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The Role of Public Transportation in Hamburg, Germany

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Abstract
Hamburg is making serious efforts to solve the transportation problem, common to most European cities-how to provide facilities to meet the rapidly increasing requirements of modern transportation and, at the same time, preserve the city's values by maintaining historic and other buildings, structures, and, particularly in the central area, its character. Being a large and relatively rich city with progressive ideas, Hamburg has accomplished some remarkable achievements in this field. The purpose of this article is to delineate some of those achievements, particularly in public transportation.

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The Role of Public Transportation in Hamburg, Germany

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Mr. Vuchic has been active in traffic and transportation engineering in the United States since 1961. He holds a diploma in Traffic and Transportation Engineering from the University of Belgrade, Yugoslavia. He was Planning Engineer with the Hamburger Hochbahn AG, and visited transit companies in many large European and American cities. He has published technical papers in Yugoslav traffic journals. He is a member of the International Union of Public Transport, Brussels, and of the Association of Traffic Engineers and Technicians of Yugoslavia.

HAMBURG is making serious efforts to solve the transportation problem, common to most European cities—how to provide facilities to meet the rapidly increasing requirements of modern transportation and, at the same time, preserve the city’s values by maintaining historic and other buildings, structures, and, particularly in the central area, its character. Being a large and relatively rich city with progressive ideas, Hamburg has accomplished some remarkable achievements in this field. The purpose of this article is to delineate some of those achievements, particularly in public transportation.

The comparison of the traffic conditions, trends and transportation policies in Hamburg with comparable cities in the United States, interesting as it is, could not be covered here. An effort has been made, however, to incorporate the basic data for Hamburg necessary for such a comparison, so that the reader will easily find similarities and dissimilarities between the developments in Hamburg and in its American counterparts.

West Germany has a population of 54 million and an area of 96,000 square miles, i.e. an average population density of 563 persons per square mile. In view of this high density, it is not surprising that West Germany has a considerable number of cities, most of which are usually classified as “medium cities.” Only three cities have populations over one million: Berlin (2,202,000,¹ not includ-

¹. As of December 31, 1960.
ing East Berlin with 1,100,000), Hamburg (1,837,000), and Munich (1,101,000). Nine cities have populations between 500,000 and 1,000,000 and 41 cities between 100,000 and 500,000.

Two cities, Hamburg and Bremen, have the status of federal states in the German Federal Republic. Both have some of the largest harbors in Europe and have long history and tradition; both are very proud of their status among the ten states and of their title, "Hansestadt," which they have retained for centuries.²

Located in North Germany on the river Elbe, some sixty miles south-east of its mouth into the North Sea, Hamburg holds a key position in the networks of nearly all modes of transportation in that part of Europe. It has many connections with various overseas countries. Its activities, the harbor activities in particular, bring considerable income, so that the city, being a state unto itself, is in a better financial position than most other German cities.

Hamburg has an area of 290 square miles. With a population of 1,848,000,³ it is comparable to Cleveland, Pittsburgh, or Washington, D.C., and has an average density of 6,400 persons per square mile.

Due to its location on the river and its widely spread harbor, Hamburg has developed asymmetrically in relation to its downtown. Its central district has a semicircular form with a base on the river Elbe to the south. This semicircle was formed originally by the city wall, which existed until 1818. With its removal, the city began to spread in three directions. The present road network clearly forms a radial pattern toward north, east, and west. Immediately north of the central business district there is a lake—Alster—which is divided in two parts by two parallel bridges, one of which is a part of the former wall line. South of the Elbe are the former independent towns of Wilhelmsburg and Harburg.

GENERAL TRAFFIC CONDITIONS AND TRENDS

The first steps which had to be made toward reviving traffic in Hamburg after the war, as in most other destroyed cities in Germany, were to repair transit vehicles and clear the streets for traffic. In a short period of time, however, street traffic intensified, and the

² The official name of Hamburg is "Free and Hanseatic City of Hamburg."
³ As of December 31, 1961.
first traffic problems appeared: frequent congestion, insufficient parking, low speeds, and, consequently, decreased efficiency of transit services.

Any major reconstruction in older, densely built European cities with many valuable buildings presents a difficult problem. At the end of the war, however, many German cities were in a unique position. Complete sections were torn down and planning could start nearly from the blank maps. This opportunity was not equally used by all cities.4

Hamburg is making great efforts to compensate for a somewhat late start in the post-war planning and to keep abreast of increasing traffic requirements. At present, its traffic situation is similar to the situation in other German cities, though the problems are of greater magnitude due to its larger size.

Traffic and Parking. During peak hours and frequently on peak shopping days, street capacities are inadequate for the present volumes of motor and pedestrian traffic. A number of narrow streets, particularly in the central area with large pedestrian concentrations, mixed traffic, and many construction works all contribute to congestion and delays which sometimes last in the busier streets for ten, twenty, or even thirty minutes. The scheduled speed of surface transit vehicles, around 13 mph, drops during the peak hours to around 6 mph in the city center.

About 220,000 persons, or every fourth person employed in the city, work in the central business district. During the peak hour 73 percent of them enter the area by public transportation, 11 percent come by car, 6 percent ride motorcycles or bicycles and 10 percent walk. The number of parking spaces in this central area in 1958 was 13,600, of which 2,300 were in the three parking garages and 2,500 were curb spaces. The remaining spaces were in public, private, and temporary lots.

Efforts toward improving this situation are continuous. Many

4. Hannover was one of the cities which knew how to use this opportunity. Plans were made for wide, divided arterials, adequate intersections, maximum possible separation of public transportation vehicles from other traffic, sufficient space reserves and possibilities for further increase of capacities and construction in stages. Today, Hannover is often taken as an example of a city with modern and well-planned traffic facilities. Some other cities, however, did not take full advantage of the post-war situation. Transportation planning began several years later and, due to this time-lag between developments and planning, those cities are not in a much better position today than many other old European cities.
existing arterials are being reconstructed and new ones constructed. Methods and devices for traffic regulation, already very modern, are constantly being improved. New parking facilities will be provided to the ultimate goal of 25,000 spaces in the central area. Plans are to increase the capacity of garages to approximately 10,000 and reduce curb parking to 1,000. Most of the other additional capacity will be provided immediately outside the limits of the downtown area.

The policy of the city is to encourage short-time parking (mostly business trips) and discourage long-time parking (work trips) in the central area. Parking rate structure is therefore progressive: DM 0.20\(^5\) for the first hour, DM 0.30 for the second, and DM 0.50 for each additional hour without maximum limit.

Public Transportation. Developments since the war have had a considerable influence on public transportation in German cities. The position of operators has become more difficult than before. The increase of private transportation has resulted in diversion of transit patronage. The traffic situation has deteriorated with street congestion and reduced speeds of both public and private vehicles. In addition to higher operational costs due to lower efficiency, labor cost has been rising steadily. There has also been a labor shortage, further complicating maintenance of regular services.

Both traffic experts and city authorities in Germany realize that one of the most efficient ways of providing good transportation and preventing an increase of traffic congestion in the central sections of cities is modern and reliable public transportation. Though certain differences in opinion naturally exist, the basic idea of the need to improve public transportation systems is generally adopted. Due to this policy, public transportation has not been allowed to deteriorate. On the contrary, parallel with comprehensive improvements for the steadily increasing automobile traffic, public transportation is being constantly modernized. At present, public transportation systems in West German cities are some of the most modern in the world.

As in most other European countries, the backbone of transit systems in large and medium-size cities in Germany are rail vehicles. They have proved to be most efficient for the main lines with high

\(^5\) One German Mark (DM 1.00) is approximately equal to $0.25.
passenger loads. Their high transportation capacity, minimum space requirement for their way, easier separation from other traffic and lower cost per passenger mile on the main lines represent considerable advantages over other forms of transport. Rail rapid transit systems are being extended in Berlin and Hamburg and planned in Munich, while all medium-size cities plan to improve street cars and raise their service on the main lines to a level of semi-rapid transit. Wherever possible, they run on their own private right-of-way, and several cities plan to put them in subways in the central areas. Rail lines are supplemented by buses and (to a smaller degree) by trolley buses.

**TABLE I—SUMMARIZED STATISTICS OF PUBLIC TRANSPORTATION IN WEST GERMANY AND WEST BERLIN***

(1961, or on 31 December 1961)

<table>
<thead>
<tr>
<th>Form of Transportation</th>
<th>Total Length (miles)</th>
<th>Number of Vehicles (miles)</th>
<th>Vehicle Miles Run (millions)</th>
<th>Persons Transported (billions)</th>
<th>Vehicle Capacity (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail Rapid Transit</td>
<td>91</td>
<td>129</td>
<td>1.329</td>
<td>50</td>
<td>0.33</td>
</tr>
<tr>
<td>Street Cars</td>
<td>1,759</td>
<td>3,009</td>
<td>11,006</td>
<td>283</td>
<td>2.70</td>
</tr>
<tr>
<td>Trolley Buses</td>
<td>431</td>
<td>475</td>
<td>899</td>
<td>30</td>
<td>0.29</td>
</tr>
<tr>
<td>Buses</td>
<td>—</td>
<td>18,360</td>
<td>10,243</td>
<td>296</td>
<td>2.04</td>
</tr>
<tr>
<td><strong>Total for 1961</strong></td>
<td>2,281</td>
<td>21,973</td>
<td>23,477</td>
<td>659</td>
<td>5.36</td>
</tr>
<tr>
<td><strong>Total for 1960</strong></td>
<td>2,367</td>
<td>21,284</td>
<td>23,110</td>
<td>672</td>
<td>5.30</td>
</tr>
</tbody>
</table>

† Track for rail services, overhead for trolley buses.
§ Trailers included.

Table I gives statistical data for different forms of transport for 163 transit companies which are members of the Verband Oeffentlicher Verkehrsbetriebe—German counterpart of the American Transit Association.

Hamburg has a relatively high number of different types of vehicles used in public transportation. The main carriers are run by two authorities: Hamburger Hochbahn A.G. (or HHA), which has

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rail rapid transit (U-Bahn), streetcars, buses, and boats on Alster Lake; and German Federal Railroads, which run the S-Bahn. In addition to these authorities, which operate over 90 percent of public transportation in the city, there are several bus companies and the Hadag Company, running the local boat transportation in the harbor. The percentage distribution of passengers carried in the city by individual modes of public transportation is given in Table II.

Before analyzing the trends in public transportation usage, several other trends influencing it will be discussed. After distortions due to the war, most of these trend lines have assumed a rather regular pattern since 1950.

Population. The rate of change of population in Hamburg has been relatively stable since the war. Both areas—the City of Hamburg and the area served by HHA—have been increasing in popu-

<p>| TABLE II—RELATIVE USE OF DIFFERENT PUBLIC TRANSPORTATION FORMS (Hamburg, 1962) |
|-----------------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|</p>
<table>
<thead>
<tr>
<th>Form of Transportation</th>
<th>HHA Passengers Carried (millions)</th>
<th>German Federal Railroads Passengers Carried (millions)</th>
<th>Other Companies Passengers Carried (millions)</th>
<th>Total Passengers Carried (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage</td>
<td>Percentage</td>
<td>Percentage</td>
<td>Percentage</td>
</tr>
<tr>
<td>Rail Rapid Transit</td>
<td>167.1</td>
<td>27.2</td>
<td>124.0</td>
<td>20.2</td>
</tr>
<tr>
<td>Streetcars</td>
<td>159.3</td>
<td>26.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Buses</td>
<td>104.6</td>
<td>17.1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Boats</td>
<td>1.9</td>
<td>0.3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>432.9</td>
<td>70.6</td>
<td>124.0</td>
<td>20.2</td>
</tr>
</tbody>
</table>

* Private Commuter Railroad Line.
† Boats on Elbe.

lation steadily, though the rate of increase shows indications of tapering off during recent years. The difference in population of these two areas remains relatively constant, the area served by HHA being more populous by about 400,000 persons. Population in Hamburg and the HHA-served area for the selected years in the period 1938–1961 is given in Table III.

7. Abbreviation for “Untergrundbahn”—Underground; the U-Bahn is sometimes also called “Hochbahn” (as in the name of company) because of its partially elevated lines.
8. Abbreviation for “Stadtbahn”—Urban Railway.
**TRAFFIC QUARTERLY**

*Employment.* The change of the number of employees in Hamburg—also shown in Table III—has an even more clearly expressed upward trend. In 1961 the number of employees was 59 percent higher than in 1950. The number of unemployed in 1961 reached the lowest point to that date since the war—only 4,200 persons.

**TABLE III—POPULATION AND EMPLOYMENT OF HAMBURG AND HHA SERVICE AREA—1938-1961**

<table>
<thead>
<tr>
<th>Year</th>
<th>HHA Service Area</th>
<th>City of Hamburg</th>
<th>City of Hamburg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population (thousands)</td>
<td>Index (1950=100)</td>
<td>Population (thousands)</td>
</tr>
<tr>
<td>1938</td>
<td>1,865</td>
<td>95</td>
<td>1,698</td>
</tr>
<tr>
<td>1950</td>
<td>1,970</td>
<td>100</td>
<td>1,620</td>
</tr>
<tr>
<td>1952</td>
<td>2,037</td>
<td>103</td>
<td>1,687</td>
</tr>
<tr>
<td>1956</td>
<td>2,157</td>
<td>109</td>
<td>1,763</td>
</tr>
<tr>
<td>1959</td>
<td>2,217</td>
<td>113</td>
<td>1,824</td>
</tr>
<tr>
<td>1960</td>
<td>2,230</td>
<td>113</td>
<td>1,837</td>
</tr>
<tr>
<td>1961</td>
<td>2,241</td>
<td>114</td>
<td>1,848</td>
</tr>
</tbody>
</table>

* Not available.

*Structure of the City.* Population distribution on different areas grouped by their distance from the city center for the period 1938–1961 is shown in Figure 1. Percent values of individual groups in Figure 1 indicate a relatively higher increase of the city's population in the outer rings, typical of many modern cities. The trend is, however, very mild and appears to be leveling off. The greatest change in the distribution between 1938 and 1950 was caused by the war, during which many sections of the central areas were practically annihilated. The change since 1950 has not amounted to more than two percent for any of the four areas.

*Passenger Car Registrations.* Individual transportation has increased steadily in the post-war years. The number of bicycles and motorcycles reached its peak several years ago and is now decreasing, but automobile registrations are still increasing at a very high rate. As shown in Table IV, the index of passenger car registrations for 1961, compared with 1950, amounted to 864 in Hamburg and 996 in West Germany. Degree of motorization has reached one passenger car per 9.1 persons and one motor vehicle per only 7.0 persons.

*Public Transport Passengers.* The number of passengers carried annually by HHA vehicles in the period 1938–1961 is also given in
### TABLE IV—PUBLIC TRANSPORT PASSENGERS AND PASSENGER CAR REGISTRATIONS—1938–1961

<table>
<thead>
<tr>
<th>Year</th>
<th>Transit Passengers (thousands)</th>
<th>Index (1950 = 100)</th>
<th>Rides Per Capita (1950 = 100)</th>
<th>Index Passenger Car Registrations† (1950 = 100)</th>
<th>Index Persons Per Car</th>
<th>West Germany* Passenger Car Registrations† (1950 = 100)</th>
<th>Index (1950 = 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>451,382</td>
<td>100</td>
<td>229</td>
<td>100</td>
<td>23,576</td>
<td>100</td>
<td>48.8</td>
</tr>
<tr>
<td>1953</td>
<td>454,056</td>
<td>101</td>
<td>219</td>
<td>96</td>
<td>49,065</td>
<td>208</td>
<td>34.8</td>
</tr>
<tr>
<td>1956</td>
<td>465,334</td>
<td>103</td>
<td>216</td>
<td>94</td>
<td>87,624</td>
<td>372</td>
<td>20.1</td>
</tr>
<tr>
<td>1959</td>
<td>439,189</td>
<td>97</td>
<td>198</td>
<td>87</td>
<td>146,911</td>
<td>624</td>
<td>12.4</td>
</tr>
<tr>
<td>1960</td>
<td>432,060</td>
<td>96</td>
<td>194</td>
<td>85</td>
<td>175,441</td>
<td>745</td>
<td>10.5</td>
</tr>
<tr>
<td>1961</td>
<td>449,390</td>
<td>98</td>
<td>196</td>
<td>86</td>
<td>203,465</td>
<td>864</td>
<td>9.1</td>
</tr>
</tbody>
</table>

* West Berlin not included.
† Passenger cars amounted in 1961 to 77 and 60 percent of total motor vehicles in Hamburg and West Germany, respectively.
§ Rounded figure.

### TABLE V—STATISTICAL DATA—Hamburger Hochbahn AG (1959–1962)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Lines</td>
<td>5</td>
<td>5</td>
<td>14</td>
<td>13</td>
<td>3</td>
<td>4</td>
<td>60</td>
<td>71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Length* (miles)</td>
<td>41.5</td>
<td>44.4</td>
<td>107.1</td>
<td>90.0</td>
<td>215.2</td>
<td>263.5</td>
<td>399.1</td>
<td>404.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of Lines (miles)</td>
<td>70.9</td>
<td>55.6</td>
<td>158.7</td>
<td>131.2</td>
<td>263.2</td>
<td>332.0</td>
<td>500.0</td>
<td>547.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Distance Between Stops (feet)</td>
<td>3,750</td>
<td>3,500</td>
<td>1,650</td>
<td>1,660</td>
<td>2,218</td>
<td>2,150</td>
<td>2,822</td>
<td>3,005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Travel Speed (mph)</td>
<td>17.8</td>
<td>17.7</td>
<td>11.4</td>
<td>11.4</td>
<td>13.0</td>
<td>13.5</td>
<td>6.1</td>
<td>6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Trip Length (miles)</td>
<td>4.4</td>
<td>4.4</td>
<td>3.1</td>
<td>3.1</td>
<td>2.9</td>
<td>2.8</td>
<td>2.6</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passengers Carried (millions)</td>
<td>142.1</td>
<td>167.1</td>
<td>233.1</td>
<td>159.3</td>
<td>61.4</td>
<td>104.6</td>
<td>2.6</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Vehicles for Passenger Service</td>
<td>495</td>
<td>533</td>
<td>826</td>
<td>630</td>
<td>350</td>
<td>542</td>
<td>16</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Miles Run (millions)</td>
<td>21.9</td>
<td>23.8</td>
<td>23.9</td>
<td>16.8</td>
<td>11.1</td>
<td>18.2</td>
<td>0.2</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load/Capacity Ratio (percent)</td>
<td>20.6</td>
<td>22.5</td>
<td>27.5</td>
<td>25.7</td>
<td>26.1</td>
<td>24.8</td>
<td>18.3</td>
<td>16.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personnel</td>
<td>2,493</td>
<td>2,434</td>
<td>4,397</td>
<td>2,740</td>
<td>1,575</td>
<td>1,967</td>
<td>72</td>
<td>64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Length of track or streets served.
Table IV. As in other European and American cities, public transport had maximum patronage during the post-war years (the record of nearly 530 million passengers was reached in 1948). Riding decreased following that peak and reached a minimum in 1951 of approximately 430 million passengers. Since that year the trend has been relatively horizontal. Riding during the last ten years has never been higher than 465 million nor lower than 430 million passengers annually. Number of rides per capita, also given in Table IV, shows a mild trend of decrease.

The upward trend of population in Hamburg and the HHA-served area, discussed above, has had a positive effect on total transit riding in the city. The increase during recent years, however, has been too slow to represent a major influential factor on the riding. Changes in the structure of the city are also too small to demonstrate their effect on the amount and character of travel in the city. Rapid increase of employment is a major positive factor for the use of public transportation.

The impact of the increased automobile ownership on transit riding is considerable. The diversion from public to individual transportation is especially strong for the trips between dispersed origins and destinations in the outlying areas. Therefore, reductions of services are taking place mostly on the circumferential lines, while the radial lines are retaining and increasing their patronage.

Automobile ownership is considered one of the main causes of decreasing public transport patronage. A general appraisal of the trends in motor vehicle registrations and transit passengers shows that the influence of motorization on transit patronage in Hamburg is considerably smaller than in most other (particularly American) cities. The number of persons per passenger car in Hamburg decreased between 1950 and 1961 by 86.8 percent, while the number of rides per capita was reduced by only 14.5 percent during the same period. This can be partly explained by the fact that many automobile owners use public transit for many of their trips.

The trends discussed above show that public transportation in Hamburg plays, at present, a dominant role in the total metropolitan transportation. Though its relative importance has somewhat decreased, all indications are that it will remain the backbone of the city’s transportation.
In the early 1950’s, when the immediate repairs of war damages were completed and the country’s economy stabilized, it was possible to start with the long-range planning for the development of the City of Hamburg. The trends in population and motor vehicle registration, as well as the transportation problems which other big cities with a higher degree of motorization were facing, made it imperative that transportation planning be given an important role in over-all city planning.

TRANSPORTATION POLICY AND PLANNING

The policy adopted for transportation planning in Hamburg, toward which the present extensive construction works are aimed, is expected to lead toward the final solution (if this word can be applied at all to transportation in any metropolitan area), which will be most adequate for that city. Some of the principles on which this policy is based are:

1. Parallel improvement and modernization of the facilities for both public and private transportation.

2. Maximum possible separation of elements of traffic with different characteristics. Specifically, this separation should be between:

   (a) motor vehicles and pedestrians; (b) public and private transportation vehicles; (c) bicycles and motor vehicles; and (d) within-the-street traffic: local and long distance, etc.

3. The best possible compromise between the preservation of the city’s values and the changes required for improvement of transportation.

Along these lines, a very ambitious program of construction of facilities for all forms of transportation has been adopted and is now under way. The first sections of the planned freeway network will enable through traffic to bypass the city, and later ones will constitute a system of six radial freeways, connecting with a circumferential route in the form of a semicircle, with an approximate radius of three miles from the CBD. One east-west freeway within the semicircle will pass about one mile north of the central area. The attention given to preservation of esthetic values in the city is illustrated by the fact that this freeway will be carried through a tunnel under Lake Alster, instead of across a less costly bridge. No freeways
are planned in or near the central area. The arterial streets will be improved, however, and the circumferential street along the former city wall will be fully grade-separated at intersections (by under- and over-passes) and, thereby, raised to expressway standards. A centralized parking policy (including control of rates) is expected to coordinate street capacities and availability of parking spaces, thereby maintaining tolerable traffic conditions in the city. Considerable effort and experience will be needed to realize the desired results in this direction—in practice.

Planning of Public Transportation Systems. Public transportation had an important place in developing the long-range plan. When it was decided that a modern and reliable system should be provided as the backbone of urban transportation, selection of the best form for that system had to be made.

Basic requirements for the main carrier of public transportation were dictated by the size and character of the city. Like most other cities of comparable size, the basic characteristics which had to be met in Hamburg were: high speed, high capacity, and full separation from any other traffic. Analyses of different systems were made with an open mind. The advantages and disadvantages of the existing rail rapid transit were weighted against those of several other systems applied or proposed in other cities. Attention was also given to the best mode of transportation for local surface lines, supplementing the main rapid transit network.

A subway with pneumatic tires, applied on one line of the Paris Metro, was appraised for its possible use in Hamburg. Its main advantages are better acceleration and deceleration (especially advantageous for lines with low-standard alignment elements), smooth ride, and extremely low level of noise. Its disadvantages are more complicated installations and vehicles and higher cost of investment, operation, and maintenance. In addition, there is no experience with the operation of this system on open sections of lines not protected from the influences of weather.

The “Alweg” (monorail) offered a considerable number of positive features, such as easier and less costly construction (if above ground), with less interruption of traffic; smooth and silent riding; relatively high speed; and attractive appearance. However, for tunnel operation—which would be the case in the central parts of
Hamburg—its construction would be more expensive and complicated than the rail system. There are also a certain number of technical problems which were not tested sufficiently in practice. Other monorail systems were not adopted for similar reasons.

The belief held after the war that technology of conventional rail vehicles was close to the ultimate and that no major improvements should be expected, proved, in the meantime, to be very wrong. When numerous modern improvements in the technology of rail transportation were taken into account, this conventional system had considerable advantages over other systems appraised. Simplest of all, it has the lowest operational and maintenance costs. With welded rails and trucks of noise-insulating construction, it offers both a smooth and relatively noiseless ride. The controls of modern equipment also allow choice of any rate of acceleration or deceleration desired, so that the advantages of the trains with pneumatic tires are reduced to a minimum. In addition, adoption of this system allowed continuation of the lines, facilities, and experience already existing in Hamburg.

On the basis of the studies, it was decided that the conventional rail rapid transit system should be extended and made the main transit carrier in the city. Buses were chosen as a supplementary mode on surface streets. The general distribution of roles of individual modes is planned as follows:

1. The S-Bahn, with its long lines, relatively few stations and high speed, will offer rapid transportation and a type of service which is something between metropolitan rapid transit system and a commuter railroad; it will enable development of the city over a large area through provision of rapid connections between distant suburbs and the center.

2. The U-Bahn will represent the main urban and suburban transit carrier, using its own right-of-way entirely. With construction of new lines and by thickening its network, it will gradually take over the present role of streetcars. As it should provide full coverage of the closer-in areas, its inter-station distances and speed are more limited than those of the S-Bahn. On the lines to the outlying low density areas (where the distribution is made by buses), the U-Bahn will have longer inter-station distances and higher speed.
The ultimate goal of rail rapid transit construction is a network of some 190 miles, with the S-Bahn and the U-Bahn having approximately the same lengths.

3. Streetcars will be gradually replaced by the U-Bahn and, on less loaded lines, by buses. This conversion has already begun. Some of the streetcar lines, however, have sections with a kind of semi-rapid service (own right-of-way) and high passenger loads, so that they are superior to buses in economy and efficiency of operation. It is expected that these lines will be retained for the next twenty to twenty-five years.

4. Buses are planned to give two types of services: express buses with higher comfort and higher fares, and regular buses which will supplement the U-Bahn as collector-distributors in the suburbs, and serve the less heavily loaded lines in the central areas. Their flexibility allows the best coverage of the outlying areas. Their use in the city center on the same streets as other traffic will be kept at a minimum.

It should be mentioned here that this general plan for the development of public transportation was not made exclusively on the basis of the lowest total transportation cost. Though HHA is very economy-conscious in its operations, several other factors were given full attention in the planning. Several of the planned subway lines are expected to have peak hourly volumes of from ten to twelve thousand persons per direction, a volume which belongs to the economic domain of streetcar operation. The decision to substitute streetcar lines by U-Bahn in such cases was made on the basis of the principles discussed before: full separation of public from private transportation for the benefit of both, increased speed of transportation in the city and a solution which is permanent and allows future expansion of the transportation capacity.

The high investment required for this extensive subway construction exceeds the financial ability of the transit company. Agreement has been reached that the city is building the tunnels and embankments, while HHA is providing the track, signals, power, and rolling stock, and is operating the lines. The shares of investment organized on this basis amount approximately to 70 percent for the city and 30 percent for the transit company. This arrangement was based on the following thinking: construction of subways is bene-
ficial for all participants in traffic because it provides better public transportation and improves conditions in the streets by eliminating surface transit vehicles. The city is paying for the construction of public streets. As rapid transit serves as a common carrier, construction of these facilities is also under the jurisdiction of the city.

It should be mentioned here that this plan of general improvement of transportation, particularly public transportation, in the city has been under way since 1955 and is progressing at a rapid pace. Construction has been accelerated and sometimes completed ahead of schedule. The program enjoys remarkable support, not only from all the authorities concerned, but also from the press and the population.

PUBLIC TRANSPORT OPERATIONS AND FACILITIES

As in other cities, there were, initially, many smaller transit operators in Hamburg, which later merged into a few companies. Hamburger Hochbahn Aktiengesellschaft,9 founded in 1911 to operate the U-Bahn (opened in 1912), merged between 1918 and 1923 with several other transit companies and thus became the main public transport operator in the city. At present, HHA has four different forms of transportation. The German Federal Railroads, with their S-Bahn, are the second largest operator, while several remaining companies carry less than 10 percent of the total passengers (Table II).

There is relatively good coordination of services between different operators. For example, there are common stations with easy transfers between U-Bahn and S-Bahn; several HHA bus lines serve as feeders to the S-Bahn. Competition is minimal as most of the operators are separated in their service areas. It is, however, becoming more and more imperative to achieve further coordination in public transportation. A major step in that direction—creation of a common tariff, allowing free transfers between the lines of different operators—is under study now. Planning of the future major facilities (stations, terminals, etc.) for all companies is fully coordinated.

*Hamburger Hochbahn Aktiengesellschaft* (HHA) is a private stockholders company. However, the State of Hamburg owns over 50 percent of the stock, which gives it a controlling interest in the

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company's work. The company has a board of three directors (technical, commercial and personnel), and a supervisory committee of fourteen members, whose chairman is the Mayor of Hamburg, ex-officio.

Basic statistical data about HHA operations and their breakdown on individual forms of transportation for 1959 and 1962 are given in Table V.

**U-Bahn.** The most interesting features of the U-Bahn network, operation and vehicles will be briefly discussed here.

The U-Bahn network, shown in Figure 2, consists at present of a ring line and four lines basically radial in character. The radial line, from Ochsenzoll, at the northwest boundary of Hamburg, to Rathaus, in the city center, has been extended since 1955 in the northeastern direction to Wandsbek. The remaining section, from Wandsbek Markt to its connection with the line to Volksdorf, is scheduled to be opened in the summer of 1963. In 1962 the construction of another subway line was started. The line is planned to go from Billstedt on the east through the central area to Hagenbecks Tierpark, west of it.

It is planned that the U-Bahn construction will proceed continually on one line after the other. Most of the future lines which are now in the planning stage will follow the existing trunk streetcar lines, transversing the central city between Alster and Elbe and spreading radially to the suburbs east and west of Alster. The long range plans also call for reconstruction of several old sections with tight radii.\(^\text{10}\)

As the future U-Bahn network will supplant surface transit lines, it has to provide maximum possible coverage of the area. This requirement imposes restrictions on the distances between stations, determined by the maximum 5-minute walking distance for the primary drawing area. The new line to Wandsbek, for example, has an average distance between the stations of 2,520 feet. Through provision of entrances to both sides of the station platforms, the distance for passengers is practically reduced to only 1,820 feet. In the outlying areas, however, distances between stations remain considerably longer, as the majority of passengers uses buses or indi-

\(^{10}\) The smallest radius of the network has only 220 feet; the smallest radius of the new line to Wandsbek has 400 feet and allows a maximum speed of 32 mph.
Figure 1. Structure of the City of Hamburg, Germany
Figure 2. Rapid transit network in Hamburg, Germany
Figure 3. Pedestrian mezzanine, with ticket booths, stores, information boards, in new Rathaus U-Bahn station
individual vehicles to reach the station. No express service is planned at this time. The relatively small time saving it would achieve does not justify the additional investments in construction necessary for the third track. The new lines are constructed nearly exclusively underground. Except at locations where only tube tunneling is possible, the cut-and-cover system is applied.

The increase in length of the rail rapid transit network in recent years has resulted not only in an increased total number of passengers, but also in an increase of passengers per route mile. This increase of "density of travel" is probably the result of a more complete system, which allows travel between a larger number of points throughout the area served.

Stations were not conceived just as "approach to trains," but as complete, multipurpose pedestrian facilities. Most stations have mezzanines between the surface and the platforms. This level has several entrances and serves not only as the location of ticket booths and barriers, but also as a pedestrian underpass. Experience from other cities (e.g., London) has shown that pedestrians do not like to use the underpasses if they are simple tunnels. Therefore, all underground areas in the stations are designed to be attractive, well lighted and free from any tunnel effects. Stores, maps, information and advertising windows in bright colors are very successfully employed for this purpose. (Figure 3.)

Transfer points between rapid transit and buses in the suburban areas are also planned carefully. The new station of that character at Wandsbek Markt provides for direct, fully covered transfer of passengers, without crossings of roadways. Passenger control is in the station, so that a maximum capacity at a rate of 120 buses with 8,000 persons per hour in five directions was reached immediately after the opening of the station.

The smallest operational train unit consists of two cars. Consequently, the trains always have an even number of cars, the maximum being 6 cars on older and 8 cars on new lines with longer platforms. The basic headway on the system is 5 minutes during the off-peak hours (with 2- or 4-car trains) and 2.5 minutes during the peak hours (with 6- or 8-car trains). As the car capacity is 133 per-

11. In 1959 there were 3.42 million passengers per route mile; in 1962—3.77 million passengers per route mile.
sons, the number of offered seats and standing places reaches 25,500 per direction per hour. However, there is a steady increase of passengers on the lines from suburbs, due to fast development of those areas, so that the new lines are planned for minimum headways of 1.5 minutes or a theoretical maximum capacity of 42,500 persons per directions per hour.

Due to shortage and high cost of labor, HHA tries to minimize the number of its operating personnel. The train crew consists only of the driver. Another person supervises the platform and gives the signal to start. The tendency is to build “island” platforms, so that one man can easily supervise trains in both directions. At the stations with side platforms, TV facilities are installed to enable one man to supervise the opposite platform.

It is worthwhile to mention here that Hamburg has an excellent solution to a problem which is not solved in many other cities: how to make the subway stations conspicuous and visible from the distance. Each U-Bahn station carries a large sign “U,” while S-Bahn stations carry an “S,” considerably easing the use of rapid transit for all potential passengers. Information on directions, maps, and exact schedules of all trains are exhibited in each station.

The U-Bahn cars can be divided in three types, which differ from each other considerably in technical characteristics and cannot be interchangeably coupled in trains. Basic technical data of all three types of cars are given in Table VI.

All cars are powered. Each has the driver’s cabin at one of its ends. Two cars, coupled “back to back,” represent a basic operating unit used in passenger transportation. The driver’s cabin in most cars is large, occupying the whole front section of the car. Passengers cannot walk between the cars.

Pickup of current (750 DC) is made by the shoe underriding the third rail. Great attention is given to safety, through different devices on the lines and vehicles. The whole system is equipped with automatic block signals. Switches are centrally controlled by a modern system with elaborate built-in mechanical safety devices. All cars are equipped with “automatic train control,” a safety braking system actuated by the magnets at the signals when the red indication is lighted. All vehicles also have a “dead man” safety installation. The doors are opened by the passengers and closed pneumatically by the driver.
PUBLIC TRANSPORTATION IN GERMANY

The first group of subway cars, consisting of the vehicles built between 1912 and 1946, is of a standard "classical" type, with relatively simple mechanical and electrical equipment.

The second group of cars, built in 1958–59 and named DT-1\textsuperscript{12} was conceived with much higher standards than the previous cars. To satisfy the considerably higher requirements of modern rapid transit service, the builders of these cars introduced a number of new technological inventions. (Figure 4.)

**TABLE VI—TECHNICAL SPECIFICATIONS OF U-BAHN CARS**

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Length over couplers</td>
<td>42 ft. 0 in.–46 ft. 6 in.</td>
<td>46 ft. 7 in.</td>
<td>45 ft. 3 in.–46 ft. 8 in.</td>
</tr>
<tr>
<td>Distance between supporting points in trucks</td>
<td>23 ft. 0 in.–26 ft. 7 in.</td>
<td>25 ft. 3 in.</td>
<td>26 ft. 3 in.</td>
</tr>
<tr>
<td>Truck wheelbase</td>
<td>6 ft. 7 in.– 6 ft. 11 in.</td>
<td>6 ft. 11 in.</td>
<td>6 ft. 11 in.</td>
</tr>
<tr>
<td>Over-all width</td>
<td>8 ft. 4 in.– 8 ft. 5 in.</td>
<td>8 ft. 4 in.</td>
<td>8 ft. 2 in.</td>
</tr>
<tr>
<td>Height above rail</td>
<td>11 ft. 1 in.</td>
<td>11 ft. 1 in.</td>
<td>11 ft. 0 in.</td>
</tr>
<tr>
<td>Weight (unloaded) (pounds)</td>
<td>53,200–56,400</td>
<td>55,800</td>
<td>43,200–39,100</td>
</tr>
<tr>
<td>Number of doors on each side</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total person capacity</td>
<td>122–148</td>
<td>134–138</td>
<td>126–133</td>
</tr>
<tr>
<td>Number of seats</td>
<td>32–46</td>
<td>40–44</td>
<td>41</td>
</tr>
<tr>
<td>Number of axles</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Number and power of motors (kw)</td>
<td>4 (N. A.)</td>
<td>4 × 74</td>
<td>2 × 80</td>
</tr>
<tr>
<td>Maximum speed (mph)</td>
<td>N. A.</td>
<td>50</td>
<td>44</td>
</tr>
<tr>
<td>Brakes</td>
<td>Pneumatic mechanical-manual</td>
<td>Dynamic pneumatic\textsuperscript{†} mechanical-manual</td>
<td>Dynamic coil magnet over disc electric</td>
</tr>
</tbody>
</table>

Number of cars, 12/31/62 394 100 38

*Operational only as two-car units.
\textsuperscript{†}Combining of dynamic and pneumatic braking possible.

The equipment (transformer, batteries, resistors, relays, switches, etc.) is distributed in two cars. Thus, the units "A" and "B" are permanently coupled and can be operated only as one unit. As the technical data in Table VI show, nearly all characteristics of these cars are better than those of the old cars. Maximum dimensions of the cars, larger capacity, more doors, improved lighting, better ventilation, soft seats, and a comfortable cabin for the driver are provided. Automatic switching of motors with three different acceleration rates (the highest being 2.0 mph/sec. with full load), and dynamic braking with three selective deceleration rates (maximum 2.5 mph/sec.) offer a considerable saving of driving time and pro-

\textsuperscript{12} DT-1 from Doppel-Triebwagen (Double Motorcoach).
vide more comfortable riding. Greater use of dynamic brakes (pneumatic braking over the brakeshoes serves only for stopping, holding and emergency braking) results in a more economical operation and reduction of metal dust in the tunnels. A number of safety devices is also provided. Maximum speed of these cars is 50 mph.

The one hundred cars of this group showed very good results in operation. They offer a comfortable ride, higher speed, and are esthetically satisfactory. Their problem, however, is high operational cost. Due to their considerable weight and the high power of their motors, their consumption of electric energy proved to be about 50 percent higher than that of the old cars. Unsatisfied with the power costs of DT-1 cars, HHA decided to develop a new prototype of cars, which would require minimum operational and maintenance cost and have the latest technological inventions, allowing also for further perfections. These features were incorporated in the cars designated as DT-2, the first of which were put in test operation in 1961.

The DT-2 cars have drawn the attention of many experts. Though some of their features are subject to controversy, their construction is very daring and incorporates many entirely new concepts. The technical specifications of these cars, shown in Table VI, include those of the prototype cars and of the later, improved cars (with increased length and reduced weight) where they differ.

DT-2 cars also operate as two-car units, but they are identical and differently connected than DT-1 cars. To save on weight, each car was built with only three axles: two, powered by one 80-kw motor each, in a complete truck, and one, not powered, at the joint with the other car, built in a “semi-truck,” which is coupled with the corresponding “semi-truck” of the other car. These two parts form a separable truck in the middle of the two-car unit. This new construction eliminates one truck and, at the same time, allows relatively easy separation of cars for maintenance. However, the supporting points of the semi-truck are located on the outer sides of its axles; this geometry does not provide the shock-absorbing effect as with regular trucks, and riding quality is, therefore, very poor. Further savings in weight are achieved through extensive use of light-weight materials. Total weight of an unloaded car is about 30 percent lower than that of a DT-1.
The electric equipment of the cars was designed to provide optimal driving under any conditions. The driver can choose different acceleration rates and different constant speeds. Special devices eliminate the influence of car loading on the acceleration rate and prevent spinning or skidding. It is also possible to get acceleration at any moment without the lost time and shock caused by the accelerator with PCC and other cars with indirect commands. Due to the relatively short distances between the stations, more attention was given to acceleration and deceleration (which have maximum rates of 2.5 and 2.8 mph/sec. respectively) than to maximum speed (which is only 44 mph!).

The principal brake is dynamic. Stopping and holding is achieved by a coil-actuated magnet, acting over a braking disc. There are no pneumatic brakes. Braking efficiency is considerably improved by this construction, without any reduction of safety. DT-2 cars have provisions for eventual, fully automatic operation.

Excellent results in noise reduction have been achieved with DT-2 cars. The wide application of rubber in the suspension is the main reason why these cars are remarkably silent. The appearance of the cars, however, leaves a lot to be desired. Purely functional, of unimaginative design, gray color (non-rusting steel) and with doors attached outside the car body, they are not likely to be attractive to the public, thereby eliminating one of the important elements in successful competition with private transportation.

Streetcars. The streetcars’ share of total passengers in Hamburg is falling, but their role in the city’s transportation is still very important. At the present time they carry over half a million passengers daily.

With the exception of the U-Bahn and S-Bahn lines, streetcars serve all the heavily travelled transit lines in the city. Ten out of thirteen lines pass through the city center, branching radially along the main arteries to the suburbs, up to seventeen miles from the center. Superiority of streetcars over buses in capacity and economy of service are the main reasons that they will be retained in service on all major lines until the U-Bahn is constructed to replace them.

Regardless of the general downward trend in the importance of their role, streetcar operations will be further improved and modernized. Several of the most important lines, planned to be operated with streetcars for some twenty years from now, are being
improved through the provision of private right-of-way for them wherever possible. At the intersections, they are regulated by special signals, so that, on some sections, they have a semi-rapid transit character. Operating in two-car units (motor coach with a trailer), with a total capacity of 228 persons, streetcars provide adequate capacity for any of the existing lines. The technical characteristics of HHA’s streetcars, however, have been surpassed by several other models developed in the course of the rapid modernization of streetcars, which has taken place in many European cities in recent years.

_Buses._ The role of buses in Hamburg has increased in importance considerably in recent years. During the period between 1955–61, the number of bus lines doubled and the number of vehicles tripled. HHA’s bus fleet and services are, today, among the most modern in Germany.

There are two types of bus lines: regular and express. They differ in the character of services, vehicles and tariff.

Regular bus lines serve mainly the outlying areas. The increasing suburban population uses public transportation for most of its commuting to work. Lower automobile ownership than in the United States is not the only reason for this, since many people leave their cars at home and take buses or use the park-and-ride system. They find it more convenient, cheaper and, sometimes—if they use rapid transit—faster than driving. Most of this increasing public transport patronage is served by bus lines, the majority of them feeders to streetcar and rapid transit lines. Only two regular bus lines pass by the central area. The vehicles are designed to be easily adaptable to street traffic. A ten-meter-long (33 feet) bus was chosen as being the most flexible and having a maximum capacity for one-man operation.

Express buses ("Schnellbus") offer higher riding comfort and higher speed for higher fares. Higher comfort consists of a greater number of seats (standees only exceptionally), pleasing appearance of vehicles, more windows, etc. They have a reduced number of stops, so that their speed is close to the travelling speed of private cars. This service, offering higher riding comfort at higher price, is used mainly by riders who would tend to use their cars in preference to regular public transportation.

Express buses have been a very successful operation and have been continually expanded since the first lines were opened in 1955.
The ten lines have 46 percent of the total length of bus lines and carry over 20 percent of all bus passengers. Serving a different patronage, they often parallel the main rail lines, forming a mainly radial network with the center in the central area.

*German Federal Railroads—S-Bahn.* German Federal Railroads are the second largest transit operator in Hamburg. Their S-Bahn, carrying over 20 percent of total public transport passengers in the city, provides rapid service for a large area, including several distant suburbs. S-Bahn lines have a high standard of alignment and long distances between stations, which allow high speeds and high riding comfort.

The S-Bahn network consists of radial lines branching in six directions, three of which are electrified, while the other three still have steam traction. Its total length is 92.4 miles; 36.6 miles are electrified (third rail, 1200 V, DC). The travel speed varies for different lines, the highest being 30.6 mph (Bergerdorf line).

Rolling stock for the electrified lines consists of 88 powered cars and 44 trailers. They are operated in 3-car units, the middle one being a trailer. The length of such a unit is 205 feet. The car width is 10 feet, and the height 12 feet. Total capacity of a 3-car unit is approximately 600 persons (202 seats). With the maximum train frequency of 15 per hour and the trains consisting of two 3-car units (three 3-car units are used only exceptionally), the total number of spaces offered reaches 18,000 per hour per direction. The maximum speed of cars is 50 mph. The cars planned for the future will have about 10 mph higher maximum speed.

With these characteristics, the S-Bahn offers rapid transportation between the outlying and central areas of the city. With the development of the outlying areas and increased commuting, it is expected that the importance of this type of service, adequately supplemented by feeder lines, will be increased. The electrification of the lines presently operated with steam traction is under way, with the financial assistance of the City of Hamburg.

**CONCLUSIONS**

Most of the large cities of the world are faced today with the very difficult question of solving the problems caused by rapidly increasing requirements of modern transportation. Some cities are too occupied with the current problems to give sufficient attention
to long-range planning and to try to develop a clear solution which will be satisfactory at the target year and serve as a guideline in planning.

Hamburg is one of those cities which has taken a clear approach toward metropolitan transportation problems and which directs its planning toward an ultimate general plan. The basic policy which has been adopted is rapid improvement of facilities for all modes of transportation, with the final aim the achievement of a complete system of modern networks for public and private transportation, as well as adequate solution for pedestrian movements, parking and other related problems. A high degree of coordination in planning, construction and operation of transportation facilities has been achieved among all the authorities concerned. Some of the major results of this well-organized effort, particularly in the field of public transportation, have already proved their values. With this clearly defined policy and coordinated planning, Hamburg deserves the special attention of transportation experts facing similar problems in other cities.

Bibliography


