Urban Transit System Cabinentaxi

Hagen Project Planning Summary

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Aerial Photograph of Hagen and Environment (1967)

Initial Situation · Objective

Initial Situation

In parallel with component development, the field of application of the short-distance Cabinentaxi system has been and is the subject of detailed investigations.

Initial traffic and structural analyses in the Perlach community of Munich with 80,000 inhabitants as well as in Freiburg with 165,000 inhabitants yielded positive results. Thus, it was possible to delineate a clear profile of requirements for the technical components of the system.

At the end of 1971, the Hagen Strassenbahn AG charged the joint DEMAG + MBB working group with the task of investigating whether the greater Hagen area in Westphalia could be covered by the Cabinentaxi as the sole public short-distance transport system.

A team carried out a relevant analysis on the basis of the following aspects:

- traffic
- structure
- costs

The following deals with the traffic-related part of project study.
A question, which emerged with regard to this part of project planning, was whether the line and station capacity of the system would suffice to satisfy the increased mobility requirements of an area with approx. 400,000 inhabitants in the year 2000.

Objective

Two planning alternatives had to be developed for the prognosis year in order to answer the question as to whether the greater Hagen area in Westphalia can be covered by the Cabinentaxi as the sole public transport means.

Planning Area

Planning alternative [101] covers part of the greater Hagen area with the structural data of the Hagen general traffic plan. Alternative [200] considers the whole greater Hagen area as well as subsequently added planning conceptions (Fig. 1).

In particular, the urban structure which is desirable for traffic reasons and which among other things results from the North Rhine-Westphalia programme of 1975, has been taken into account in the traffic volume for the Cabinentaxi network of planning alternative [200]. The following statements are therefore limited to this network.

Traffic Data

The year 2000 was taken as the prognosis period. Apart from future-oriented network planning, in this case the findings can be compared directly with the prognosis of conventional short-distance public transport under the general traffic plan as well as with a separate expertise on "Public Short-distance Transport in Hagen".

For this investigation, the whole of the short-distance traffic volume was broken down into two elements:

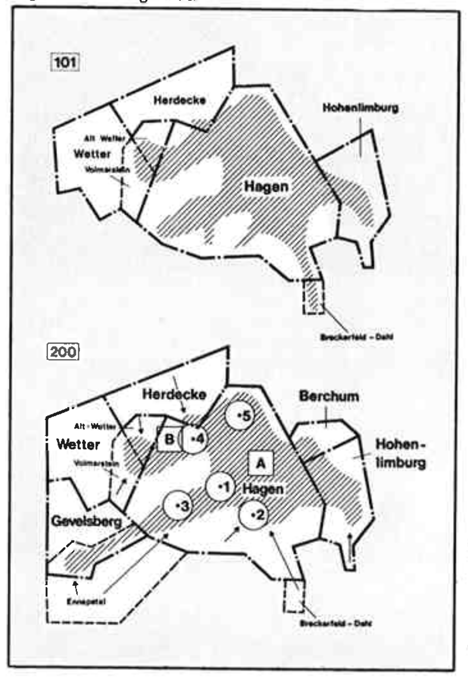
- Business Traffic
- Occasional Traffic (shopping, visiting and pleasure trips)

The traffic volume is as follows (passenger journeys/day):

Traffic per day (24 h) approx. 572,000,
of which business traffic 158,000,
of which occasional traffic 414,000.

The traffic volume in the morning peak hour is approx. 56,000 passenger journeys.

Fig. 1: Planning Area



Political Borders (generalized)
Borders of Traffic Zones (generalized)
Major Congestion Points in the Hagen Urban Area
Main Station (2,3,4,5)
Additional Planning Conceptions
A University, B Recreation Centre
Area directly covered by Cabinentaxi
Shuttle service by Bus

Methods of Calculation

It is of significance to state that the planning is based on the overall traffic volume (cars + public short-distance transport). Adequate criteria permit splitting up overall transport into public and personal transport.

This method corresponds to advanced planning approaches which for example are also applied to planning of new underground and commuter lines.

Modal Split

Traffic is split up in the planning area into Cabinentaxi and car. A modal split calculation indicates the percentage of users changing over to the new Cabinentaxi transport system. To evaluate the modal split this calculation uses the travel time difference resulting for a user if there is a free choice among two transport means (Fig. 2).

The modal split model is taken from the Hagen general traffic plan. Thus, the forecasts for conventional public short-distance transport and the new system can be compared directly.

Travel Times

The travel time using the Cabinentaxi comprises ride and connection times. The ride time is determined from the shortest route in the network for each possible station link and a running speed of 36 km/h. The connection time (walking time, occasionally also arrival and departure time when using the bus) is defined in accordance with structural and topographic conditions. The greater Hagen area is subdivided into traffic zones.

The average walking times are obtained by a zone-station breakdown split according to destination and origin of trips as well as according to the travelling purposes.

The private car travel times relate to the road network of the year 2000; the ride times were made available by the general traffic plan expert. These times are based on an extremely well-developed municipal road network, largely lacking at the present time, featuring some arterial roads.

The travel time difference determines the modal split value of the public transport means. The breakdown is effected separately according to the purposes of business and occasional traffic, in fact, individually for each zonal traffic relationship. This was calculated for the morning peak hour 7 – 8 a.m. (determination of the required capacities and number of vehicles) as well as for the daily traffic (daily average capacities and fare determination).

Steps of prognosis

The complete flow of the prognosis calculation can now, after these preliminary remarks, be traced in Fig. 3; at this stage it has been clarified up to the line "Statistics 1".

The determined "Cabinentaxi users" are assigned to the stations. Thus, the station loads and a matrix of all journeys desired between all stations (station matrix) are known. The decision as to the use of the upper and lower ride level is met by taking into consideration the criterion of the shortest route in the Cabinentaxi network.

The station imbalances – namely the difference between the arrivals and departures at a station – provide the basis for calculating empty runs as well as for ascertaining the number of cabins.

Useful and empty runs are apportioned to the network and assigned to individual network elements. This yields the traffic turn-over on a line.

Line and station loading provides the basis for dimensioning the elements and is illustrated graphically in the load plan.

Besides the print-outs of the EDP computations and the load plan, statistics are well suited for interpretation of the results. The values depicted in Fig. 4 are used to assess the alternatives.

Fig. 2: Modal Split Models

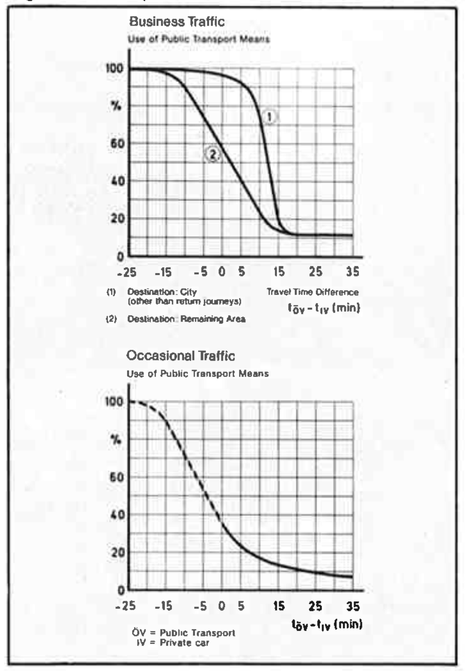


Fig. 3: Prognosis Scheme

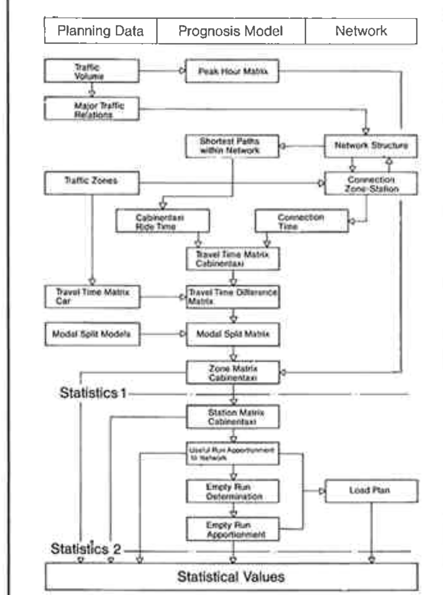


Fig. 4: Statistical Characteristics

Statistics 1	Statistics 2
Traffic Service	**Station Loading**
Conveyance cases (modal split)	Passengers entering
Connection times	Passengers getting off
Distances and ride times	Sum
Travel times using Cabinentaxi	**Line Loading**
Travel times using car	Useful runs
Travel time differences	Empty runs
	Sum
	Network Characteristics
	Network length
	Number of stations

Cabinentaxi Network

The general traffic plan for Hagen, with its structural analysis and prognosis, decisively determines the magnitude and direction of the traffic volume. The main traffic flows are indicated in the plan of network 200 by arrows (Fig. 5).

The network design takes into consideration the system features of the Cabinentaxi, in particular the network mesh formed by simple track branching and interweaving. Junctions are avoided for architectural as well as expenditure reasons.

The special structural data take into account

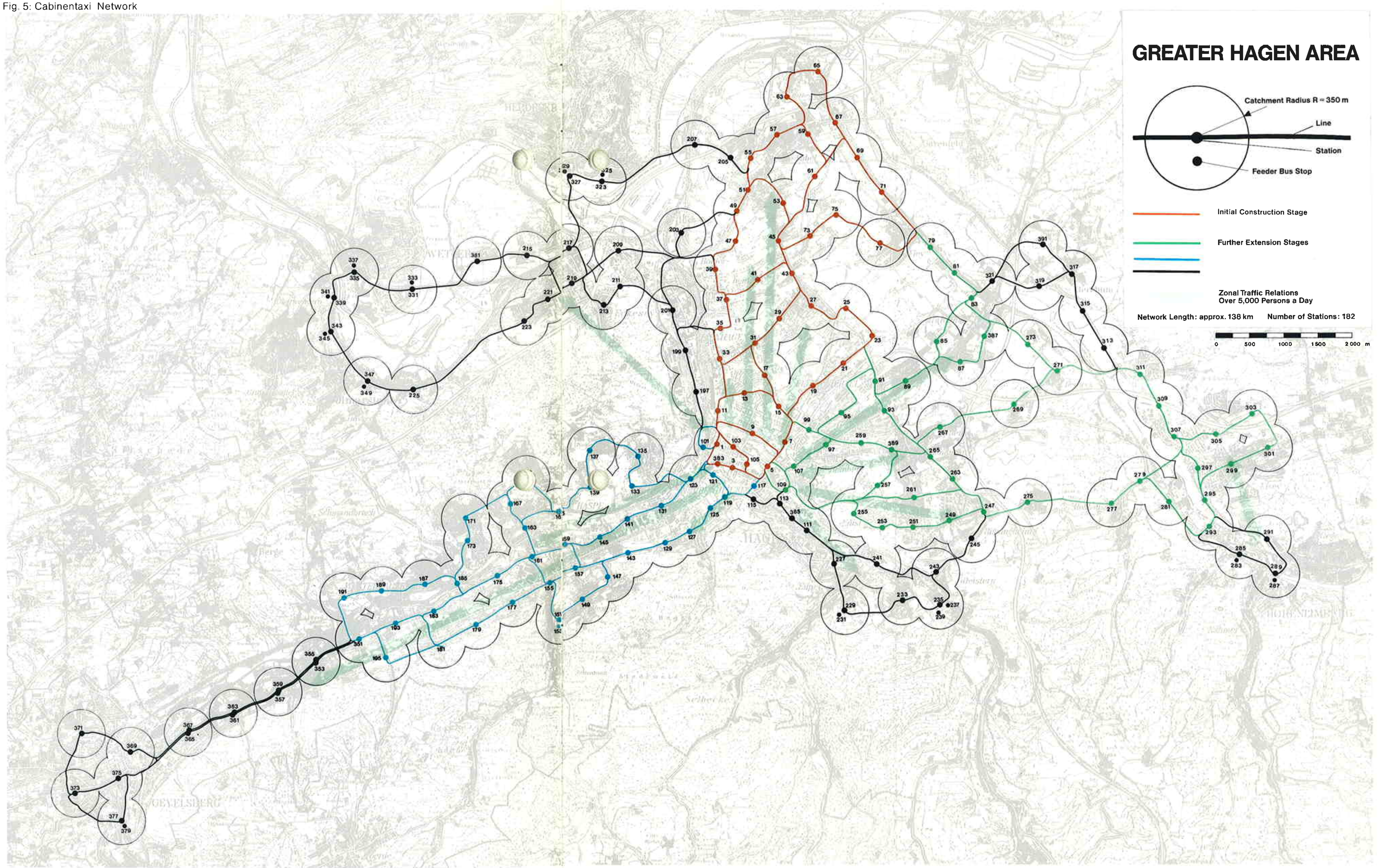
- the nature of the terrain
- the architectural situation according to current status and planning based primarily on the most recent land development schemes
- adequate coverage through the catchment areas served by the stations (cp.catchment radii), the location of which are partially related to today's tram and bus stops
- the connection to other transport means (Federal German Railways, planned commuter railway, bus feeder services within network 200
- the possibility of extending the network in several stages

The network with its 182 stations and a length of 138 km represents the result of iterative rough planning coordinating the number of stations, station density, traffic volume and traffic turnover on a line.

More accurate planning will still require partial adjustment of individual routings and station locations in conformance with findings regarding expedient station density as well as with the topographical situation.

This has already been effected by way of example in the design part of the study (1) for a first subnetwork.

Fig. 5: Cabinentaxi Network



Cabinentaxi Network Loading

Load Plan

The peak hour load on each individual station, split up according to direction of travel as well as to passengers alighting and entering, and the load on each individual link – separately for upper and lower system – were calculated on the basis of the described EDP-oriented prognosis model.

These loads are plotted in Fig. 6 and summarised in categories of the width indicated in the legend.

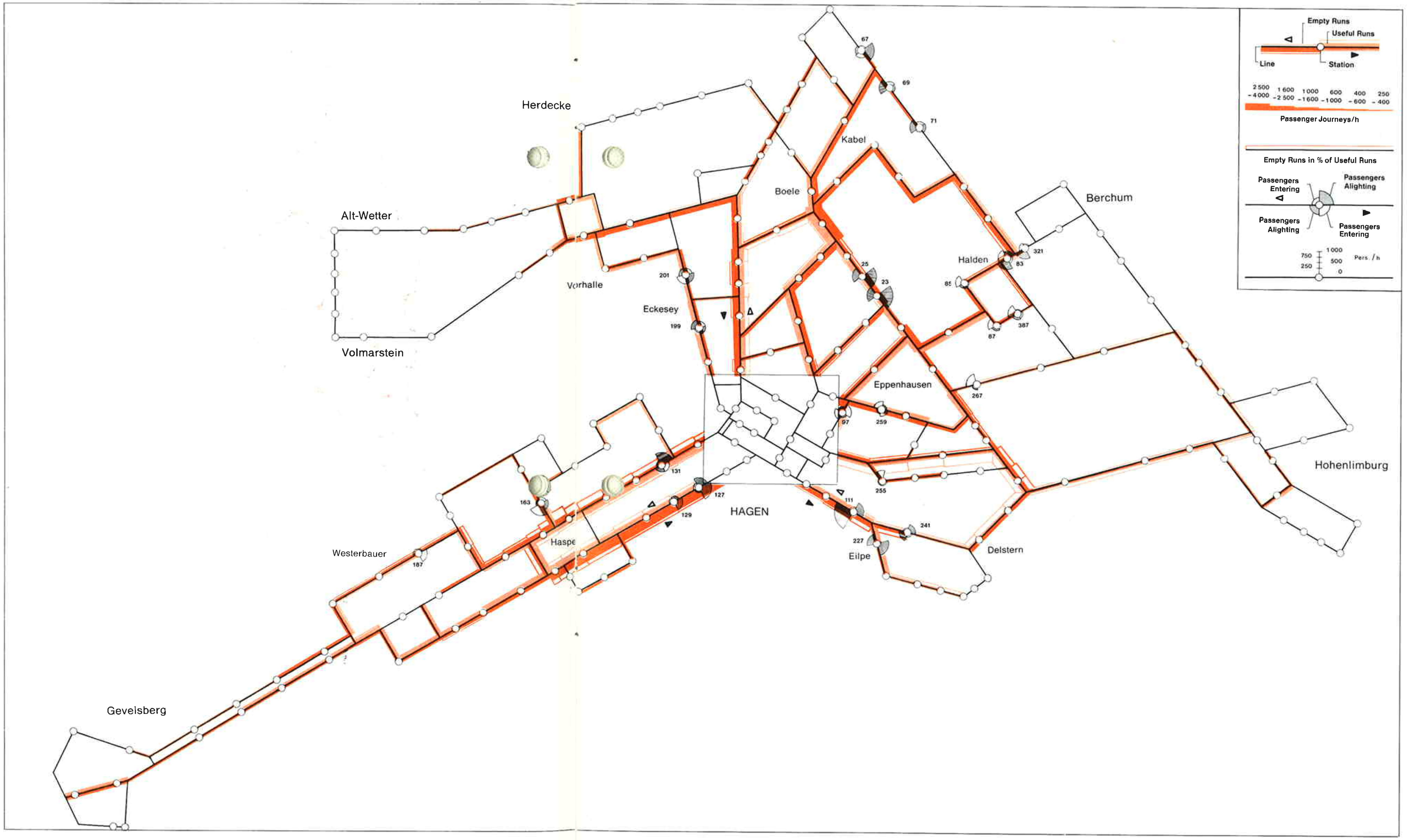
The following are plotted in detail:

- all values split according to direction of travel
- for the links:
  - passenger journeys during the peak hour (identical with the useful journeys at a degree of occupancy of 1.0 passenger per cabin) represented in geometrical graduation
  - empty journeys in % of the useful journeys, established on the basis at a degree of occupancy of 1.0 and on complete information concerning all passenger wishes during the peak hour
- for the stations:
  - passengers entering
  - passengers getting off

For reasons of clarity, the traffic turnover on a line of 250 passenger journeys per hour and station loading exceeding 200 passengers leaving or entering, are highlighted graphically.

The evening peak hour tendency can also be assessed by reversing the direction of travel. Hence, this plan is better suited for assessment purposes than many customary representations of daily traffic or of traffic at a certain hour.

Fig. 6: Load Plan



Traffic turn-over on a line

Low to average demand predominates for passenger journeys. For about 96% of the line length a capacity of less than 4,000 cabins per hour is required (at the pessimistically estimated degree of occupancy of 1.0).

As a rule the empty runs occupy the lines utilised largely for useful runs to a low degree only. This is favourable for the overall line loading during the peak hour.

Loading exceeding the above-quoted value occurs merely for specific collective sections, primarily in town centers.

The fact is neglected that the network control, which is requisite in any case, as well as specific line amendments contribute considerably to relieving the network.

Station Loading

It is anticipated that with this closely meshed transport system, station loading will remain low, namely averaging about 190 alighting and entering passengers per peak hour over both directions of travel.

In general, station loading will only in exceptional cases exceed the figure of 300 passengers alighting or entering per hour and direction (town centre) (Fig. 7).

These values justify considering the question of station capacity as unproblematic.

Station dimensioning is based on the maximum load values occuring during peak hours and in the daily traffic situation.

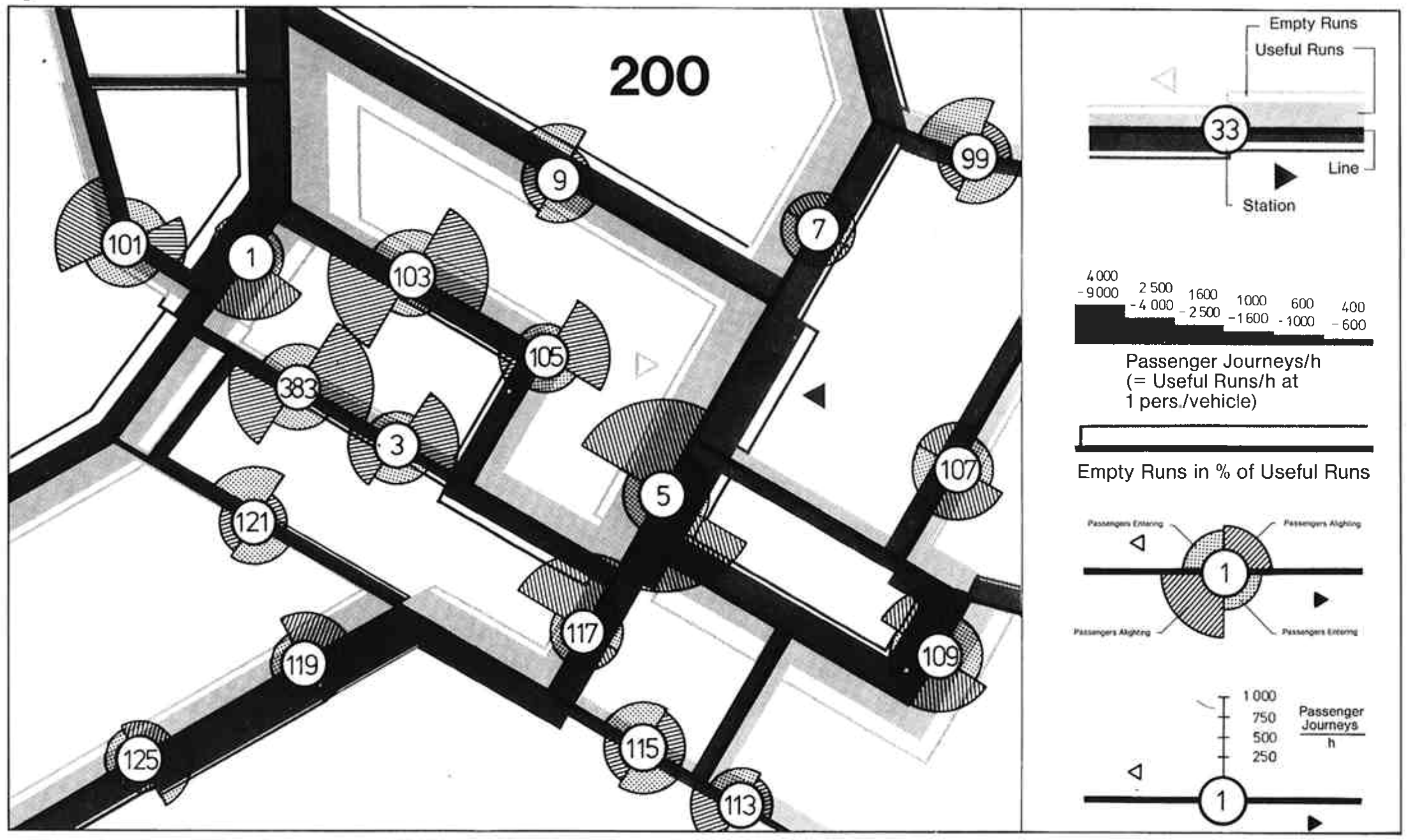
Conclusion

The upper capacity limits as offered by the system conform well with the suburban area structure considered here.

Structural assessment of other average cities shows a similar picture.

With this closely meshed system the network capacity – comprising the specific capacities and taking into account the interconnecting directions of the lines – must also be considered for assessment purposes besides the previously compared individual line and station capacities.

Fig. 7: Load Plan for City



Statistics

The following details constitute an instructive supplement to the load plan. Besides comparing the innovative short-distance transport system with the car, they also permit a demarcation against the conventional means of transport, bus and tram.

Connection times

The travel time comprises the connection time and the ride time. The connection time is the sum of the

- time to reach the nearest station from the starting point of the journey,
- time to reach the ultimate destination from the nearest station.

Walking times are usually required. Additional bus connections are envisaged at some points only (approx. 25 km/h, fixed timetable) (Fig. 8).

Fig. 8: Connection Times

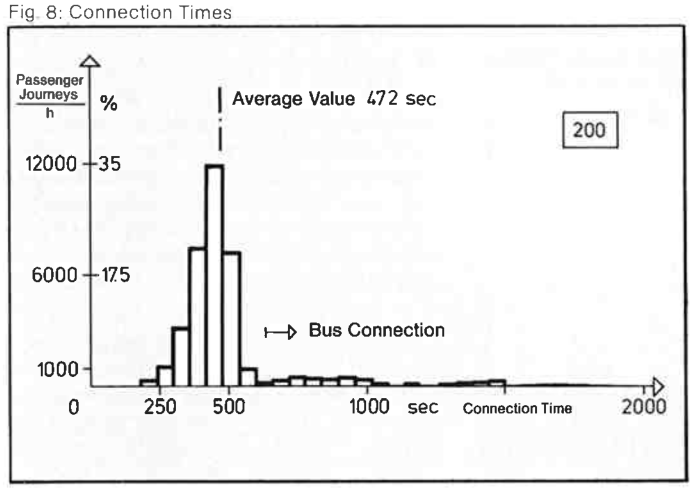


Fig. 9: Ride Times Using Cabinentaxi

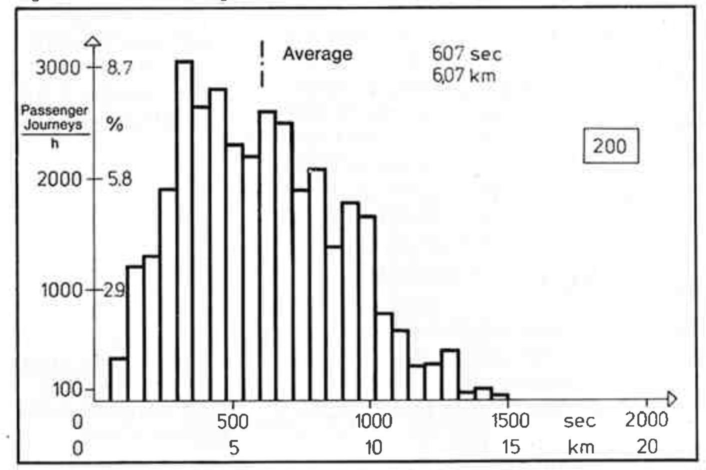


Fig. 10: Travel Times Using Cabinentaxi and Car

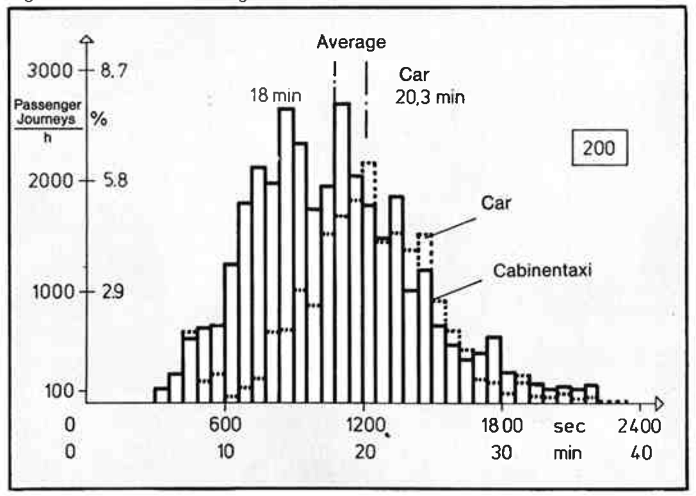
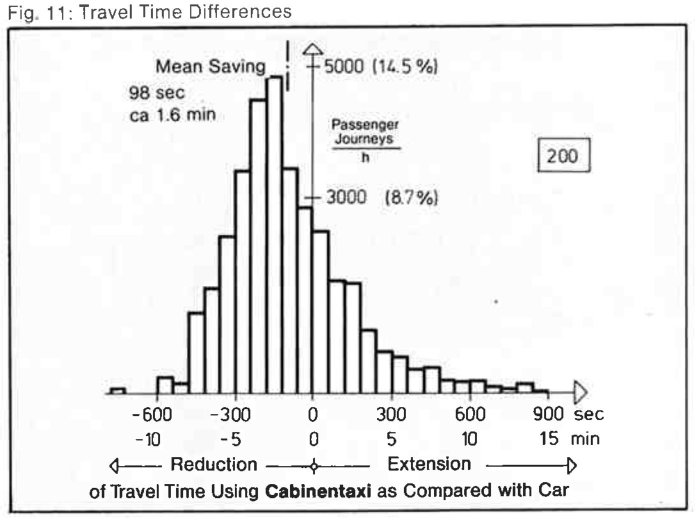


Fig. 11: Travel Time Differences



Ride Times using the Cabinentaxi

The ride time as mentioned here signifies the time needed for the shortest route in the respective Cabinentaxi network between two focal points within traffic zones with a travelling speed estimated as 10 m/s = 36 km/h, weighted with the values of the zone stations breakdown (Fig. 9).

Travelling Times using Cabinentaxi and Car

Travel times using the Cabinentaxi are determined from the connection and ride times for all traffic relations between the zones of the respective network. Car travel times are determined from the ride time plus a time allowance taking into consideration the walk to and from the car and the time needed to find a parking space for all zonal relations. Weighting is effected on the basis of the number of persons using the respective means of transport.

Short and medium journeys are primarily undertaken using the Cabinentaxi, whereas car users predominate on longer journeys (Fig. 10).

Travel Time Differences

The travel time difference is the divergence between the travel time required by a Cabinentaxi passenger and the travel time of a car user. All zonal traffic relations during the peak hour are evaluated statistically.

This basic result for the modal split calculation illustrates that the majority of the passengers (72%) travel more rapidly using the Cabinentaxi than by car (Fig. 11).

Line and station loading

Link loading can likewise be evaluated and represented statistically. The main results have already been described.

Number of Cabins

The number of useful and empty runs calculated for the peak hour and the respective average lengths of journeys determine the overall kilometric performance of all cabins. This yields the minimum number of cabins required, based on the maximum kilometric performance of a single cabin in the peak hour.

The peak hour data for network 200

- transport cases approx. 34,000 passenger journeys/h
- mean distance of one useful run 6.07 km

yield by computation the following number of cabins as a function of the degree of occupancy, the mean distance of 6.0 km covered by an empty cabin (determined at 1.0 passenger per cabin) remains unchanged (Fig. 12).

Fig. 12: Number of Cabins

Degree of occupancy	1,0	1,2	1,4	1,6	1,8	2,0
Useful runs	34 300	28 580	24 500	21 440	19 060	17 150
Empty runs	18 000	15 000	12 860	11 250	10 000	9 000
Number of cabins	8 900	7 400	6 400	5 600	5 000	4 500

Comparison with Conventional Transport Systems

Overall modal split

The previously indicated results provide information as to how the Cabinentaxi users, determined by computation, utilize the system.

The following remarks provide evidence of whether the efficiency achieved by the Cabinentaxi exceeds that of conventional means of transport.

Due to the varying traffic purposes and pertinent modal split models, the final result consists of several components.

The modal split models for business traffic apply to the peak hour 7 – 8 a.m. Here the Cabinentaxi constitutes about 60% of the overall traffic. The same ratios as for the peak hour apply for the business traffic over one day (journeys to and from) Cabinentaxi users constitute approximately 40% of the occasional traffic.

The overall traffic comprises both travelling purposes. Despite the high proportion of occasional trips, the Cabinentaxi portion lies at about 50% of the daily average.

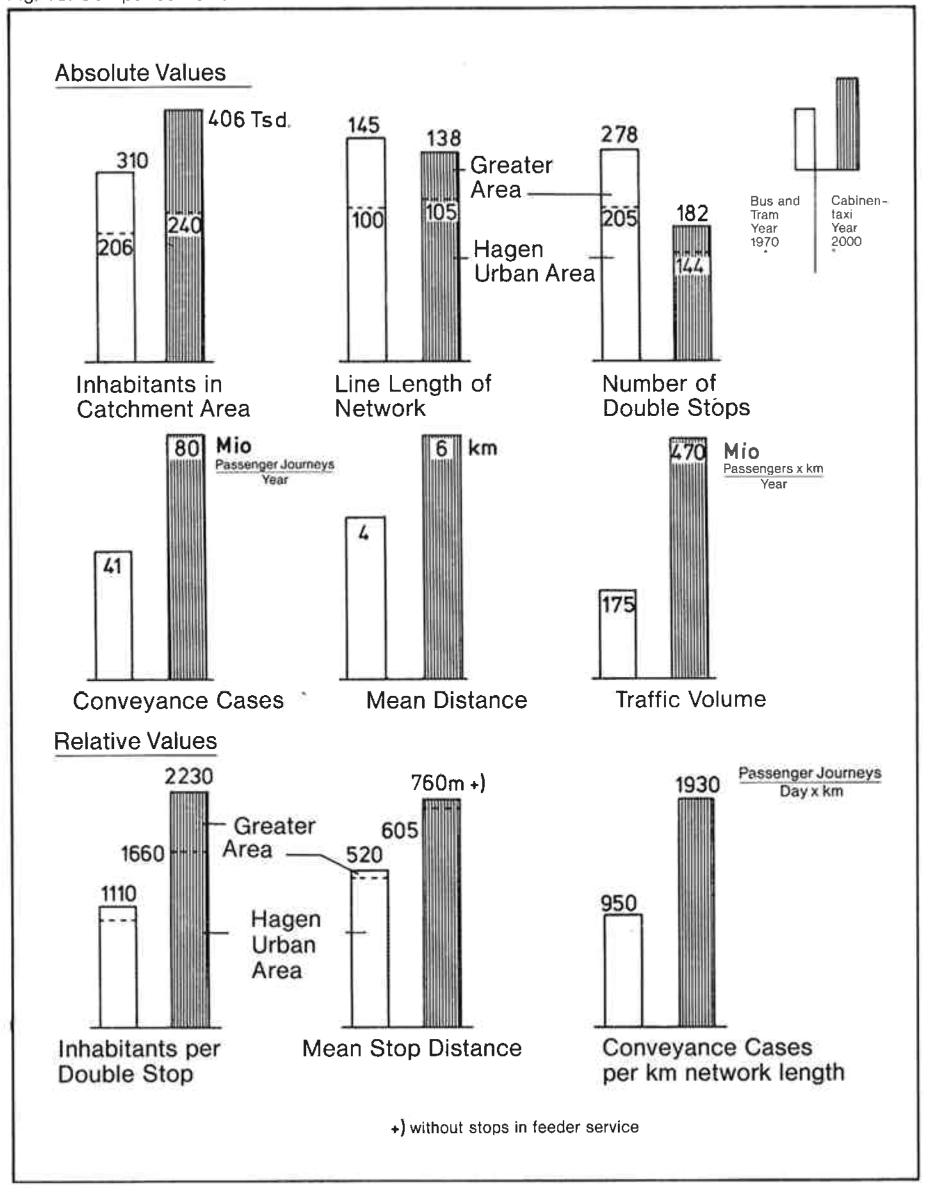
Comparison with today's Bus and Streetcar Networks.

Prior to comparing the prognoses, comparison of absolute (upper and middle row of columns) and relative characteristics is useful for traffic service evalution (Fig. 13).

As far as direct comparable networks are concerned (upper row of columns), transport cases and traffic volume (middle row) will increase for the Cabinentaxi system as against the current status by about 2 or 2.7 times.

The prognosis given in the general traffic plan for Hagen indicates a drop in the transport cases for conventional public short-distance transport means as against present values. This drop is not figuratively represented. The increase in passenger trips per kilometer route length as compared with today's traffic service is worthy of note when considering the relative values (bottom row).

Fig. 13: Comparison of Characteristics



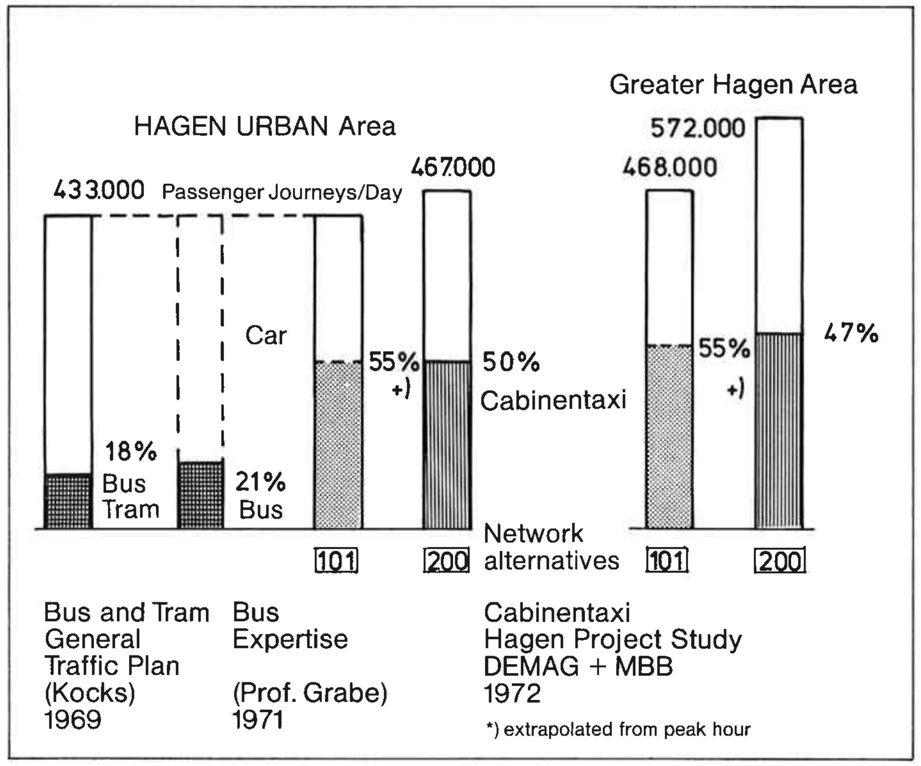
Comparison of prognoses for the year 2000

The similarity of the points of departure permits direct comparison of the results. The results for the two previously mentioned planning alternatives are elaborated here.

The prognoses for conventional public short-distance transport by bus or tram are discouraging. Four out of five road users will in future no longer utilize the alternative offered by public short-distance means of transport but will prefer to travel by car, provided that municipal roads are developed appropriately.

In contrast, the Cabinentaxi will draw every second road user in its favour, if only for the sake of its attractive feature "speed" (Fig. 14).

Fig. 14: Comparison of Forecasts for the Year 2000



Commentary

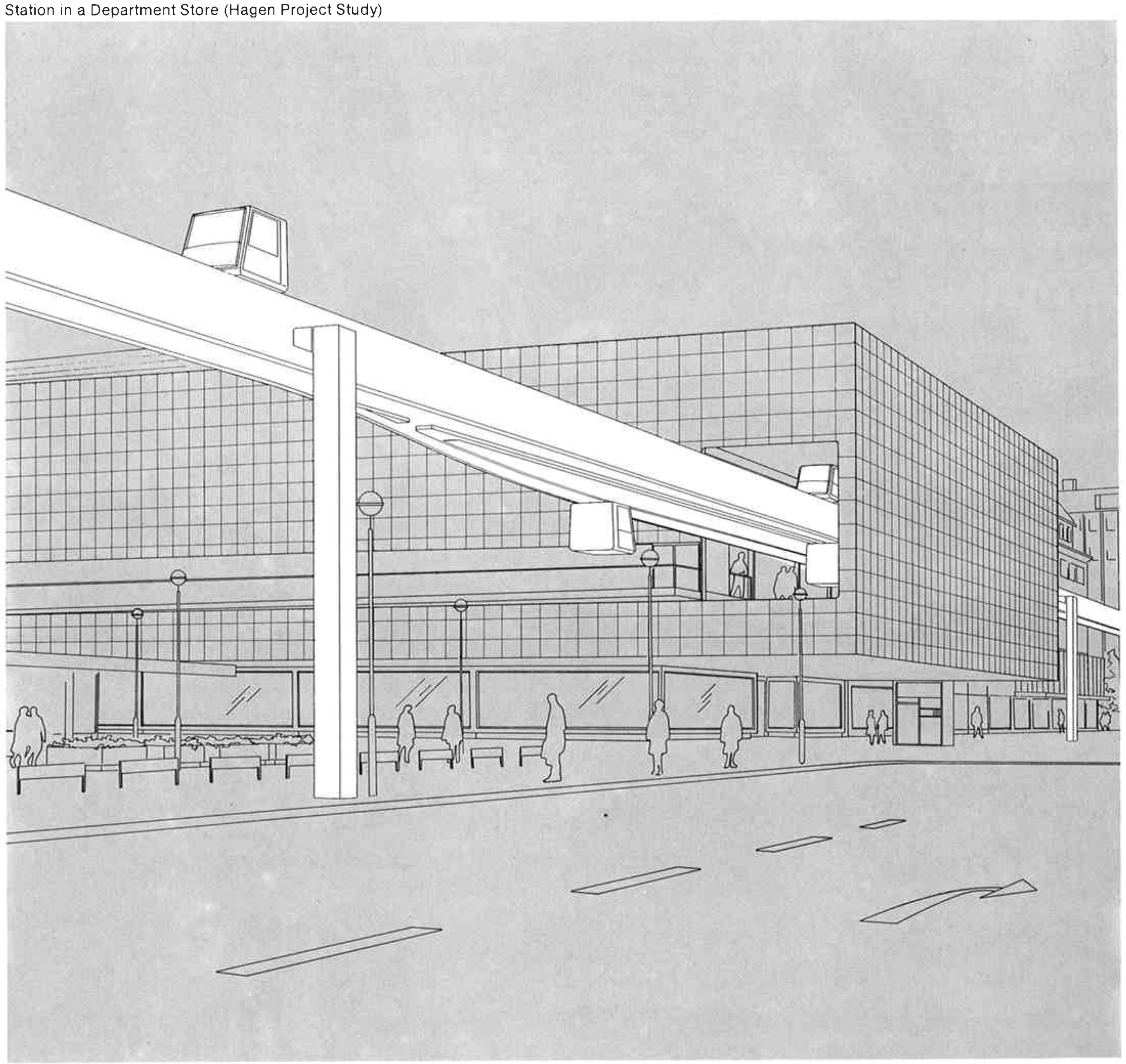
- The proportion of traffic for the Cabinentaxi of approx. 60% in the peak hour and approx. 50% averaged over the day at a travelling speed of 36 km/h is calculated as the current objective of the first realisation stage. The magnitude of the proportion of traffic as against 18 to 21% for conventional public transport means confirms the assumed attractiveness of the novel short-distance Cabinentaxi transport system.
- The prognosis is based solely on the advantage in terms of time offered by a public short-distance transport system and does not pay special attention to additional features attractive to the passenger such as freedom from constraints and convenience.

Summary

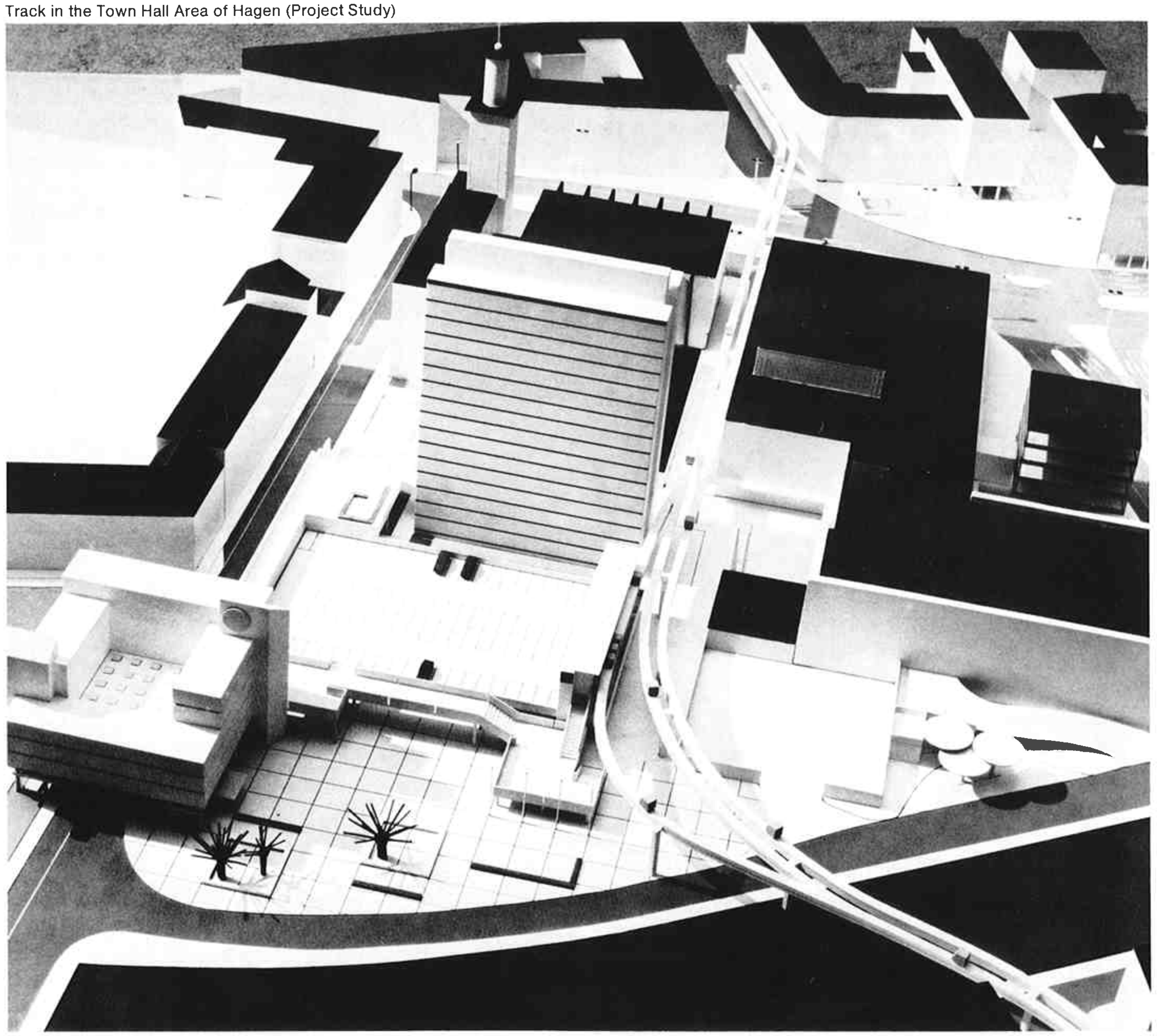
The detailed traffic study for the greater Hagen area demonstrates on the basis of two overall networks that:

- The Cabinentaxi represents a real alternative to the car
- The Cabinentaxi serves a developed area on an average more rapidly than a car on suitably designed municipal roads and moreover, as rapidly, for instance, as a closely meshed underground railway network
- Only about 20% of the overall passenger short-distance traffic was forecast for the conventional bus and tram systems. The Cabinentaxi, in contrast, attracts about 50% of this traffic
- The Cabinentaxi is adequate for coping with the number of anticipated journeys

Station in a Department Store (Hagen Project Study)



Track in the Town Hall Area of Hagen (Project Study)



Concluding Remarks

Serving the greater Hagen area with approx. 400,000 inhabitants on the basis of the Cabinentaxi system is feasible from a transport engineering point of view.

Investigations on various subnetworks with interesting results supplemented the traffic planning.

Moreover, the results of the following studies undertaken by a larger team in cooperation with the Hagener Strassenbahn AG and the Construction Board of the town of Hagen are also available.

Architectural integration of the Cabinentaxi system at prominent points of the town (study conducted on the basis of ground plan alternatives, photographic layouts and perspectives); detailed layout of the routing of a subnetwork as the preliminary stage for the construction planning; determination of investments, service of capital and overall operating costs as well as of fare covering costs.

All aspects of the new short-distance transport systems have not been, herewith, exhaustively handled. Because of this, an analysis contrasting cost and benefits (such as, for instance, absence of exhaust gases, noise abatement, advantage in terms of time, decrease in deaths and injuries due to town traffic) is planned.

Pictures by

Arbeitsgemeinschaft Cabinentaxi
DEMAG + MBB

Literature

1) Nahverkehrssystem Cabinentaxi
Projekt Hagen in Westfalen
Arbeitsgemeinschaft DEMAG + MBB
Juni 1972