

# Modern LRVs – Flexible Design



- "Light Rail Vehicle"
- 80'-95' L x 8'9"-9'6"
  - 55-65 mph max
  - 70-80 seats
  - 140-170 total psgrs

2005

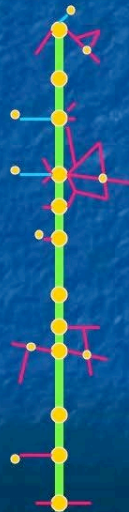


- "Streetcar"
- 66' L x 8'1" W
  - 40-45 mph max
  - 30 seats
  - 115 total psgrs



# Cascadia Multimodal Corridor

*A place for every mode, & every mode in its place*

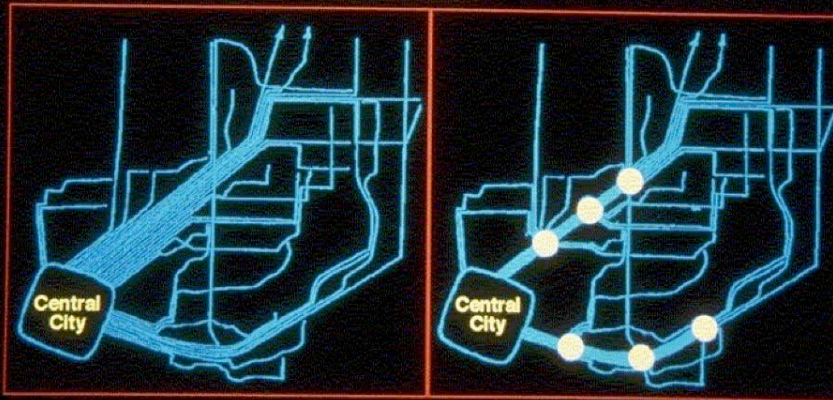


- Intercity Main Line
- Regional Connections
- Primary trunks
- Feeders/Circulators



## Bus/ LRT Service Concept

Shows Northeast and East bus services before and after introduction of LRT in Sacramento.



Before: Radial Routes, Random Transfers

After: Trunks & Feeders, Transit Ctrs, Timed Transfers

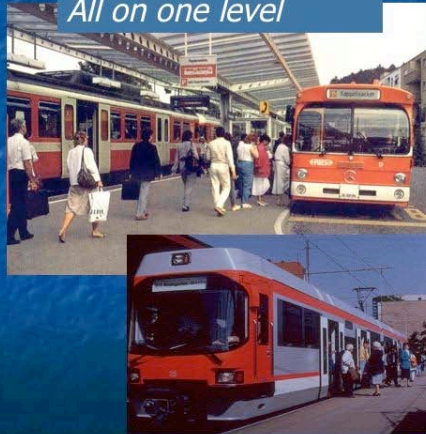
## Creating Rider Density

- Multi-destinational transit
  - *Trunks and feeders*
  - *Match modes & services*
- Park-ride lots
  - *Concentrate patrons from dispersed subdivisions*
- Population density on line
  - *TODs, transit friendly neighborhoods*



# Make Transfers Easy

Cross-Platform (Bern)  
*All on one level*



Different Levels (Vancouver)  
*Stairs, escalators, elevators*



Cost Diffs: Capital, O&M?

# Surface Design Opportunities

*String R-O-W Opportunities Together*



- Arterials, local streets
- Freeways, highways
- Railroads
- Utility corridors

## Moving 4,800 PHPD Riders @PLP

Mode	Veh Capy	PHPD Runs	Crew	Headway
Bus:				
Std (40')	65	74	74	48 Sec
Artic (60')	110	44	44	82 Sec
LRT (150/Car):				
2-Car Trains	300	16	16	3.75 Min
4-Car Trains	600	8	8	7.5 Min
Cmtr (150/Car):				
4-Car Trains	600	8	16	7.5 Min
8-Car Trains	1,200	4	8	15 Min

## AGT/PRT Challenges

Stations: Complex, Costly  
(Miami Metromover)



Systems: Developmental,  
Proprietary (Raytheon, Discontinued  
Prototypes)

## Calgary & Vancouver in 1987

Category	Calgary	Vancouver
System:		
Miles/Vehicles	17.2/83	13.3/114
Psgs/Yr (mil)	24.3	18.0
Rail Budget (mil)	\$7.7	\$19.1
Employees:		
Operations	117	132
Maintenance	90	144
Other	--	<u>42</u>
Total	207	318

## US/Canada Light Rail Growth

- 1975 – 8 survivor systems
  - *Boston, Newark, Philadelphia, Pittsburgh, Cleveland, New Orleans, San Francisco, Toronto*
- 1976-85 – 4 new starts, 12 total
  - *Edmonton, Calgary, San Diego, Buffalo*
- 1986-95 – 7 more new starts, 19 total
  - *Portland, Sacramento, San Jose, Los Angeles, Baltimore, St. Louis, Denver*
- 1996-2005 – 6 further new starts, 25 total
  - *Dallas, Salt Lake, Jersey City, Tacoma, Houston, Minneapolis*
- Under Construction, 3 more new + extensions
  - *Phoenix, Charlotte, Seattle*

# RAIL IN MULTI-MODAL TRANSIT SYSTEMS

## IMPROVING URBAN MOBILITY BY INCREASING CHOICES FOR TRAVEL AND LIFESTYLE (Abridged Version)

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Improved transit is needed to help urbanized areas become at once more livable and less auto dependent. Since all cities have at least a modicum of bus service today, improvements need not start from zero, but can build on the existing base in stepwise fashion as short, interim and longer term plans are implemented. An essential first step is creation of a seamless, multi-destinational bus system using timed transfer schedules and regionally integrated fares, with transit centers and park-rides. Regional rail planning and design also should start in the short term, with the goal of opening a starter system early in the interim term (5-to-10 years out), then expanding it in the longer term.

### CITIES AND TRANSIT SHOULD WORK TOGETHER

Metropolitan regions should evolve - over time - complementary communities and public transit systems combining these features:

- **CBD-centered.** Every city still has a downtown. It is, or should be, the cultural heart of the metropolis, and the logical place for highly specialized activities occurring in just one location within an entire urban region. With its concentration of jobs, it is transit's best market. Symbiotically, good transit makes downtown work better.
- **Major Activity Centers (MACs).** Universities, cultural and sports venues, employment centers (commercial, government, medical), intercity ground transport terminals, airports, and regional shopping centers all should be connected by the transit system.
- **Urban villages.** Develop (or redevelop) at rail stations outside the CBD, with a hierarchy within a quarter-mile radius of stations of retail/commercial/office, apartments, then townhouses before reaching single family homes. Resulting human-scale residential densities are well matched to LRT and commuter rail carrying capacities without resorting to the gargantuan scale of development associated with heavy rail.
- **Customer-Oriented Transit.** The key to improved performance that attracts more choice riders is to coordinate and develop services catering to a range of trip purposes. This requires a *multi-destinational system, transit centers, timed transfer scheduling, and a unified regional fare structure.* Transit centers should be placed within MACs. It should not be necessary to go downtown to transfer on a suburb-to-suburb trip. A *multi-modal* range of bus and rail technologies should be employed to satisfy demand varying by route and time of day. Fares should be fully integrated throughout the metro area, across modes and operating entities if there is more than one. Transfers should be free.

### TAILORING SERVICES TO PEOPLES' NEEDS

Transit remains vital as an alternative to congested roads at peak commuting hours, as an essential public service for people without a car, and as an option for trip makers of all kinds who would prefer not to drive everywhere. The old pattern of mostly radial routes oriented

only to the CBD is no longer enough to attract people traveling for many different purposes comprising a range of *niche markets*. Increasing efforts to provide "good" service are necessary so that:

- **Commuters** will choose transit as an attractive alternative to driving (i.e., convenient transit vs. awful driving and/or parking conditions).
- **Captive riders** can make more trips more easily, improving their mobility and increasing opportunities for satisfying and productive lives.
- **Other trip makers** can be coaxed on to a transit system serving a variety of destinations, each a *niche market*, with reasonable frequency, speed, comfort and reliability.

## MULTI-MODAL MULTI-DESTINATIONAL TRANSIT

The basic idea is to offer through service on the heavier transit links, and one-transfer service for as many other trips as possible. Unless there are connections between lines with very short headways, transfers at transit centers should be timed to minimize total trip time. Transit services, coordinated by timed transfer scheduling, should be arranged in a tiered hierarchy:

- **Regional connections** are like major arteries, "transit freeways" linking transit centers and MACs with one another. Capacity must be adjustable to demand varying through the day. The busiest *regional connections* are the best opportunities for effective use of rail.
- **Primary trunk routes** - analogous to arterial streets - supplement *regional connections* along less heavily used key lines, usually originating and terminating at transit centers.
- **Feeders and shuttles** - like collector and local streets - collect and distribute riders to and from nearby transit centers, and circulate people within communities and neighborhoods.

This hierarchy underlies several transit agencies' application of timed transfer scheduling to create multi-destinational networks using modern vehicles. To ensure operating efficiency and the reliability of connections, major passenger flows are separated from general motor traffic wherever possible, given priority in public rights-of-way, concentrated on the highest capacity vehicles justified by demand, and coordinated with other routes and modes:

- **Regional Rail.** Light rail or, where railroads are usable, commuter rail to link the CBD with MACs and suburban stations along principal radial corridors. Lines should be *through-routed* -- east-west, north-south, etc. -- with the CBD in the middle to attract not only trips to the CBD, but also reverse commute and cross-regional trips.
- **Rail and bus integration.** Bus routes restructured to feed rail and connect better with one another to create a multi-destinational network serving the entire area, including cross-suburban buses between rail stations/transit centers, to MACs and other key destinations not on rail lines. Timed transfer schedules and a coordinated regional fare structure promote intermodal transfers, as well as bus-to-bus connections.
- **Park-ride.** As many potential riders will continue to live beyond walking distance from rail lines and not all will use feeder buses, park-rides must be a part of suburban stations. Over time, electric commuter cars hold promise for relieving air quality concerns at these facilities. Eventually, some park-rides may be redeveloped as urban

villages.

## APPROPRIATE ROLES FOR TRAINS AND BUSES

Because of varying market factors such as trip lengths and potential riders' propensities to use transit, operators typically use different vehicles, loading standards, service frequencies and stop spacing for urban and suburban services. It is generally accepted that some passengers will stand on shorter "urban" trips during peak commuting hours, but that insofar as possible, a seat should be provided for each rider making a longer "suburban" trip.

These same factors govern rail transit. Short-to-medium trips through areas in and adjacent to the urban core can be served by light rail accommodating seated and standing riders. Commuter trains serving longer trips usually offer greater comfort, and a seat for every patron.

Initially, buses may provide all services. Extra peak-only runs are likely to be needed for commuters, even if they trace the routes of all-day *regional connections*. Over time, the volume of peak transit vehicles is likely to increase to the point that larger vehicle units become desirable to increase fleet and labor efficiency. Articulated buses are a typical first step. Further increases in productivity can be achieved using rail cars coupled into trains:

• 40' Bus	1 Driver	45 Seated/65 Total Passengers
• Articulated Bus	1 Driver	65 Seated/110 Total Passengers
• 4-Car Train (90' LRVs)	1 Driver	300 Seated/600 Total Passengers
• 4-Car Commuter Train	2 Crew	600 Seated Passengers (No Standees)

Mature transit systems deploy a combination of technologies to offer riders service with appropriate capacity for each route, and superior levels of safety, convenience, comfort, and reliability, as well as matching each mode's technological efficiency to service requirements:

- **Bus Transit:** Local and regional routes form a coordinated, multi-destinational network serving radial and circumferential trips. On-street or more elaborate off-street transit centers are built to facilitate passenger transfers between *feeder* and *trunk* routes. HOV lanes and other traffic engineering measures speed buses through congested areas.
- **Light Rail Transit:** Electric rail vehicles operate in short trains on exclusive, but not necessarily grade-separated rights-of-way and/or semi-exclusive street lanes, with on-line stations (of which some may be built as transit centers and/or park-rides). Short trains balance service frequency and driver productivity.
- **Commuter Rail:** Diesel trains use existing railroads, which may have to be upgraded for passenger train speeds and traffic increases, with on-line stations (of which some may be built as transit centers and/or park-rides). Longer trains emphasize driver productivity over service frequency.

The modal choice is rarely clear, and must be evaluated for each specific application. Whichever rail technologies are chosen, they must provide adequate capacity, high standards of passenger comfort, fast and reliable service; and be a *good neighbor* within the community. As major transit capital investments, rail systems almost always focus on the most heavily used *regional connections* in the overall transit system. Differences in the mix of these factors often lead to different choices for *urban* or *regional* trunk services. For *urban* lines accommodating both seated and standing riders, articulated buses approach the practical limits of their capability

above the 1,500/hour level; but LRT can accommodate a wide range of demand at operationally comfortable headways. For longer *suburban* services providing every rider a seat, bi-level commuter trains offer the high capacity of 1,500 passengers on a single 10-car train.

## NETWORK SYNERGY -- MAKING REGIONAL AND LOCAL CONNECTIONS

Only the largest, most densely developed central cities (e.g., New York City, San Francisco) generate passenger volumes sufficient to justify heavy rail lines and short-headway, grid-type surface transit systems. *Timed transfers* and *clock headways* are essential to providing a level of convenience and connectivity approaching a grid system on the lower-density, lower-frequency route networks more typical of moderately large urban regions.

The various links are interconnected through stations designated as *transit centers*. Clock headways on all routes, careful definition of route links, and the timing of vehicle runs along them so that connections are made reliably are important parts of this system strategy.

*Regional connections* form the base on which all other schedules are built. Individual route links must be timed so connections are made at transit centers, between local and regional services, as well as among local services. Based on the patronage of recent new commuter rail and LRT systems, as well as bus patronage in moderately large urban regions, a 15-30-60 minute headway pattern appears to offer a mix of memory schedules, service frequency and capacity balanced to likely PHPD passenger loads in the region's various urban and suburban sub-areas.

Although headways are long compared to transit lines in the largest central cities, they are appropriate for *regional connections* serving suburbs and exurbs. The inconvenience of longer service intervals is largely offset by regular clock headway operation. Riders quickly learn departure times for their stations; so average waits are in the 2-to-5 minute range, not half the headway as some demand modelers wrongly insist. Objectives are to reduce total travel time for transit trips relative to automobile travel times for the same trips, and to do this for more trips.

As ridership builds, more trains can be added. PHPD capacity with trains of 4 LRVs would be doubled to from 2,400 to 4,800 by reducing headways from 15 to 7.5 minutes (8 trains per hour), and tripled to 7,200 by shifting to 5-minute intervals (12 trains per hour). By further reducing headways to 3 minutes, PHPD capacity would grow to 12,000 - the equivalent of 4-to-5 freeway lanes, a volume likely to be seen only in the larger cities, and that can be achieved by incrementally increasing service on a basic double-track rail line.

These characteristics have been used to advantage on several new rail projects. For example, the relatively small transit system in Sacramento removed 60 peak hour buses from downtown streets by substituting just eight LRT train. Since restructuring, trains and buses connect at transit centers to provide improved radial and crosstown services. It is no longer necessary to ride downtown to transfer. Total transit system patronage grew by 100%, and light rail riding exceeded the forecast for the line as built by 50%.

## COST-CONSCIOUS, INCREMENTAL DEVELOPMENT

It is possible to develop Regional Rail "starter lines" and then expand them adhering to an affordable incremental approach. The principal elements of such a program include:

- Maximize the utility of initial regional rail investments by following principles for low-cost implementation (San Diego criteria):

- Select a relatively long-distance corridor that provides for high speed operation.
- Prefer an alignment with low capital cost.
- Locate the line primarily at grade and primarily in exclusive right-of-way.
- Develop a system that will have low operating costs and high farebox recovery.
- Build lines, or segments of lines sequentially over time. Placing the CBD in the middle of a starter line serving two travel sheds, as in Sacramento, is likely to increase initial productivity compared to serving a single radial corridor.
- Adhere to a budget-conscious design ethic. Rail can provide a cost effective increase in transit productivity by observing to these key design principles (Sacramento criteria):
  - Use available rights-of-way.
  - Limit the initial investment in facilities to essentials.
  - Buy service-proven equipment.
  - Operate the system on an efficient, no frills basis.
  - Avoid design elaborations that may be construed as "gold plating".

## WORKABLE TRANSIT FOR SPREAD-OUT AMERICAN CITIES

After World War II, planners seemed to fixate on just two transit technologies: buses on streets, and fully grade separated rail rapid transit. Later, it became clear this approach left a void between the upper bounds of bus system capability and the lower end of heavy rail capacity, a middle range that can be served effectively by LRT and commuter rail.

This break corresponds to demand levels most likely to be found in the main travel corridors of moderately large U.S. cities; therefore, attractive high-quality multi-modal transit alternatives should include some combination of **commuter rail** for longer regional trunk lines; **light rail** for shorter regional and urban trunk lines; **clean-fuel buses** in various sizes for urban shuttles and grids, suburban feeders and crosstown routes; and **paratransit** for people unable to use fixed route services for part or all of their travel.

Simply building rail lines is never enough to ensure effective service. The best systems coordinate all operations - regional rail lines, urban transit networks, suburban buses and paratransit - to provide an understandable regional network easy and convenient to use. In spread-out U.S. cities, timed transfer scheduling and transit centers are crucial to a successful system. Transit "nodes" should be central elements in the fabric of major activity centers.

Progressive transit operators and community leaders are finding that in moderately large U.S. cities, well-conceived and operated transit can provide an attractive alternative to people frustrated by congested roads, slice the tops off commuter traffic peaks to avoid costly freeway expansion, and offer improved mobility to non-drivers:

- Such systems should be anchored by LRT or commuter rail *regional connections* on the main routes. Proven, readily available rail technology should be used so a lengthy research and development program does not delay the start of service.
- Schedule reliability and convenient access to multiple destinations are important to build peak and all-day ridership, and are promoted by the timed-transfer, multi-destination concept wherein a hierarchy of *regional connections*, primary trunk routes, feeders and shuttles are coordinated at transit centers. Networks with many easily made transfers offer more options to users and attract more riders than traditional radial systems.
- Coordinating connections of several routes at transit centers produces a synergistic effect in that local routes making simultaneous timed transfers to a *regional connection* also

connect with one another to provide enhanced community circulation.

- It is neither economical nor necessary to offer close headways throughout the system; but schedules must be regular and reliable. Passengers do read timetables. Clock headways make remembering easier, and provide the basis for synergistic timed transfer scheduling. Service frequency (headways) and operating efficiency (large capacity vehicles) should be balanced to promote efficient and cost-effective service people will use.
- On *regional connections*, trains offer enhanced reliability and comfort, offsetting negatives of longer-headway service, and transfers to feeder and circulator buses.

The tools are available to build effective transit systems, and to coordinate them with people-oriented urban and suburban communities that are lively and varied. Such systems are working in U.S. and foreign cities now. There are numerous opportunities to use commuter rail and LRT creatively and effectively as the *regional rail* mode to serve medium and longer distance urban trips in additional places currently without rail transit.

What is suggested embraces the idea of *neo-traditional* town planning but at a metro scale, an overlay of transit-oriented communities on top of today's malignant auto-dominated sprawl. The goal is to provide a user-friendly alternative for those who would prefer to use transit, both choice and captive riders, initially fitting the system within the constraints of the existing urban structure, then gradually improving both the system and the portions of the urban area it directly serves to create a modern, convivial, interesting, human-scale city where people can live, work, relax and move about conveniently as they choose: by foot, bicycle, transit, and private car.