# APPENDIX

## ISSUES IN SELECTING CIRCULATOR ROUTE TECHNOLOGIES

This brief technical memorandum is for the purpose of identifying some of the possibilities available to Austin in developing plans for the intended circulator routes. Issues affecting choices among possible routes and possible transit technologies include:

- Whether any of the possible circulator technologies could share track with commuter rail
- Possible choices of propulsion technology for circulator routes
- Acceptability of and alternatives to the introduction of overhead electrification as the energy source for circulator routes

These issues are explored briefly in this memorandum, based on information regarding existing transit applications including technologies undergoing development and trial as well as more established approaches.

### Mixed-vehicle operations

In Pittsburgh, Pennsylvania, light rail vehicles and buses share a tunnel, around a half mile or less in length. Track is embedded in a concrete tunnel floor. The tunnel is on private right-of-way and restricted to transit use only. This operation has continued for many years without problems.

In Cleveland Ohio, heavy-rail rapid transit trains and light rail share several miles of track in a section east of downtown. At stations, separate platforms are provided for the two service types – high platforms for the rapid transit trains, and low platforms for light rail. Both modes use the same electrical supply voltage and operate from the same overhead contact system.

Current plans for the Downtown Seattle Transit Tunnel anticipate running a mixed service of light rail and buses in the tunnel. The tunnel initially was served by dual-mode buses (diesel and electric trolley – see next section) but currently uses quiet low-emission diesel-electric hybrid buses.


### Dual-powered vehicles

We have not found examples of dual-powered rail vehicles, although it is likely they exist somewhere among passenger rail systems. There are electric-powered systems that


alternately use third rail and overhead wire. Since about 2003, a tram (streetcar) system in Bordeaux has been operating with parts of the system using overhead wire and a central section using a street-surface contact system (see discussion of overhead wires later in this memorandum).

Dual-powered transit buses have been used in various cities. Some use hybrid-power technology, with internal combustion engines generating electricity to power electric drive motors that also can receive electric current from trolley wires, while others have separate internal-combustion and electric trolley propulsion systems. The latter approach was used in the Downtown Seattle Transit Tunnel, where buses operated under diesel power outside the tunnel, but switched to trolley wires providing energy to an electric drive train for operation within the tunnel.

The four vintage trolley replicas operated by Island Transit in Galveston, Texas, are unusual in that they do not use overhead wire. Instead, a diesel bus engine is mounted in each car, which drives a generator to supply electricity for the motors. The reason given for this technological decision is that the city is often hit by hurricanes, and there was concern that these storms would blow down the trolley wire and subject the city to lawsuits. The line was one of the first new vintage trolleys built. No other major system has chosen to emulate Galveston's use of on-board diesel generators to provide electric power.

**Hybrid and fuel cell technologies**

Considerable development is underway to employ hybrid power and fuel-cell technology for transit bus propulsion. Hybrid power trains are now commonplace in buses. Most are diesel-electric, but variations include the use of CNG fuel, “micro turbines,” and flywheels.

Ultra-low sulfur diesel (ULSD), often referred to as "clean diesel," is being introduced into use in transit fleets across the U.S. ULSD contains 95% less sulfur than conventional diesel, and requires no major changes to transit operations or infrastructure. The adoption of ULSD is being driven by the 2006 U.S. Environmental Protection Agency (EPA) standards mandating that the sulfur content in diesel fuel be reduced from 500 to 15 parts per million.

Battery-powered buses are in limited use. Fuel cell power has been employed in transit buses at least since late 2002, and currently, there are at least two cities in the United States, both in California, and at least ten European cities that are testing buses powered by fuel cells.

**Visual impact of overhead wires**

Objection to overhead wires, primarily on aesthetic grounds, is often expressed as an argument against electrified transit systems, whether bus or rail. While there are cases of notable visual “pollution” caused by overhead contact systems, careful design minimizes negative effects.

For rail systems, three types of overhead electrification are commonly used. Conventional catenary, which is suitable for very high speed applications such as intercity trains, allows the largest distance between support

poles but has the most prominently visible wire arrangement, consisting of catenary wires which support the contact wire by means of vertical suspender wires. There is also a low-profile catenary system, which is suitable for intermediate speeds. Support poles are more closely spaced, and allow the arrangement of support and contact wires to be less conspicuous. Finally there is a system using trolley wire only, without additional support. This method can have the least visual impact, except for the fact that support poles must be closer than required for catenary systems.

Trolley buses require two overhead wires, one for supply and one for return current, with the result that the overhead wire installation is somewhat more prominent than for rail systems. A recent development by Bombardier is a guided trolley bus. The guidance system is mechanical, using a rail imbedded in the street surface. The rail serves as the electrical current return as well as its guidance purpose, and thus allows use of a single overhead wire.

In a well-designed electrification system, attention is given to selection among the three types, and also to the placement and use of support poles. Poles are often used for multiple purposes, thus replacing light poles, sign posts, or poles carrying overhead utility wires, and their design may provide a valued decorative feature in the streetscape.

Even so, efforts continue toward development of other means of supplying electrical energy to transit vehicles. Several years ago, an urban bus system in Italy was designed to use a contact surface in the street. The contact surface, flush with the adjoining road surface, is divided into short sections along the route. Sections are energized only while the transit vehicle is passing and is directly over the energized section or sections, so as not to expose pedestrians or other vehicles to the powered section of the contact surface. The technology uses electromagnets to lift an underground power cable, thus connecting it with a specific contact surface section as the transit vehicle passes above that section. Reliability problems have been reported.

More recently, with first passenger service initiated in 2003, a new tram (streetcar) system in Bordeaux is the proving ground for a variant of this contact surface concept. The Bordeaux system employs solid-state technology to energize sections of the contact surface, and this is expected to provide a safer and more reliable result. The Bordeaux tram routes use the contact surface system in a central part of the city where overhead electrification was considered to be least acceptable, while the remainder of the routes have overhead electrification. Tram operators switch from one power source to the other while stopped at stations where the transition occurs.


Strasbourg Eurotram


Los Angeles

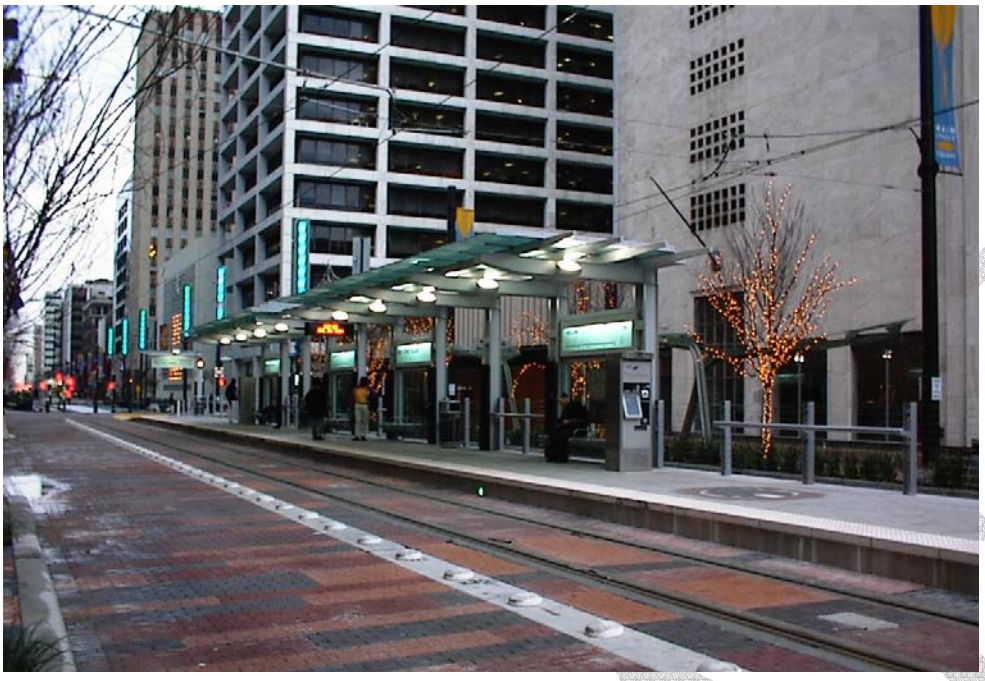
San Diego

San Francisco – LRV and Trolley Bus

Tasman LRT, California

Amsterdam


Portland Streetcar



Houston METRORail


Houston METRORail