
Rail Transit Systems Worldwide: Traffic Density & Related Statistics

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Abstract

The authors calculated annual traffic density statistics for all rail transport systems worldwide for which data could be obtained. Annual traffic density describes the number of passengers who, on average, travel over each kilometer (or mile) of system length. It is the product of annual ridership and average travel distance, divided by system length. Rail systems were classified as "Tramway, Light Railway and LRT" if compatible with operation on track built in streets and roads, or as "Metro and Suburban Rail" if not.

Public transport consumers in Africa, Asia, the Commonwealth of Independent States (former USSR), Eastern Europe and Latin America tolerate higher levels of peak-period crowding than elsewhere, leading to higher traffic densities. For this reason, the authors arranged each category of rail system into two groups, by country: 1.) Africa, Asia, CIS, Eastern Europe and Latin America, and 2) US, Canada, Western Europe and Australasia.

The compilation includes four groups of tables. Supporting information on background and methodology includes calculation and significance of annual traffic density, and organization and presentation of statistics. Subsequent sections provide supplemental information, references and appendices.

Introduction

This paper, together with accompanying tables and charts, is a revised, updated and expanded version of our comparison of rail systems in terms of annual traffic density. We have added "Metro and Suburban Rail" systems to the previous category "Tramway, Light Railway and LRT," and have also added systems in Africa, Asia, Eastern Europe, the Commonwealth of Independent States, and Latin America to the previous compilation including the US, Canada, Western Europe and Australia. Our primary goal is to share passenger traffic data related to urban and suburban transport.

We have corrected scattered typographical errors and moved a small number of operators from the "Tramway, Light Railway and LRT" category to the "Metro and Suburban Rail" tabulation. We have also added selected historic data, and have moved some of the supplemental information presented in earlier versions of this paper to appendices.

We shall update this tabulation periodically as additional information becomes available.

1) Grouping of Countries

Public transport consumers in Africa, Asia, the Commonwealth of Independent States (former USSR), Eastern Europe and Latin America tolerate significantly higher levels of peak-period crowding than their counterparts in other countries. As a consequence, annual traffic densities transported by tramway, light railway and LRT systems are significantly higher than may be observed elsewhere. For this reason, the authors have arranged the world's rail transport systems into two groups, by countries:

--Africa, Asia, CIS, Eastern Europe and Latin America.

--US, Canada, Western Europe and Australasia.

For the sake of brevity, the authors have labeled sub-Saharan Africa as "Africa," and North Africa and Southwest Asia as "Middle East." "CIS" refers specifically to the members of the Commonwealth of Independent States: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. "Eastern Europe" includes Estonia, Latvia and Lithuania (which are not members of the CIS), and Turkey (a candidate state for accession to the European Union).

Consumers in urban regions where private automobiles are relatively common are not likely to tolerate the levels of crowding that may be observed in regions where private autos are relatively scarce. Consumers outside the US, Canada, Western Europe and Australasia might become less tolerant of such crowding as personal income levels increase and private autos become more common.

2) Presentation of Data and Statistics

The authors have prepared four sets of tables:

Africa, Asia, CIS, Eastern Europe and Latin America.

Table 1: Tramway, light railway and LRT systems.

Table 2: Metro and suburban rail systems.

US, Canada, Western Europe and Australasia.

Table 3: Tramway, light railway and LRT systems.

Table 4: Metro and suburban rail systems.

Links are listed under each table heading, grouped alphabetically by city.

The primary characteristic used to distinguish "Tramway, light railway and LRT" from "Metro and Suburban Rail" was compatibility with operation on track built in streets and roads. See Sections 6-8 below for additional details.

The abbreviations "met" and "rly" were used to distinguish between urban metro and suburban rail networks in cases where operator titles create ambiguities. The abbreviations "AGT," "fn" and "mo" were used to distinguish automated guideway transit lines, funicular railways and monorails, respectively.

Data are summarized in Table 1-4, with operators arranged alphabetically by city, and grouped in one file with other cities, following the convention shown on the links page. Cities are arranged according to English alphabetical order, by prevailing local spelling. To expedite use of "find" or search functions, common English spellings have been entered (e.g. "Cologne" together with Köln) in small type, together with names spelled without diacritical marks (e.g. Malaga together with Málaga).

Implied conversion factors between metric and customary (US) units of length do not always coincide because of rounding.

See Appendix 1 for International Organization for Standardization (ISO) country codes. For operator titles, see Appendix 2 (countries other than Switzerland) or Appendix 3 (Switzerland).

3) Annual Traffic Density: Definition, Calculation, Relevance

"Annual traffic density" describes the number of passengers who, on average, travel over each kilometer (or mile) of system length during the calendar (or fiscal) year. It is the product of annual ridership and average distance traveled by each passenger (ATD), divided by system length. It may be calculated in straightforward fashion:

$$(\text{annual ridership} * \text{ATD}) / \text{system length}.$$

The authors have chosen to present annual rather than "weekday" or "daily" traffic density statistics in order to account for all ridership.

Annual traffic density may also be calculated using annual passenger-km / passenger-mile statistics, if available. These are simply divided by system length to determine annual passenger-km / mi of route.

If ATD or annual passenger-km / mi statistics are not available, average travel distance may be estimated from other statistics. Detailed explanation is here:

<http://www.publictransit.us/ptlibrary/TrafficDensityPrimer.htm>

. . . allowance must be made for the difference in length of haul [i.e. average travel distance], as with a shorter haul more passengers per mile can be carried (Taylor 1913).

It is essential to understand that 5 million passengers per year, ATD 10 km, represents exactly the same nominal "workload" as 10 million passengers per year, ATD 5 km. The latter scenario may require relatively more service (annual vehicle-km) because longer ATD implies greater time on board vehicles. Transport consumers traveling longer distances may be less willing to tolerate peak-period crowding, and less willing to travel as standing passengers, than those traveling longer distances. Implications for transport planning should be clear.

Annual traffic density is not a "fixed" characteristic of a transport service, but may change significantly given fluctuations in passenger traffic and ATD. It may also change significantly with expansion or contraction of system length. The annual traffic density statistics presented below

should therefore be interpreted with care; e.g. small differences are not likely to have much significance. Many "suburban" ("commuter") rail services share tracks with long-distance services. In most cases, the "long-distance" share of "total" traffic density is not considered.

Comparisons between lines, operators and cities based on annual traffic density can be useful, but should be interpreted with care. The authors emphasize that the caveats above apply in addition to crude annual passenger traffic statistics (e.g. "boardings," "passengers").

4) Annual Traffic Density: World Records

The 123.1-km / 76.3-mi Western Railway (WR) line extending north from Churchgate terminal, Mumbai (Bombay), India, is believed to carry the greatest traffic density of any individual passenger rail line in the world. Electric multiple unit (EMU) formations ("rakes") are 9 or 12 cars long, the maximum service frequency is 1.8 minutes, and the number of daily services exceeds 900. Nine-car trains carry as many as 4,500 passengers during peak periods, nearly four times the stated "capacity" of 1,170 passengers per train. This line accounts for 33 percent of the Mumbai suburban system length and 2.6 million passengers per day, or 41 percent of the total of 6.4 million suburban rail passengers per day. The busiest segment, 60.6 km / 37.6 mi between Churchgate terminal and Virar, carries almost 900 million passengers per year; the annual traffic density is about 255 million passenger-km per km of route.

The IRT Lexington Avenue Line, New York City, is believed to carry the greatest traffic density of any individual metro "line" in the world. The Lexington Avenue Line extends currently from Bowling Green to 125th Street, 14.0 km / 8.7 mi. Trains are 10 cars long. The maximum service frequency is 2-3 minutes on the express tracks (services 4 and 5) and 2-4 minutes on the local tracks (service 6). Average weekday ("daily") passenger traffic (ca. 2005) is stated at 1.3 million, "about 338 million annually." Annual traffic density is about 155 million passenger-km per km of route.

5) Classification: "Tramway, Light Railway and LRT"

"Light Rail Transit" or "LRT," at least as this term is used in the US, implies compatibility with operation on track built in streets and roads. However, no clear distinctions can be made among the categories "tramway," "light railway," "light rail transit," "metro" and "suburban rail." No such distinctions can be applied uniformly to all countries.

In some countries, visible technical distinctions between "tramway and light railway" and "metro and other railway" are subtle; this is true in particular of Japan and Switzerland.

Formal and legal distinctions between the above may vary considerably between countries – and strict adherence to these would lead to absurd results. To give one example: the Ôsaka metro network was built under a "tramway" concession ("license"); all other Japanese metro networks were built under "railway" concessions.

In some countries (e.g. Italy, Spain), railways built and operated independently of state-owned networks are sometimes classified as "light railway" rather than "suburban rail." Today, most such lines have few "light railway" characteristics.

The problem of distinguishing between "Tramway, Light Railway and LRT" and "other" rail transport appears likely to increase given the popularity of "Tram-Train" or "Karlsruhe Model" LRT strategies.

The authors wish to present all available data in a reasonably "user-friendly" manner. Doing so requires some degree of flexibility. For example, the NICTD line between Chicago and South Bend was built as an "interurban electric railway" but has few remaining "light rail" characteristics. To avoid arbitrary separation of "historic" and "current" data into different tables, the authors classified the "South Shore Line" as "Tramway, Light Railway and LRT."

6) Classification: “Metro and Suburban Rail”

The term *Metro* is "a synonym all over the world for many different kinds of urban rail transport systems" (Schwandl). This was adapted in somewhat roundabout fashion from the company title of the world's first underground railway, the Metropolitan Railway (London, 1863). The first metro line in Paris was operated by *Compagnie de Chemin de Fer Métropolitain de Paris* (CMP). The famed Art Nouveau station entries, designed by Hector Guimard, feature the bold lettering "METROPOLITAIN." These perhaps inspired the popular name among Parisians for the new underground railway: *le Métropolitain*, soon shortened to *le Métro*.

Within the "Metro and Suburban Rail" category, the distinction between urban metro ("heavy rail," "rapid transit" or "subway") and suburban rail ("commuter rail" or "regional rail") services is not always clear. Certain "suburban" or "regional" systems closely resemble urban metro lines. Examples include the Berlin and Hamburg *S-Bahn* networks, and the "es-

established" private-sector railways serving large Japanese conurbations. The distinction between "light railway" and "suburban rail" is also not always clear in certain countries, e.g. Spain. The authors chose to present all available data, including all US and Canadian "commuter rail" operations, rather than attempt arbitrary classifications.

The German term *S-Bahn* (abbreviation for *schnellbahn*; "fast railway") refers to urban and suburban networks operated over dedicated infrastructure using dedicated stock. The "classic" Berlin and Hamburg networks use third rail current collection and stock resembling metro vehicles. These were developed by the national railway administration but have since been spun off. Other *S-Bahn* networks use overhead current collection and have a more "suburban" character. In the former *Deutsche Demokratische Republik* (DDR, "East Germany"), the *S-Bahn* label was applied in several cities to services that had few "S-Bahn" characteristics.

The distinction between "metro" and "other" is not necessarily determined by street track – or lack thereof. Apart from historic examples (e.g. New York, Wien), metro stock may be observed in operation on street track in two Japanese cities: Ôtsu (east of Kyôto) and Fukui (on the central Sea of Japan coast). At Ôtsu, Keihan Electric Railway Keishin Line trains work through to central Kyôto on metro Tôzai Line tracks. The Keishin Line has 0.8 km / 0.5 mi of street track in central Ôtsu. The four-car formations of metro-type stock used here are 66 meters (216 ft) long, considerably greater than the 30 m / 98 ft permitted under a 1921 law regulating street tramway operation. These trains operate over the Ôtsu street track under special license granted by the ministry responsible. At Fukui, the Fukui Railroad Co., Ltd., operates a small number of ex-Nagoya metro cars equipped with folding steps for operation on street track.

7) Classification of Rail Transport: “Additional Information”

The authors have grouped all fixed-track urban and suburban passenger transport facilities, not classified as "Tramway, Light Railway and LRT," into the "Metro and Suburban Rail" category. However, as noted above, the distinction between the categories "Metro and Suburban Rail" and "Tramway, Light Railway and LRT" is not always clear.

In Spain, broad-gauge (1,668mm / 5' 5½") lines are operated by RENFE. Standard-gauge (1,435mm / 4' 8½") and meter-gauge (1,000mm / 3' 3¾") lines are operated by other undertakings (e.g. Euskotren, FEVE, FGC, FGV). Non-RENFE lines are sometimes classified as "light rail-

ways" for historic reasons but most have few "light railway" characteristics. We have chosen not to follow this pattern rigidly in order to avoid arbitrary division of the "regional railway" networks serving several cities into "divisions" listed in two separate tables.

Most Italian concessional (*ferrovie concesse all'uso privato*; i.e. "private") railways have few "light railway" characteristics. Non-FS lines using electric traction are sometimes classified as "light railways" but those using diesel traction are seldom classified in this manner. As above, we have chosen not to adhere rigidly to this pattern.

Swiss concessional railways vary significantly in character. Some are very much "light rail transit" in character, while others have few "light railway" characteristics. Persons so inclined might spend considerable time categorizing these railways, e.g. as "LRT" and "non-LRT." We have chosen in general to tabulate Swiss railways not operated by SBB as "light railways" – but did not adhere rigidly to this pattern. We have made several exceptions based on technical compatibility and integration of operations with SBB (BLS and subsidiaries BN, GBS and SEZ, RM predecessors EBT, SMB and VHB, all now merged into BLS; BT and SOB, now merged; MThB and STB).

The authors chose to classify Japanese railways into the categories "Tramway, Light Railway and LRT" and "Metro and Suburban Rail" based on current operations and historic factors.

Monorail lines were tabulated together with "Metro and Suburban Rail" systems because monorail technologies are inherently unsuited to ground-level operation in streets and roads.

"Rack and funicular railways" obviously have little in common with "metro" or "suburban railway" networks but are generally not "compatible with in-street operation." For this reason, most rack and funicular railways were tabulated together with "Metro and Suburban Rail" systems. Exceptions were made in cases of lines operating in public streets or roads, e.g. the Lisboa (PT) street funiculars.

The authors chose to reclassify a small number of systems, tabulated previously as "Tramway, Light Railway and LRT," into the "Metro and Suburban Rail" category based on current scope of operations and historic factors. The Docklands Light Railway (London, GB) provides one example. This system is not compatible with "in-street" operation because of third-rail current collection and nominal driverless operation. It is therefore better described as a "light metro." The initial build of rolling stock was sold to Essen (DE) where it operates on *Stadtbahn* lines using overhead current collection. However, this does not influence the classification of DLR itself as

a "light metro" and therefore something that does not "fit" into the category "Tramway, Light Railway and LRT."

As noted above, the authors' primary goal is to share passenger traffic data related to urban and suburban transport. The authors believe that slavish adherence to rigid, inflexible classification of fixed-track urban and suburban transport, e.g. as "LRT" and "other," would tend to impede this effort. In addition, the authors prefer to err by inclusion rather than by exclusion. Public lifts (elevators), for example, are relatively rare but do exist; Genova (IT) has ten and the oldest dates to 1929. If we had passenger traffic data on hand, we would not fail to share it.

The authors have also chosen to include data for selected guided-bus and busway systems.

8) Annual Ridership Statistics

The "passenger" counts and statistics reported by many public transport operators worldwide pertain to "boardings" (also known as "unlinked trips"). An individual is counted as a "passenger" upon boarding a vehicle; therefore, an individual who changes ("transfers") once between vehicles during the course of a journey is counted as two "passengers." Other undertakings report "passenger trips" or "passenger journeys" (also known as "linked trips"). Traditional US (and Canadian) practice used the term "revenue passengers" (as distinguished from "transfer passengers").

The authors have attempted to use "boardings" as the consistent measure of "passenger traffic." Doing so is straightforward with reference to small metro and regional rail operators. In some cases, it is not clear whether operators of large, complex metro and regional rail networks attempt to account for changes between vehicles. For operators (e.g. the Toronto Transit Commission) that report "revenue passengers" explicitly, data have been adjusted to account for passengers who transfer between vehicles. The authors have done so to provide conformity with data from other cities. The authors also note that this issue need not affect passenger traffic *density* calculations, for these are based on passenger-kilometer statistics that are reported separately.

Many German operators report passenger and passenger-km data for all modes combined, but report vehicle-km data for each mode. This makes it possible to estimate modal shares of annual passenger and passenger-km (the ratio of passenger-km to vehicle-km for each mode cannot be impossibly high nor implausibly low). In these cases, "Annual Passengers," "Annual Passenger-km" and "Annual Traffic Density" statistics are presented to a single significant digit.

Some Swiss operators report annual passenger and passenger-km data for all divisions combined. In these cases, annual passenger and passenger-km shares were estimated based on historic data and information contained in annual reports.

Comparisons among systems, and comparisons among data from different years for the same system, should be undertaken with care. Some degree of uncertainty is associated with the statistics (e.g. system length, annual passengers) used to calculate annual passenger traffic density - and therefore with the calculated statistics. In terms of percentage differences, the authors suggest 15-25 percent as the (flexible) threshold of significance. A higher threshold might be appropriate when making comparisons among cities in different countries.

Readers are advised that local and national factors may give rise to significantly greater public transport ridership in some cities than in others with similar population (and employment) levels. In France, for example, the ratio of annual total to average workday ridership is significantly less than the 1 / 300 that is typical of US cities. This, the authors believe, reflects the fact that many people in France take month-long vacations during August. Another well-known factor in Southern European countries (e.g. Spain, Italy), and also México and other Latin American countries, are closures of most offices and businesses during early afternoon. In Spain, *la siesta* extends by tradition from about 1300 to 1700; businesses then reopen until about 2000. This gives rise to four workday peak travel periods in cities such as Madrid, which in turn creates higher ridership and traffic density than would occur otherwise. The Spanish *siesta* tradition has declined in recent years because of suburbanization (which makes impractical the traditional trip home for lunch) and economic changes, and at the beginning of 2006 the Spanish government replaced the long *siesta* break with an hour-long lunch for government employees. The authors emphasize that "siesta" is by no means a "southern European" or "Latin" tradition; many shops and businesses in Switzerland close for a two-hour lunch break during the early afternoon, and this is certainly a factor in the very high levels of public transport ridership characteristic of Zürich and other Swiss cities.

Readers are advised in addition that apparent changes in ridership over time might reflect factors other than changes in the actual number of passengers carried. For example: in Philadelphia, a share of the decline in public transport traffic recorded post-1956 occurred as the result of an increase in fraudulent travel. As explained to the authors by Edson L. Tennyson, PE (former Transit Commissioner, City of Philadelphia and former Deputy Transportation Secretary, Commonwealth of Pennsylvania), drivers or conductors had to collect the proper fare from each passenger, and had to make good any shortage at the end of each workday. Then, following a change of management in 1955, the company installed locked fareboxes on its vehi-

cles, forbade operating staff from handling money, and discouraged staff from arguing with passengers over fares. Result: some passengers found they could "get away" with paying less than the full fare - and did so in sufficient numbers to cause a 14 percent decline in receipts. Reported passenger traffic also declined, because this was estimated from receipts.

9) Scope and Topicality

The authors have tabulated all tramway, light railway, LRT, metro and suburban railway systems currently in operation, under construction or in planning. Tabulation of rack and funicular railways was, in general, limited to those for which the authors could locate passenger traffic data.

"Intramural transport systems," e.g. airport circulator systems, were excluded from this tabulation because they do not serve a "public transport" function. However, if we had passenger traffic data on hand, we would not fail to share it.

The authors have not attempted exclude systems, licensed, regulated and operated as "public" transport facilities on grounds of domination by excursion ("tourist") traffic. A few long-established systems serve areas with no resident population, e.g. the *Jungfraubahn* (CH). Inclusion of the *Jungfraubahn* in this tabulation has been criticized as inappropriate. Similar arguments might also be advanced with reference to certain Austrian and German railways worked by steam traction, certain Swiss funiculars and most Austrian funiculars. However, these systems are licensed, regulated and operated as "public" transport facilities and do not function as "intramural" transport services. Again, our primary goal is to share information.

The historic data presented in this tabulation, although extensive, are very much a "convenience sample," selected from data on hand or conveniently accessible. The authors attempted to include a variety of countries, regions and system lengths, but did not attempt to secure historic data for "all" systems in any geographic region.

In general, passenger traffic data are the most recent available, and pertain to the year(s) specified, whether fiscal year or calendar year.

Data for many tramway systems in CIS countries (former USSR) are from the immediate post-Soviet period. Readers are advised that many such systems have experienced precipitous declines in traffic, and (less frequently) in route length from the early 1990s.

Population data are specific to transit service areas for Canada, Germany (*Einwohner im Verkehrsgebiet*) and the US. For other countries, the most recent data for regional or urban population was used as appropriate.

Bulgarian, Czech, Greek, Latvian, Slovak and Slovenian "regional" populations are those for "regions." Croatian, Estonian, Hungarian, Lithuanian and Romanian "regional" populations are those for "counties." French "regional" populations are those for *agglomérations*. Korean (KR), Polish and Turkish "regional" populations are those for "provinces." The Ljubljana (Slovenia) "regional" population is that for the "statistical region." The Skopje (Macedonia) "regional" population is that for the "municipality."

The population statistics presented for Chinese cities distinguish between the urban area proper (市区, *shìqū*) and administrative divisions which include a primary urban core and surrounding rural areas, villages and towns. China has nearly 300 "prefecture-level cities" (prefecture-level municipalities, 地级市, *dìjí shì*). Of these, 15 are "sub-provincial cities" (sub-provincial municipalities, 副省级城市, *fù shěngjí chéngshì*) having substantial autonomy. In addition, four Chinese cities - Běijīng 北京, Chóngqìng 重庆, Shànghǎi 上海 and Tiānjīn 天津 - are "municipalities" (直辖市, *zhíxiáshì*, "direct-controlled municipalities"). These are not part of adjoining or surrounding provinces. The land area administered by each municipality is much larger than the urbanized area proper. This is true in particular of Chóngqìng. Most population statistics for China are for 2004.

Significant uncertainty is associated with population statistics for Chinese provinces and major cities, because these are exclusive of "migrant workers." Throughout China, an estimated 200 million people (15 percent of the population) live away from the areas where they are registered officially. Migrant workers (e.g. persons without residence permits) make a considerable portion of the "actual" population of large cities; e.g. Běijīng (1 million, estimate) and Guǎngzhōu (5 million, estimate).

Station names, where stated, were those current at 2008 February. Sources consulted by the authors do not agree on how the names of various railway stations and terminals in Russia should be written in languages other than Russian. Names and spellings used by JSC "Russian Railways" were consulted by the authors as the primary reference.

10) Swiss Light Railways

It is ironic that, among existing light railways with the lowest relative traffic densities, most are found in Switzerland. This nation is widely recognized as having the best, and most successful, public transit networks in the Western world (e.g., excluding Asia, former USSR and former Communist countries in Eastern Europe, and the "Third World"). An additional irony is that Switzerland is among the most affluent nations on the planet, and has no cities larger than Zürich (approximately 360,000 in the City proper and about 560,000 in the local transit service area).

It should be noted that Swiss concessional railways, although organized along the lines of for-profit enterprises, are owned and financed typically by cantonal and local authorities. Many, probably the large majority, have little if any true "private-sector" investment.

The authors believe that many Swiss communities have chosen to subsidize light railways in order to avoid expenditures for road improvements, land-acquisition and tunnel construction costs in particular. Environmental factors are also significant.

Population data and links to various information sources for Swiss concessional railways are presented in Appendix 3. The "percentage of operating receipts" statistics refer to income from fares, baggage charges, freight charges, and so forth, and are exclusive of subsidies.

At the time of compilation, the authors did not have complete data for Swiss light railways, for years prior to 1940, on hand. However, primary source documents for 1940 do present annual traffic data for 1910, 1920 and 1930. The authors decided to present these statistics to give some idea of the evolution of passenger traffic pre-1940.

11) Japanese Railway and Tramway Operating Data

Japanese provincial railways and tramways are listed under the city or town stated as the location of the company head office. In some cases, this does not correspond to the name, or location, of the JR connection. The authors have added notes as appropriate so that readers may locate these systems without undue difficulty.

Sources consulted by the authors do not agree on how the names of various railway stations and terminals in Japan should be written in languages other than Japanese.

The authors have not included operating data such as annual vehicle-km because such information is generally available from other sources. We have, however, made an exception for various Japanese systems because such data are not widely available for many operators in English.

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