investments and their potential for providing regional benefits over the short, medium and long term.

Service Concepts

In order to plan an effective and successful transit system, it is important to consider the type of service that is needed in particular corridors. Service concepts define the type of transit service, the way the service functions rather than the kind of vehicle used. Service concepts do not define any particular technology. In fact, any one of several transit technologies can satisfy a service concept. Because service concepts are geared to address types of travel patterns, many elements of a service concept are related to the land use patterns along a corridor.

By starting with service concepts, the Special Transit Advisory Commission (STAC) was able to focus on the elements of transit service that are experienced by users. To build a successful, high-ridership transit system, it is more important to find the appropriate service concept that is best suited to particular land use and travel patterns of the corridor than to debate the merits of specific technologies.

The STAC used three service concepts in developing its recommendations for the region:

- ***Circulating in Town:*** Focuses on moving people through areas with very intense activity, such as downtowns or university campuses. Since the intensity of activity means that stops are close together, the trips most people are taking are short. Service is very frequent, and operates on a Full Schedule Service schedule. A current example of this service concept is the “Greek Court” campus bus route operated by Wolfline, the North Carolina State University (NCSU) transit system, which connects student residences with central campus, libraries and sports facilities.

- ***Serving Long Haul Commuters:*** Focuses on carrying passengers from outlying areas into major employment centers, with Rush Hour Only Service. Current examples of this service concept are the express bus routes operated by Triangle Transit between Chapel Hill and Raleigh and Raleigh and Durham.

- ***Connecting Transit-Friendly Neighborhoods:*** Focuses on providing high-quality, reliable Full Schedule Service for many types of trips. Works best when coordinated with transit-supportive land use policies that seek to focus development around stops, stations or along the corridor. A current example of this service concept is the east-west “F” route operated by Chapel Hill Transit that connects apartment complexes, the downtown commercial and residential areas and the University of North Carolina at Chapel Hill (UNC-CH).

More information on service concepts is available in Appendix E.

It is important to recognize that service concepts can change within a corridor depending on the travel patterns that need to be served. For example a bus route can originate at an outlying park and ride lot and make no stops until it approaches a downtown district where stops become more frequent. This example would provide Serving Long Haul Commuters service, switching to the Circulating in Town concept in the downtown. Each service concept works best in corridors with certain characteristics:

- ***Corridors for Serving Long Haul Commuters:*** Longer corridors with concentrated development at one or both ends, or have park and ride lots or major transit hub facilities that present the opportunity to concentrate trips to or from many places. Most trips are concentrated in peak commuting hours.

- ***Corridors for Circulating in Town:*** Areas with high density and a variety of activities or special trip generators that need to have frequent and convenient service to the rest of the transit system; trips are relatively short in length but spread throughout daytime and evening hours. This service concept reinforces compact, mixed-use, walkable development which in turn enhances transit ridership.

- ***Corridors for Connecting Transit-Friendly Neighborhoods:*** Existing or potential nodes or centers of activity along a corridor with higher trip-making potential for a variety of trip types. Trips are spread throughout daytime and evening hours. This service concept can induce and support denser, compact, mixed-use walkable development which in turn enhances transit ridership.

Rush Hour Only Service: Transit service during peak commuting hours, with frequencies of 1 to 3 times per hour, on workdays only.

Full Schedule Service: Transit service during peak commuting hours with frequencies of 4 to 6 times per hour, plus service during midday, evening, and weekends at frequencies of 1 to 4 times per hour.

Peak Commuting Hours: The periods of the day during which highways are most congested are generally referred to peak travel periods or rush hour. In our region, the morning peak travel period is roughly 4 hours long, from 6 AM to 10 AM and in the evening, it is roughly 4 hours long, from 3:30 PM to 7:30 PM.

Evaluating corridors from the perspective of service concepts brings into focus user needs for service, and allows for dovetailing transit service with the particular needs of each corridor and segments of corridors. In some cases a service concept can change along a corridor, reflecting a change in trip volumes or patterns, or in the density of development which must be matched with a change in the transit service concept in order to maintain efficient and effective service. The particular service concept needed for individual corridors may change over time, requiring phasing in of increasing levels of service. By tailoring the transit service to meet current and projected future needs in each corridor, the Regional Transit Vision Plan can provide transit service

Completing the Transit Connection

For a transit system to successfully attract riders and reduce auto use, a high level of bicycle and pedestrian accessibility to the transit system is essential. When a transit trip can begin and end with a safe and comfortable segment on foot or by bicycle, the attractiveness of transit increases. Building pedestrian and bicycle friendly development means:

- *A high level of connectivity, including short street blocks*
- *Clear, comfortable and direct routes and pathways between transit stops and stations and residential, employment, commercial and other destinations*
- *Designing transit stops and stations to be secure, comfortable and attractive for users*
- *Integrating transit operations into the physical design and traffic flow of the development*
- *Diverse and complimentary day and night-time uses, close together to reduce the need for cars, especially for short trips*
- *Commercial and office buildings adjacent to the sidewalks with ground floor windows and parking areas behind buildings*
- *Inviting public and private spaces*
- *Ensuring that the roadway and roadside design includes facilities and space for pedestrian and bicycle travel*
- *Influencing driver behavior by design to create a safe walking and cycling environment*

For a transit system to provide a real alternative to driving and realize the full range of potential benefits, the system must be supported by development designed and built with the needs of pedestrians and cyclists in mind. The connection with these non-motorized modes of travel greatly increases the benefits from transit to our physical health, our air quality, our travel cost savings and our community cohesion. According to transportation researcher Robert Cervero, PhD, "Transit-oriented development is synonymous with pedestrian-oriented development" (May 2007 lecture at the Progress Energy Center, Raleigh).

for our diverse region, and focus transit investments in locations that will maximize ridership and enhance long-term economic development opportunities.

Transit Technologies

A transit technology is a combination of a particular type of transit vehicle combined with infrastructure and facilities on which it operates. Specific technologies may require infrastructure or operations strategies related in order to achieve some service concepts more efficiently, such as infrastructure to separate the transit vehicles from regular vehicle traffic. Investments in a given transit technology also can provide service for more than one service concept. Most transit technologies can be operated in different configurations. The technologies can be combined with infrastructure and operating strategies in various ways. Regulatory requirements related to safety and shared facilities define some aspects of how and where technologies can operate. The STAC considered the following transit technologies:

- ***Conventional Express Bus:*** Operates in traffic on highways and freeways; make fewer stops so offer faster trips than local buses. Can use standard buses or articulated double buses depending on passenger volumes.

- ***Low-Level Bus Priority Strategies:*** Combines any type of bus with limited roadway improvements to enhance travel time and reliability through congested areas. Low-level bus strategies are generally “spot improvements” such as using dedicated bus-on-shoulder lanes for short distances at traffic “chokepoints” or under especially congested conditions, or giving buses signal priority at intersections.

- ***High-Level Bus Priority Strategies:*** Combines any type of bus with roadway improvements or other investments that give buses special lanes or priority over regular traffic for greater distances, such as allowing buses to operate in carpool lanes.

- ***Bus Rapid Transit (BRT):*** Buses operating in a dedicated right of way, fully separated from traffic. Can use any regular bus transit vehicle, or vehicles equipped with guidewheels to follow a concrete curb in the busway (known as Curb Guided Bus Rapid Transit or CGBRT).

What’s Curb-Guided BRT?

The STAC investigated curb-guided bus technology for several corridors. Curb-guided bus rapid transit (CGBRT) uses horizontally-oriented guidewheels mounted under buses that fit on a concrete curb, and operates in a designated busway. The guidewheels help reduce oscillation and eliminates driver steering error, resulting in a smoother ride than regular buses and reducing the amount of right of way needed for the narrower busways. Guided buses can also negotiate tighter turns at higher speeds than non-guided buses.

Because guidewheels are retractable, buses can exit the busways and operate on regular streets. This allows a CGBRT system to be constructed incrementally over time, linking portions of busway with regular bus routes as right of way and funding become available.

Most existing CGBRT facilities are relatively short in length, and are combined with other bus strategies.

Current Transit Service in the Triangle

The Triangle region currently has multiple transit providers operating a range of services:

- *Regional: Triangle Transit*
- *Municipal: Cary Transit (C-Tran), Capital Area Transit (CAT), Chapel Hill Transit (also serves UNC and Carrboro), Durham Area Transit (DATA)*
- *University: Duke University Transit and NCSU's Wolfline*

Durham, Orange and Wake counties each operate community transportation systems, which provide transportation for human services clients and people living outside urbanized areas

In 2005, CAT, DATA, Chapel Hill Transit and Triangle Transit combined to provide over 14.4 million passenger trips, carrying Triangle residents over 53.3 million passenger miles, which is the equivalent of over 112 trips from Earth to the moon and back. These figures represent a 27% increase in passenger trips and a 56% increase in passenger miles over the year 2000.

Rail transit in our region is currently provided by Amtrak which operates intercity rail service within North Carolina and beyond. There are Amtrak stations open 365 days per year in Cary, Durham and Raleigh. In 2007, 181,379 passengers boarded Amtrak trains at these three Triangle stations. Durham is served by four trains each day, including service to Charlotte, Washington DC and New York. Cary and Raleigh are served by the same trains as Durham, as well as two more trains connecting to Columbia, SC, Savannah, GA, Orlando, FL and Miami, FL. In 2006, two North Carolina trains, the Piedmont and the Carolinian, were among national leaders in train ridership growth, with 25% and 17% increases in the number of passengers, respectively.

Sources: National Transit Database, NASA

- ***Diesel Multiple Unit (DMU) Rail:*** Self-propelled, diesel-powered passenger rail cars that can be driven from either end. DMU trains can be adjusted to changes in passenger volumes by increasing or reducing the number of rail cars in a train. DMUs operate completely separated from regular vehicle traffic in rail corridors that may also be used by freight trains. High cruising speeds, with relatively slow acceleration and deceleration in and out of stations make DMUs more suitable for longer trips where most stations are spaced over a mile apart.

- ***Light Rail Transit (LRT):*** Electrically powered trains that can operate on their own tracks or tracks shared with freight or intercity rail operations. Nimble LRT vehicles can navigate tight turns and accelerate and decelerate quickly to efficiently serve frequent stops and corridors with tight rights of way. Trains can adjust to changes in passenger volumes by increasing or reducing the number of rail cars. LRT can operate alongside regular vehicle traffic in a dedicated lane.

- ***Commuter Rail:*** Large, self-propelled locomotives that can reach high cruising speeds, but accelerate and decelerate slowly. Passenger cars can be single or double decked.

- ***Modern Streetcar:*** Relatively short vehicles that can operate on streets either in their own lanes or in mixed traffic. Electric-powered, with power delivered by overhead (catenary) wires.

For more details on these technologies, including typical costs, see Appendix E.

It is important to understand that different transit technologies vary in the proportion of costs required in two categories of costs: capital costs and operations and maintenance costs. Understanding these differences helps explain some of the cost trade-offs among the technologies and service concepts.

Capital investments include:
- Vehicles, including replacement vehicles as the fleet ages
- Real estate for right of way to operate transit routes and for maintenance facilities
- Facilities for vehicle operation including tracks, special lanes and over- or underpasses
- Shelters, stations, maintenance garages and railyards
- Other equipment, such as signage, bicycle racks or systems to give passengers real-time information on when vehicles will arrive.

Operations and maintenance costs include:
- Fuel and oil
- Labor, including drivers, maintenance staff, passenger information/service center staff
- Vehicle parts and tires
- Insurance
- Ongoing planning for expansion and service changes to schedules and stops

All these cost categories differ by technology and service concept. For example, although rail cars are more expensive than buses to purchase, they typically last 30 years while buses usually must be replaced every 12 years. This makes capital investment in rail transit front-loaded, while bus capital investments are spread over a longer time frame. Similarly, the benefits from different transit investments vary, with some types of benefits, especially those related to land use and economic development, delivered in the longer term.

Connection with Service Concepts

Because of the differences in how vehicles operate and where they can operate, certain technologies are better suited to certain service concepts. For example, long distance commuters are better served by commuter rail, DMU, high-level bus priority strategies (especially BRT), or express bus—technologies that operate at high speeds between widely spaced stops. Selecting between highway- and rail-based technologies for a particular corridor may be dependent on whether the highway facility has the appropriate level of capacity or right of way, whether sharing freight railroad tracks is feasible, or if there is room in an existing rail corridor to operate passenger trains, thus saving or reducing the cost of purchasing right of way. If the corridor has a major highway, a bus technology might be more appropriate, however operating buses in traffic on heavily congested highways is less attractive to riders because their travel time is not reduced. To make bus transit on highways competitive with auto travel, investments need to be made such as purchasing property for new rights of way for busways, widening existing highways to include new bus lanes, or reconfiguring existing lanes or shoulders for use by buses.

The volume of passengers served in a corridor clearly shapes the service concept, but also influences the selection of technology. For example, buses typically seat 30 passengers, and can accommodate up to an additional 20 standing passengers. When ridership exceeds this amount for a route, an articulated bus can be purchased and put into service, which can accommodate 60 seated passengers plus 50 standing passengers. Beyond this level of ridership, an additional bus must be deployed, thus doubling operating and labor costs. In short as bus ridership increases, the operating cost per passenger also increases. If a high-volume corridor is served by a rail technology, when ridership increases, the increase is handled by adding a rail car to a train that is still operated by one driver. Therefore, as rail ridership increases, the operating cost per passenger decreases. The long-term savings in operations and maintenance costs can offset some of the initial high capital investment needed for rail transit.

There are also safety regulations that govern what types of transit vehicles can be operated in corridors shared with either mixed traffic or freight rail operations. Federal regulations specify the amount of separation–distance between tracks and timing between vehicles–between passenger rail vehicles and freight rail vehicles. Careful consideration to roadway safety is also required when designing bus priority facilities to prevent conflicts and crashes with regular vehicular traffic.

In keeping with their goals for the region, the STAC felt it was important to select combinations of service concepts and transit technologies that would shape land use patterns. Experience in the US has shown that high-frequency rail transit can influence land markets, increasing opportunities for development that is oriented toward transit service both in its design and mix of uses. This relationship is attributed to the permanence of the rail corridor and the dependable, high frequency service which generates a consistent flow of people. Much the same as a freeway interchange signals a level of permanent, high-volume access for autos and trucks.

Although a fixed guideway can be built for either buses or trains, it is much more common for trains. While some US transit systems do include segments of fully separated busways, there are no fully separated BRT transit systems in this country.

Further there is no conclusive evidence of market forces responding to create transit-oriented development around the low- to medium-level BRT investments that do exist. There are, however, international examples of major BRT systems that have affected land prices and apartment rents in cities. The STAC's interest in recommending transit investments with a proven track record of attracting a broad cross-section of riders and inducing market responses from the development community was a major consideration in their recommendation for investment in rail transit in our high-volume corridors where there are development and redevelopment opportunities. Additionally there are limited opportunities to build fully separated busways along existing corridors in the Triangle region.

An understanding of the different service concepts and transit technologies provided a foundation of knowledge about transit that shaped the Regional Transit Vision Plan. The STAC built on this information, by aligning technical recommendations for corridors with their qualitative goals for the regional system. The complete set of recommendations is presented in Section 6.

Transfers

Many believe that requiring transit passengers to make a transfer from one vehicle to another will discourage people from using the system. Transfers can sometimes introduce a level of uncertainty into an overall transit trip, but the quality of the transfer experience greatly affects whether the transfer is perceived as a positive or a negative by the rider. A transfer with a long wait between transit vehicles, an uncomfortable waiting environment exposed to the weather, or a lack of customer information about when the next vehicle arrives can be a deterrent to using transit. A transfer at a location with comfortable seating out of the rain and sun, where vehicle arrivals are coordinated to minimize waiting, with real-time information signs tracking the arrival of the next bus or train, can provide a convenient connection to a destination. Even major transit systems that have been in place for decades require transfers, and making a transfer can sometimes shorten travel time, or provide a shorter walk at the end of a trip.

Here in the Triangle, one of our greatest strengths is the variety of places where people can live, work, learn and play. While getting to and from future rail transit stations should ideally involve walking or bicycling, many transit riders will, at least initially, have to be dropped off (kiss-and-ride) or drive themselves at one end of their transit trip. This will especially be the case for trips that begin and/or end in lower density areas. A reasonable goal in a region like the Triangle would be to have no more than 2 transfers for most riders. But ultimately, the most successful way to reduce transfers is to support the development of significant housing and employment near transit stations.

Transit Service to Airports

Although widely perceived to be the norm and necessary for generating overall transit system ridership, direct rail access to airports is relatively uncommon in US cities. In the US, only 15 airports have direct rail transit access. Dallas-Fort Worth; Harrisburg, PA; Phoenix; Seattle-Tacoma, and Washington Dulles airports anticipate replacing current shuttle bus or busway-to-rail connections with direct rail transit access within the next 9 years. Most of the remaining metropolitan airports have scheduled municipal/regional bus service which varies in terms of frequency, hours of operation and weekday versus weekend schedules.

While 11 of the 12 regions of comparable size to the Triangle have rail transit, among these regions only the airports serving Baltimore, Cleveland, Portland and St Louis can be directly accessed via rail. In most cases direct rail service to airports is added long after the basic framework of the regional system is in service.

There are several reasons for this. First, decisions about investments are based on the largest, consistent travel market: generally the volume of daily peak hour traffic, most of which is not destined for the airport. Volumes of trips to airports are much smaller and spread over the day so serving them with rail raises per passenger costs. Second, airports must manage and control access to their facilities. Therefore most airports prefer to have a connection from their facilities to the regional system rather than having the system run through their properties. The Raleigh-Durham Airport Authority is including a connection from their facilities out to any future regional transit route passing by their property, although the technology for this connection is not yet determined.

Unquestionably, high quality transit connections to the airport provide convenience for air travelers and a savings on parking costs. However, the benefits of these services must be balanced with the usually much higher trip demands elsewhere in a region.

Source: National Association of Railroad Passengers.