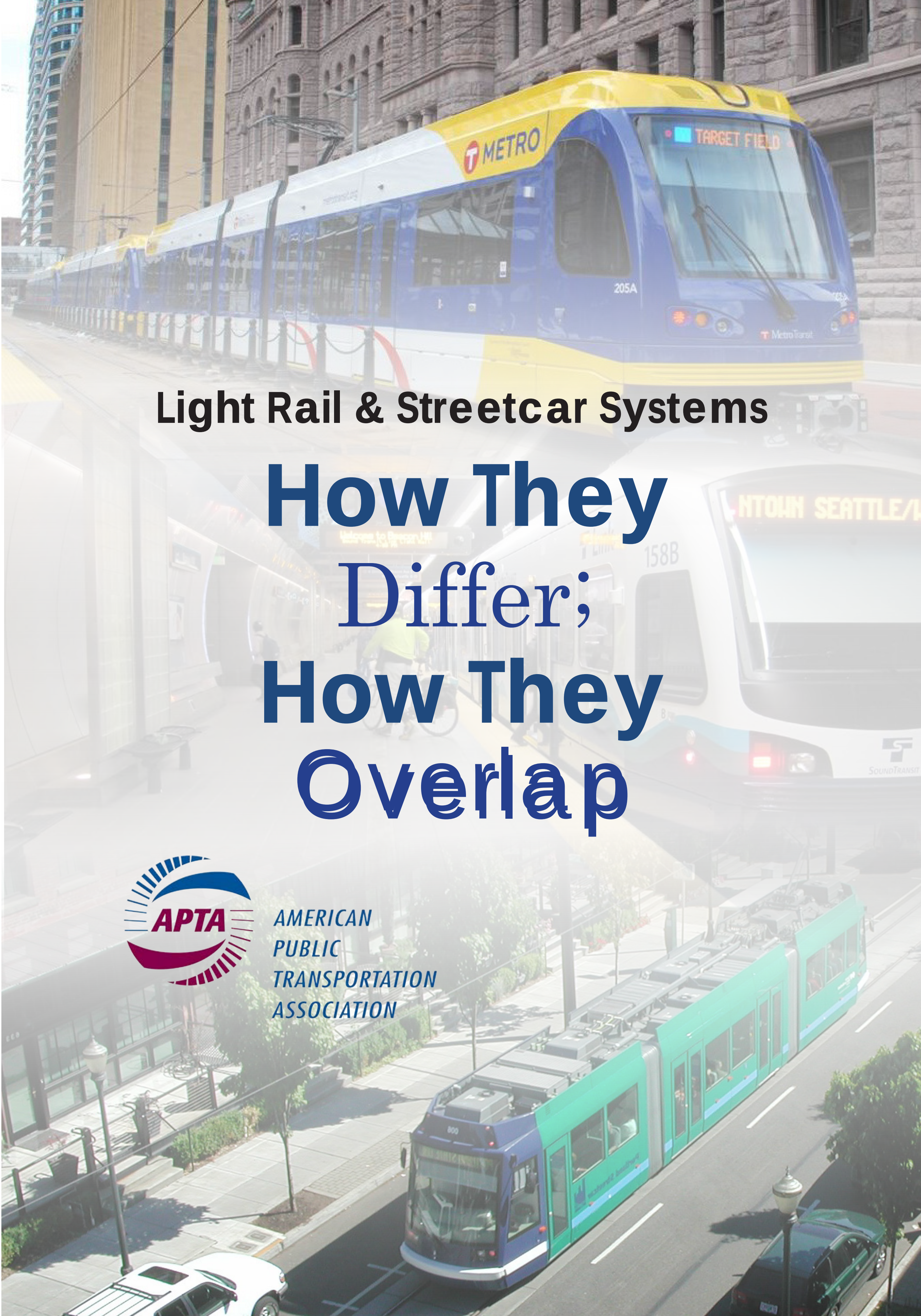

Light Rail & Streetcar Systems

How They Differ; How They Overlap

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AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

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This publication is a joint effort of APTA's Light Rail Technical Forum and Streetcar Subcommittee.

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Purpose

This brochure provides an easy-to-use guide that explains the typical characteristics of light rail and streetcar systems, highlighting what sets them apart and where the differences become fuzzy.

This is intended to be a useful tool for civic leaders and the general public as new transportation initiatives are being proposed in their communities, and for practitioners as they strive to explain these initiatives in broadly understandable terms.

Background

A century ago, cities throughout North America were laced with electric streetcar lines, while interurban trolleys connected cities with each other and outlying towns. (See Photos 1 and 2). This network began to shrink after World War I, and had disappeared almost entirely by 1960. That left only grade-separated rapid transit systems and commuter rail services in a few major metropolitan areas providing the bulk of rail travel in major corridors, while motor buses provided nearly all surface transit service. Los Angeles was the epitome of this transition, having dismantled a vast network of interurban and streetcar lines and converted to rubber-tired transit. A decade later, transportation leaders began realizing there was a gap in the nation’s transit capabilities. Something was needed that could offer improved passenger comfort at an affordable cost, with carrying capacities between the practical upper limits of buses and the much higher numbers required to justify building new rapid transit systems. The solution is what we now call Light Rail Transit.

In essence, surface electric railway technology that laid fallow for 70 years or so was updated and rebranded

1: Interurban service on the Liberty Bell Route of Lehigh Valley Transit; west of Philadelphia, PA; circa 1950

2: Streetcars on Market Street; Philadelphia, PA; circa 1905 as Light Rail Transit. APTA defined it as "operating passenger rail cars singly or in short trains on fixed rails in right-of-way that is often separated from other traffic for part or much of the way. Light rail vehicles are typically driven electrically with power being drawn from an overhead electric line, driven by an operator on board the vehicle, and may have level loading from high or low platforms, or low level boarding with steps."

The last four decades have seen a rebirth of interest and activity. Now, a variety of light rail systems serve regional travel and, in some places, city streetcar lines again serve as urban circulators.

By the mid-1970s, only nine metropolitan areas in North America were operating legacy streetcar or light rail systems: Boston, Cleveland, Mexico City, Newark NJ, New Orleans, Philadelphia, Pittsburgh, San Francisco and Toronto. Now, there are 22 completely new regional light rail systems and 10 new streetcar systems serving as urban circulators. These are listed in Tables 1 and 2, respectively. Most of the light rail systems continue to expand, and a few additional metro areas will soon be added to this list. Several new streetcar systems are expanding, and many new ones are in various stages of development.

This maturity has created some confusion as to what is light rail, what is a streetcar, and are they, in fact, one and the same. We hope to dispense with that confusion here.

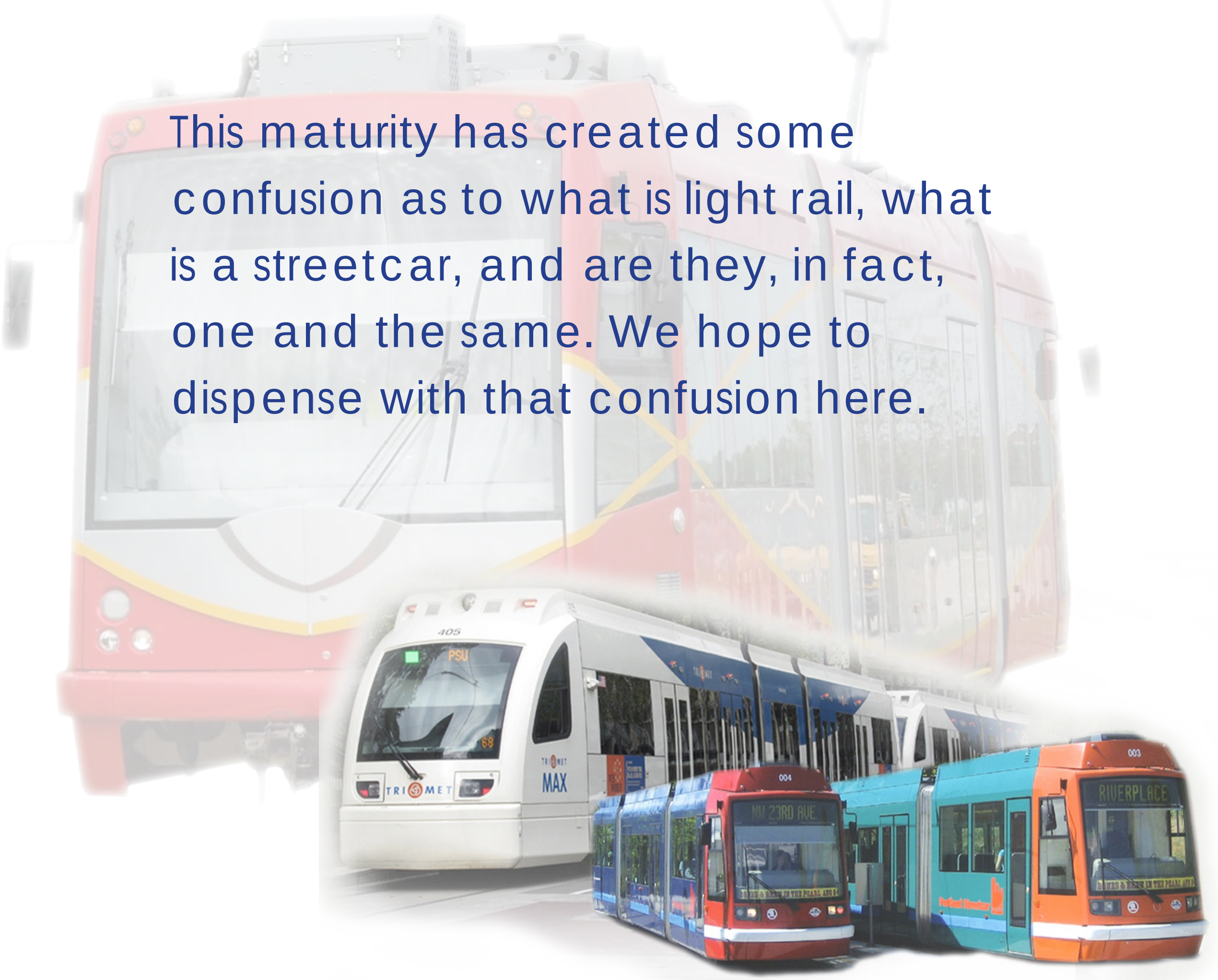

Table 1

New Start Light Rail Systems						
City	Opening Year	New Extensions			Route Length in Service mid-2014 (Mile/Km)	
		Built	Under Construction	Planned		
Edmonton	1978	✓	✓	✓	13.1	21.0
Calgary	1981	✓		✓	35.0	56.0
San Diego	1981	✓		✓	53.5	86.1
Buffalo	1985			✓	6.4	10.3
Portland	1986	✓	✓	✓	52.4	84.3
Sacramento	1987	✓	✓	✓	38.6	62.1
San Jose	1987	✓			42.2	67.9
Los Angeles	1990	✓	✓	✓	87.7	141.1
Monterrey	1991	✓		✓	20.0	32.2
Baltimore	1992	✓		✓	30.0	48.3
St. Louis	1993	✓		✓	46.0	74.0
Denver	1994	✓	✓	✓	48.0	77.2
Dallas	1996	✓	✓	✓	85.0	136.8
Guadalajara	1998	✓		✓	14.9	24.0
Salt Lake City	1999	✓			44.8	72.1
Jersey City	2000	✓		✓	20.6	33.2
Houston	2004	✓	✓	✓	12.8	20.6
Minneapolis	2004			✓	23.3	37.5
Charlotte	2007		✓	✓	9.6	15.5
Phoenix	2008		✓	✓	20.0	32.2
Seattle	2009	✓	✓	✓	15.6	25.1
Norfolk	2011			✓	7.4	11.9

Table 2

New Start Streetcar Systems						
City	Opening Year	New Extensions			Route Length in Service mid-2014 (Mile/Km)	
		Built	Under Construction	Planned		
Lowell	1984	✓		✓	2.0	3.2
Dallas	1989	✓	✓	✓	4.2	6.8
Memphis	1993	✓		✓	6.3	10.1
Kenosha	2000			✓	2.0	3.2
Portland	2001	✓	✓	✓	7.2	11.6
Tampa	2002	✓		✓	2.7	4.4
Tacoma	2003			✓	1.6	2.6
Little Rock	2004	✓		✓	3.4	5.5
Seattle	2007		✓	✓	1.3	2.1
Salt Lake City	2013			✓	2.0	3.2
Tucson	2014	✓			3.9	6.3
Washington, DC	2014		✓	✓	2.4	3.9
Atlanta	2014		✓	✓	1.4	2.3

Characteristics of a Rail System

As with any other transportation network, rail systems can be characterized and distinguished by the locations and markets they serve, how their infrastructure is configured, the types of vehicles they use, and how they operate. Let's see how they compare.

Location and Markets Served

Light Rail systems, by and large, have filled the gaps formerly served by interurban and suburban trolley lines. They generally provide regional service connecting suburban communities with central business districts, typically in the range of 15-20 miles, with stations spaced between a half-mile and a mile apart. A substantial number of passengers are workers and students, many traveling during weekday peak periods. In contrast, **Streetcars** largely serve as urban circulators. They connect neighborhoods and activity centers with lines that are about 2-5 miles long and have stops less than a half-mile apart. They serve some shorter commute and student trips, but are also heavily patronized throughout the day and on weekends by riders going shopping, keeping medical appointments, attending local entertainment venues, enjoying tourist attractions, and meeting other personal travel needs and preferences. They essentially provide travel that may be deemed a bit too far to walk and yet inconvenient to use a car. Indeed, Portland, Oregon's mayor refers to its streetcar system as a 'pedestrian accelerator' as it serves to speed and expand these local trips.

Using Portland as an example, Photo 3 is a map of the regional light rail system operated by the Tri-County Metropolitan Transportation District of Oregon, or TriMet. This system stretches radially 15 miles to the east of downtown, with several shorter branches emanating from it to the north and south, and 18 miles to the west. The newest line under construction extends southeast from downtown about 8 miles. In contrast, the Portland Streetcar shown in the map in Photo 4 operates in a loop configuration through the downtown and close-in neighborhoods, providing local circulation and intersecting with TriMet's light rail system at several locations.

3

Infrastructure

Infrastructure includes all the elements that comprise the physical features of a rail project. This includes the right-of-way, track, passenger stations or stops, the electric power supply to the trains, any signal controls needed to provide safe operation, the communications equipment used for train operation and for passenger information, and fare collection equipment.

Right-of-way is essentially the real estate the rail system occupies. **Light Rail** typically has dedicated rights-of-way, whether a totally separated strip of land or reserved space in streets. Dedicated routes may cross streets at grade, in tunnels, or on elevated structures. The routes may include extended tunnel sections through downtown. **Streetcars** typically occupy travel lanes in local streets and run with local traffic. (Photos 5 though 9 provide several examples of the foregoing).

Where ***track*** is located on separate rights-of-way, as is typically the case for **Light Rail**, it is usually composed of steel rails fastened to wood or concrete 'ties' supported on a

3: Light Rail system map; Portland, OR; Source: TriMet

4: Streetcar system map; Portland, OR; Source: Portland Streetcar, Inc.

5: Light Rail dedicated right-of-way; Charlotte, NC

6: LRT on aerial structure; Dallas, TX

7: Light Rail in tunnel; Seattle, WA

8: Streetcar in local travel lanes; Portland, OR

9: Light Rail in dedicated street lanes; Denver, CO

bed of crushed stone referred to as ‘ballast’. (See Photo 11). In some instances, the rails are embedded in concrete in lieu of ballast. The track for **Streetcars** is typically embedded in concrete or asphalt in the street surface, as shown in Photo 10.

Light Rail normally has highly developed ***stations*** with platforms sized to accommodate the longest trains. Platforms are outfitted with large canopies or shelters, seating, dedicated lighting, signage, and accommodations for communications and fare collection equipment. Light rail stations may also have large ‘park-and-ride’ lots or parking structures and bus transfer facilities. Two examples are shown in Photos 12 and 13. **Streetcar** systems typically employ sidewalk ‘stops’ much akin to bus stops, or mid-street safety islands. They often consist of a modest shelter, perhaps some seating, passenger information signage, and possibly some simple fare collection equipment. Illumination is provided mostly by nearby streetlamps. A typical streetcar stop is shown in Photo 14.

The elements of electric ***power supply*** for both light rail and streetcars are the same. Substations receive high voltage commercial alternating current (AC) electric power from the local utility and convert it to medium voltage direct current (DC). This DC power is distributed by overhead wires above the tracks and picked up by roof-mounted collectors on the rail vehicles, such as ‘pantographs’ or ‘trolley poles’. However, if you visualize a substation as an electrical

10: Streetcar track embedded in concrete in city street; Portland, OR 11: Light Rail track with rail on concrete ties and stone ballast; Dallas, TX
12: Light Rail high-level platform station; Los Angeles, CA 13: Light Rail low-level platform; Phoenix, AZ 14: Streetcar stop; Portland, OR

‘pump’ and the wire as the electrical ‘pipe’, this electrical equipment differs in robustness between the two applications. **Light Rail** normally operates long, high-performance rail vehicles assembled into multiple-car trains. **Streetcars** are usually shorter, operate as single units, and run at lower speeds. This translates to larger substations and more wire in the air and/or underground conduit for **Light Rail**, while **Streetcars** can usually operate with smaller substations and just a single overhead wire. These

15: LRT substation with architectural treatment; Portland, OR

16: LRT substation factory-assembled; Charlotte, NC

17: Streetcar substation factory-assembled; Portland, OR

18: LRT catenary overhead power supply; Portland, OR

19: Streetcar simple overhead power supply supported by span wire; Portland, OR

contrasts are illustrated by Photos 15 through 19.

Light Rail requires a ***signal system*** to maintain safe distance between trains and possibly control train speeds where it operates on separate right-of-way and usually at higher speeds and frequent intervals. In addition, traffic signals or crossing gates are required where light rail tracks cross streets. **Streetcars** operate with traffic on local streets and are subject to the same line-of-sight precautions, traffic signals, and rules of the road. In some cases, they may have some form of traffic signal priority or pre-emption at specific locations, such as turns at intersections. Some examples of these devices are included in Photos 20 through 23.

With long corridors, developed stations, and a higher capacity and frequency of service, **Light Rail** requires significantly more ***communications*** equipment. In addition to radio communication between the trains and a central control office, light rail stations employ passenger information signage, public address equipment, passenger emergency phones, closed-circuit television surveillance, and fare vending equipment. This equipment is linked by some form of communications line, such as a fiber optic cable, along the entire route. The station shown in Photo 22 has most of these features, although they are difficult to show. **Streetcars** also require a train radio system, but their stops are very simple, employing, at most, electronic 'next train arrival' signs and perhaps simple fare vending machines. Because the stops are essentially part of the sidewalk, they are highly visible and do not require dedicated communications and monitoring equipment. Again, think attractive bus stops. Photo 24 is an example of the extent of communication at a streetcar stop.


20


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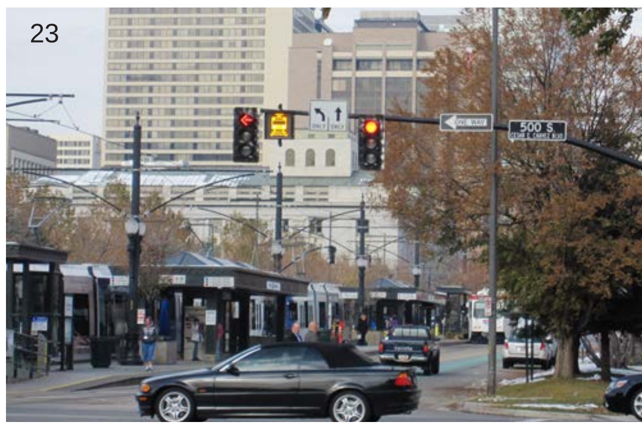

23

24


25

20: LRT grade crossing warning system; Charlotte, NC

21: LRT wayside signals and pedestrian crossing warning lights; San Jose, CA

22: LRT station with full array of communications and security devices; Houston, TX

23: LRT train warning sign for left turn lanes; Salt Lake City, UT

24: 'Next Train' arrival sign at streetcar stop; Portland, OR

25: Unique traffic signals for streecars; Seattle, WA

Fare Collection

Fare Collection on both light rail and streetcar systems is typically based on the 'proof of payment' approach where passengers are required to pay for their trips prior to boarding and are subject to spot checks by fare inspectors. Court-enforced fines are levied for those found to not have paid their fare. The difference in fare collection equipment between light rail and streetcar systems is the quantity, complexity, and location of the equipment. For **Light Rail**, as shown in Photo 26, ticket vending machines are usually full service devices, offering all forms of ticket types and means of fare payment. They are also geared to accommodate a high volume of transactions given the larger numbers and more intense concentration of light rail passengers. Stations are equipped with ticket vending machines near each access point, with at least two per station. **Streetcars**, however, cover shorter distances and have a simpler fare structure, such that ticket choices are fewer, and ticket vending machines are sized for fewer transactions. Typically, there is one ticket vending machine per stop. Some streetcar operators use sidewalk parking ticket vending machines for this purpose, similar to that shown in Photo 27, and supplement them

26: LRT full-service ticket vending machine and smart card reader; Minneapolis, MN

27: Simple ticket vending machine at streetcar stop; Portland, OR

28: Streetcar simple ticket vending machine on-board streetcar; Seattle, WA with small ticket vending machines on board the cars, as seen in Photo 28. Operators of vintage or vintage-look streetcars, which do not have enclosed driver's cabs, collect fares using a farebox, such as those on buses. And some streetcar operators provide free service and do not collect fares at all.

Vehicles

Differentiating between light rail vehicles and streetcars can be difficult because they share several common features. They use the same thoroughly proven electric railway technology; they are clean and quiet; they draw electric power from overhead wire; they have the ability to operate in a variety of alignment types; and they have level or near-level boarding capability for accessibility. What sets them apart is capacity and performance. **Light Rail** vehicles are typically longer (80-95 feet or more) and wider (8.75 feet or more), and provide seats and standing space to reasonably accommodate up to about 150-170 passengers. They are also limited to curves no tighter than about 82 feet in radius. In addition, they are capable of being linked into trains of up to four cars and designed to operate at maximum speeds up to 55-65 miles per hour. Two basic variations are shown in Photos 29 (high-floor vehicle) and 30 (low-floor vehicle).

By contrast, the **Streetcars** found in the US today include vintage/vintage-look

29: High floor light rail vehicles in 3-car train; Los Angeles, CA

and modern cars which are shorter (40-66 feet) and often narrower (8 feet), and, therefore, have lower capacity (roughly 70-120 seated and standing passengers). Typical examples can be seen in Photos 31 and 32. They also can negotiate tighter curves of as little as 60 feet in radius. However, the cars built for some legacy systems have to accommodate much tighter radius (36 feet) curves due to the geometry of their lines, which was set decades ago. In addition, streetcars are configured to operate as single units and designed to reach maximum speeds of about 35-40 miles per hour. Their smaller size and lower speed is largely dictated by the need to fit into city streets and run with urban traffic where higher speeds are not practical.

30: Low floor light rail vehicles in 3-car train; Minneapolis, MN 31: Modern low-floor streetcar; Tacoma, WA 32: Replica of vintage streetcar; New Orleans, LA

Now Comes the Fuzzy Part...

The foregoing descriptions illustrate that there are clear differences between light rail and streetcar applications. However, in looking at some of the light rail and streetcar systems that have been built recently, the boundaries between them are not crisp, but fuzzy. Here are a few examples:

Operating Environment

The operating environment is simply a function of the market, infrastructure, and vehicle configuration variations described above. So, **Light Rail**, which is focused on radial/regional trips, can be described as having partially exclusive right-of-way, running in multiple-car trains at reasonably high speeds, serving purpose-built stations spaced somewhat far apart. **Streetcars**, which provide local circulation in urban areas, can be described as operating smaller, single vehicles in mixed traffic on city streets at street speeds, serving sidewalk stops which are several blocks apart. Table 3 summarizes the comparisons we have highlighted here.

33: Light rail vehicle operating in mixed traffic on city street; Sacramento, CA

....when Light Rail does not look like or operate like Light Rail

In Sacramento, Regional Transit operates trains as long as four cars like streetcars in the downtown (Photo 33), where they run in mixed traffic at slower speeds (35 mph or less). But outside the downtown, they operate on largely dedicated rights-of-way at speeds reaching 55 mph and higher. Light rail or streetcar?

Other places where light rail systems act like streetcars, with some in-traffic street running, include a short segment in Salt Lake City and portions of varying lengths on legacy systems in Boston, Philadelphia, Pittsburgh, and San Francisco. Light rail or streetcar?

Table 3: Typical Characteristics of Light Rail Transit and Streetcar Systems

Characteristics	Light Rail	Streetcar
Location and Markets Served		
Route Orientation/Trip Type	Radial; connecting close-in suburbs w/ Central Business Districts	Local Circulation in urban neighborhoods
Trip Length	Up to ~20 miles	~1-2 miles
Infrastructure		
Right-of-Way	Mostly reserved right-of-way; some grade separation at major streets and arterials with tunnels and aerial structures; level crossings with street traffic	Operation in mixed traffic on urban streets
Track		
Maximum grades	7%	9%
Minimum curves	82ft (25m)	60ft (18m)
Composition	Rail on ties and ballast; embedded rail on dedicated trackway	Embedded rails in street surface
Utilities	Relocation usually required due to inability to easily shift the alignment, depth of trackway and conduit	Avoidance where possible; shallow trackway structure
Stations/Stops		
Size	Sufficient length for multi-car trains	Single-car length
Spacing	~0.5-1 mile (0.8-1.5km)	Several city blocks
Location	Separate, dedicated platform	Sidewalk extensions
Amenities	Park-and-ride, kiss-and-ride, feeder transit services, large shelters, seating, lighting	Pedestrian access, minimal shelter, minimal seating, nearby street lighting
Electric Power Supply		
Substations	Large substations (1-2MW) spaced about one mile apart, linked to utility medium voltage power grid Underground feeder/return cable typically required for length of line	Smaller substations (<1MW) spaced less than one mile apart, possibly able to draw from local commercial 480Vac Minimal underground feeder/return cable, typically between substation and nearest pole
Overhead Wire	Catenary structure with pole supports	Simple trolley wire with pole supports, span wire connected to poles on sidewalks or attached to adjacent buildings

Characteristics	Light Rail	Streetcar
Infrastructure (continued)		
Signals		
Safe Train Separation	Wayside or onboard signals on reserved right-of-way	Line of sight
Traffic Priority/Pre-emption	Grade crossing warning systems and traffic signals	Traffic signals where needed to protect conflicts with street traffic
Central Control	Train location, train routing, monitoring and control of equipment in the field (e.g., substations), station CCTV monitoring	Streetcar location display from external systems (e.g., NextBus); no remote monitoring or control of field equipment
Communications		
Operator/Dispatch	Radio system with consoles in Control Center	Radio channel on existing system, or cell phones
Passenger Information	Active signage, public address	Active signage
Passenger Security	CCTV, passenger emergency phones	Sidewalk line of sight
Networking	Communications trunk lines	Little or no trunk lines
Fare Collection		
Fare Media Sales	Full-feature ticket vending machines; sales outlets	Simple ticket machines at stops and/or onboard; onboard fareboxes
Fare Collection/Payment Enforcements	Barrier-free, proof-of-payment w/ inspection	Free fare; or operator-monitored; or barrier-free, proof-of-payment w/inspection
Modern Vehicles		
Length	80-95ft	66-80ft
Width	8.6ft (2.65m)	8-8.6ft (2.46-2.65m)
Maximum Speed	55-65mph (100-110kph)	42mph (70kph)
Trainability	Yes (couplers)	No (Towbars)
Vehicle Capacity (Seated/ Standees)	70/130	30/90
Operating Environment		
Average Schedule Speed	20-25mph	8-12mph
Train Length	Up to 4 cars	Single cars

34: Streetcar operating in dedicated right of way; New Orleans, LA

35: Streetcar operating in mixed traffic; New Orleans, LA

.... when a Streetcar does not look like or operate like a Streetcar

A major portion of the New Orleans Streetcar network, the oldest continuously operating system in the US, runs in dedicated right-of-way rather than in mixed traffic for much of its distance. (See Photos 34 and 35.) Streetcar or light rail?

The Utah Transit Authority (UTA) recently opened its Sugar House Streetcar line (now called the S-Line) using vehicles nearly identical to those that operate on its extensive light rail network. The streetcars run on what was once a freight branch line situated behind homes and businesses, both commercial and industrial. Running on dedicated right-of-way with no mixed traffic, as shown in Photo 36, is it streetcar or light rail?

The city of Atlanta has acquired some of these same vehicles, through UTA, that will run on its new streetcar system in the downtown. The system is planned to be extended to a corridor dubbed the BeltLine, a collection of former railroad freight lines which, when joined, form a ring around the city close to the downtown. While still in the planning stages, if the streetcars leave mixed traffic and turn onto the BeltLine right-of-way, do they lose their identity as streetcars and become light rail vehicles?

The city of Portland is well known for its regional light rail system operated by TriMet and its own downtown streetcar system. Light rail runs down its own lane on city streets, but at slow speeds and subject to the traffic signals that control roadway vehicles. The streetcars run in mixed traffic at similar slow speeds and are also subject to traffic signals. In the near future, light rail will extend to the southeast part of the region crossing over the Willamette River on a new transit-only bridge (Photo 37) ... the same bridge and on the same rail that the streetcars will use to complete a loop of the downtown.

36: Streetcar operating on dedicated right of way; Salt Lake City, UT

37: New bridge over the Willamette River that will carry light rail, streetcars, buses, bikes and pedestrians; Portland, OR

Conclusion

There are many examples that clearly illustrate how we have described light rail and streetcars, as well as the fuzzy middle. Hopefully, this brochure has been an aid in better understanding these two modes of rail transit and a recognition of their common features.

Perhaps the best conclusion from this information is that it is less important what you call a rail transit project than it is to understand what flexibility you have in making it work best for you in your community.

Credits

The primary authors of this document were Thomas B. Furmaniak, P.E., and John W. Schumann of LTK Engineering Services. The graphic design and layout was done by Alexis O'Rourke, also of LTK. Valuable critique and edits were provided by members of APTA's Light Rail Technical Forum and Streetcar Subcommittee.

The majority of the photographs in this publication were supplied by staff of LTK Engineering Services. By exception, others include:

Photo 1, Page 3: Seashore Trolley Museum
Photo 2, Page 3: www.shorpy.com
Photo 36, Page 19: Salt Lake City Corporation

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