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# Morning Peak Hours in the Stuttgart Transit and Tariff Authority

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## ABSTRACT

The problem of traveling on public transportation during the morning peak hours is well known but has not been solved. This is because peak-hour traffic volume can only be reduced if the individuals who have the option of starting work at different times actually make use of this option. However, changing work and school schedules has an impact not only on the transport system but also on an individual's private life. The results of a study conducted by the Stuttgart Transit and Tariff Authority are described. The characteristics of public transit use in the morning peak hours are shown. The potential of transit users who have flexible schedules is indicated and a number of policies to deal with the problem are suggested. Furthermore, the potential number is determined of those who can react to the negative conditions of public transit in peak hours by switching to other modes of transportation.

The focus of specialist discussions geared at finding ways to reduce peak-hour travel is to extend the times when work and school begin (1) over a longer period of time. The effectiveness of policies that might accomplish such a change has repeatedly been proven theoretically but the problem has not been solved. This is because peak-hour traffic volume can only be reduced if the individuals who have the option of starting work at different times actually make use of this option. However, changing work and school schedules has an impact not only on the transport system but also on an individual's private life. Accustomed daily routines are interfered with and usual social contacts are hampered (2).

The Stuttgart Transit and Tariff Authority (VVS) commissioned a team of social scientists to conduct a study (3) in order to get information on the problem of peak-hour travel in a specific area and

on the impact that different policies would have on the problem of peak-hour travel. VVS wanted special attention paid to the social situation of public transit passengers.

VVS serves an area of 3012 km<sup>2</sup> (about 1,145 miles<sup>2</sup>) with a population of 2.14 million. In 1979, 655,000 passenger trips per weekday were made by buses, streetcars, and S-bahn (rail rapid transit) in the system (4). About 13 percent of these trips are peak-hour trips in the definition of this study (incoming traffic to the central zone of the service area between 6:00 and 8:00 a.m.). During the morning peak hours, public transit is used to the limit of its capacity.

The study of peak-hour traffic was done in two stages. From a regional travel survey (5) there was information on 67,700 persons and 51,900 public transit trips. These data were used for a descriptive evaluation of peak-hour travel. They also gave the base for in-depth interviews with a subsample of 316 households in which peak-hour passengers lived. The results of these interviews are presented in this paper.

## FLEXIBILITY OF PEAK-HOUR PASSENGERS

The analysis is based on those trips recorded in the travel survey that are defined as peak-hour trips. For these trips, it must be determined whether and under what conditions flexibility in scheduling is possible.

To make temporal flexibility operational, a 30-min adjustment in the beginning time of trips is used in accordance with the literature on the subject (6). An interviewee is said to be flexible in scheduling his time if he can organize his daily routine so that the peak-hour trips can be made either 0.5 hr earlier or later.

For the situational analysis, all of the characteristics explored in the interview that pertain to the individual and the trip and that are of explanatory value in the given instance are used. Thus, it is necessary to divide the temporal variability into individual dimensions to which the characteristics determining the situation can be assigned (see Figure 1).

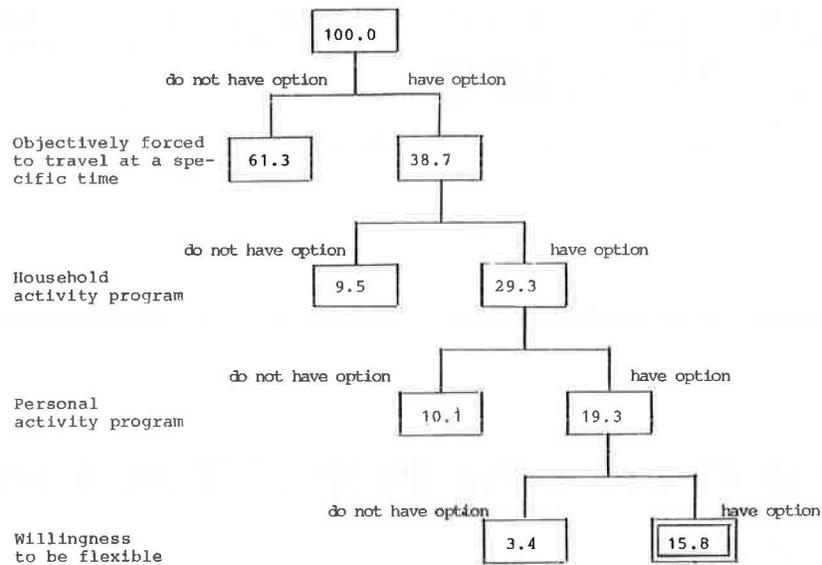


FIGURE 1 Option of traveling at another time: situational groups.

### Objective Time Constraints

The objective necessity of traveling at a specific time depends on the extent to which given conditions, externally fixed appointments, and so on, limit a person's flexibility. This included, on the one hand, appointments at specific times at the destination of the trip made during the peak period (such as the beginning of work) and, on the other hand, the service offered by the public transit system. The most important objectively fixed times are the beginning of work and school. Constraints caused by departures of and connections between the VVS vehicles are negligible. Of all the dimensions, objective time constraints include the greatest proportion of those with no options. This shows how important new policies in this area could be.

### Household Activity Program

In the second dimension, the influence of the household activity program in keeping the peak-hour passenger from making his trips during off-peak hours was investigated. Activities with other family members or household members can be of a similarly obligatory nature as externally fixed appointments (7, Chapter 3).

Restrictions occur when the activity program of the entire household would have to start earlier if the individual in question were to begin his peak-period trip earlier. The time schedule of the other household members does not always make this possible, however. In a few instances, time limits occur because multiperson trips (e.g., taking passengers to the public transit stop) are made that cannot be made either earlier or later.

Eating and preparing meals together during the morning, evening, and especially at midday is one of the most important fixed activities of the household. Joint leisure activities and other occupations in the house and outside the house are less important in limiting the flexibility of peak-hour passengers.

### Personal Activity Program and Willingness to Be Flexible

Because the peak-hour trips made by the individuals studied were almost always the first trips of the

day and because they were usually trips to work or school, that is, mandatory activities of a definite duration, making the same trip either earlier or later would affect the entire daily routine, from getting up in the morning to going to sleep at night. Changing this personal activity program, which is frequently subject to externally fixed times in personal, and especially in social and leisure, activities, is difficult for many of those traveling during the peak hours.

A superficial view of the problem leads one to conclude that "soft" constraints more or less predominate, such as getting up too early or leaving work too late. However, one should not forget that this is not merely unpleasant but also restrictive to the entire activity program as it exists: If a person starts work either earlier or later, this means that the hours that he keeps no longer fit the routine of his social environment. A person's willingness to be flexible in scheduling his time naturally also influences potential rescheduling.

An individual can only make his peak-period trip either earlier or later if he has the option of behaving differently open to him in all of the dimensions. This shows one the proportion of trips that are definitively determined by each dimension and also which group of persons has no reason not to make their peak-hour trips either earlier or later (Figure 1).

The restrictions to travel at certain times are the most important reasons why trips are made at specific times; three out of five persons are restricted because of this dimension. Because of their household and personal activity programs, another 10 percent of the peak-hour passengers are not free to make their trips at other times. Only every 30th peak-hour passenger travels at the time he does because he is subjectively unwilling to be flexible in scheduling his time. Of all passengers traveling during peak hours, approximately every sixth peak-period passenger (15.8 percent) has open the option of traveling at another time. This defines the upper limit of the current potential of persons flexible in scheduling their time if no steps are taken to change the status quo.

### Situational Analysis

It is possible to show individual temporal flexibil-

ity under changed conditions by using this situational analysis of options. The model structure can be used to show the impact of eliminating fixed schedules on the potential number of persons flexible in scheduling their time. This can be done for each dimension. Thus, the situational group model is used to show the change in temporal flexibility that results when the restrictions usually existing in the various dimensions are eliminated. This so-called dynamized situation then shows how many of the relevant peak-hour passengers then enter the situational group with options and how many are still subject to restrictions in other dimensions.

The dynamization of the dimension of being forced to travel at a specific time shows the situation when the externally defined restrictions for beginning the peak-period trip, that is, the time when work begins or school begins or other appointments at the destination begin or the public transit schedules, are eliminated. The peak-period passengers who are not flexible because they are forced to travel at a specific time account for 61.3 percent of the total, the largest situational group. Thus, doing away with these external constraints would have an especially great impact on travel.

Surprisingly, however, the result of the dynamization is that the group with options only increases by 16.7 to 32.5 percent. Not even every third peak-period passenger who is forced to leave when he does in the morning because of externally fixed appointments can (or wants to be) flexible in scheduling his traveling time when the appointment begins at a different time. The majority of the two-thirds of the peak-period passengers in this situational group are inflexible in scheduling their time because of constraints in other dimensions.

When the restrictions to travel at specific times are eliminated, the restrictions caused by the personal activity program become more important than other dimensions in defining the options that a person has to travel at another time. One can assume that the additional temporal flexibility will not change the behavior of 13.2 percent of the peak passengers studied because their daily routines would then begin either too early or too late.

It is important to note that if the objective time-scheduling restrictions are eliminated, the peak-period passengers might still be subject to constraints, because some of the passengers are influenced by constraints not only in one dimension but also in other dimensions. When persons are no longer objectively compelled to travel at specific times, the situation for those with fixed work hours and flextime is similar for all the situational groups.

Thus, surprisingly enough, the greater freedom of those with flexible work hours is not reflected in their scheduling their hours more flexibly or their being willing to reorganize their daily routines. Even those on flextime are subject to a routine and their activity programs are quite regular. It has frequently been shown that when flextime is introduced, it is not used in a manner to effectively reduce peak-hour travel; most people tend to continue to start work at the same time as previously.

For purposes of comparison, the result in the other dimensions of doing away with the restrictions will be discussed. In contrast to the group of peak-period passengers forced to make their trips at specific times because of objective constraints, the other situational groups are naturally less important, because on the one hand they are more difficult to influence by putting different types of policies into effect and on the other hand they are considerably smaller. Thus, the impact that might be expected is limited from the start.

When constraints relating to the household activ-

ity program are eliminated, the group of persons with options is increased by only 1.2 percent. Most persons are subject to other constraints because of their personal activity programs.

The impact of policies aimed solely at the personal activity program is only a minimal increase (3.9 percent) in the size of the group with options. The majority of persons forced to travel at specific times are not willing to change their daily routine. Those with options are the target group whose traveling might be done at other times than during peak hours. Thus, it is worthwhile to look at this group more closely and to characterize the individuals according to sociodemography, attitudes, and behavior. Of those persons with the option of traveling at another time:

1. Two-thirds are male,
2. All are over 18 years of age,
3. Those who are employed are most flexible as regards time,
4. More than two-thirds work at places of employment that have flexible work hours,
5. An above-average number of persons in this group (three-fourths) have a car that is always or sometimes at their disposal,
6. Their displeasure caused by the overcrowding of the vehicles is somewhat greater than average,
7. More than 50 percent use commuter rail as their primary transit mode, and
8. The proportion with a pass for public transit is somewhat smaller than average.

A target group is thus defined that can be approached with information and motivational strategies. For this purpose, it is of great practical importance that a large number of these target persons use the S-bahn as their primary travel mode and can thus be directly approached there.

#### POLICIES TO REDUCE PEAK-HOUR PASSENGER CONCENTRATION

Based on the results of the situational analysis, measures can be deduced to increase flexibility in scheduling time, and the effectiveness of these measures can be studied. Steps can be taken to increase temporal flexibility in all of the dimensions responsible for determining travel situations. Thus, possible measures can be discussed based on these dimensions.

The reasons persons are objectively forced to travel at specific times are more or less governed by the times when work and school begin. For about 4 percent, the set travel time is determined by the VVS connections.

It is possible to alter these temporal restrictions by having work begin either earlier or later or by introducing flextime. Both of these steps have a number of advantages and disadvantages. Changing the fixed hours when work begins has a greater impact on reducing peak-hour travel than introducing flextime, according to available model calculations. However, a prerequisite for this change is a planning scheme tailored to the local situation; that is, the time when work begins in the participating employment sites must be coordinated to suit the location and the transit conditions.

A situational analysis of temporal flexibility shows clearly that if people are forced to begin work either earlier or later, only one-third of those affected would be subjectively or objectively flexible in scheduling their time. This means that changing the time when work begins would cause more or less severe scheduling conflicts for household and personal activities; it would also cause prob-

lems on another level because persons would be unwilling to reschedule their activities.

Thus, in order to reduce the number of objectively fixed time schedules for employed persons, flextime should be introduced; it is then possible for the individual peak-hour passenger to voluntarily travel either earlier or later. This makes it possible for the passenger to optionally reorganize his daily routine on an individual basis to adjust to the new conditions. In order to encourage a large enough number of individuals to make use of flextime in such a way that it will have an impact on the reduction of peak-hour travel, supportive measures that inform people of the advantages of traveling at other times and motivate them to use their flextime accordingly should be used.

There is additional potential to be gained by adding those whose flextime does not allow them to travel at another time for the time being. All in all, doing away with objective time constraints can increase the group of employed persons with the option of traveling at another time by 16.1 percent. This reflects an increase of 9.7 percent for all peak-period passengers.

Decreasing objective time constraints for persons traveling to school or training sites is mainly possible by changing the time when school or training hours start. Giving students more leeway to organize their daily routines is usually impossible. Situational analysis shows that a high proportion of school children and trainees are restricted by other dimensions when lessons start either 30 min earlier or later. Thus, rescheduling will cause problems for most of this group. The rescheduling should therefore be kept to a minimum and the effects of this rescheduling should be cushioned by supportive steps in the other dimensions.

The proportion of VVS passengers forced by VVS connections to travel when they do is very small; it is only 4.4 percent. Thus, taking steps (usually quite expensive) in this area would have only a minimal impact. Also, to the extent that flextime is introduced, restrictions in this dimension will be reduced, because persons will then have more leeway in deciding when to begin their trips to work.

The possible impact of eliminating restrictions caused by the household activity program is minimal when compared with the impact of changing the time when work and school begin. Furthermore, it is also difficult to influence household activities. It is only possible to take steps that would make it easier for households to reorganize their activity programs, that is, steps that would have only an indirect influence on the households.

The two single most important components of the restrictions on time scheduling in this dimension were identified as household activities in the morning and the family lunch at midday. In the first case, different solutions would have to be found in each household; at the most, the possibility of coordinating activities could be increased if flextime were introduced.

On the other hand, it is possible that friction because of household activities in the morning would increase even more if peak-hour travel were reduced and the times when work and school began were dispersed. It is not possible to suggest here any specific steps that might be taken.

However, the fixed times set for eating lunch together, which cause peak-period trips, could be eliminated (especially for school children) by making it possible for them to eat lunch at school or by introducing all-day schools. Furthermore, one can expect that as a result of shorter work hours and an increased number of schools that do not hold classes on Saturdays, there will be more time for household activity programs.

In some ways, people have more leeway in rescheduling their time when they are subject to personal rather than household restrictions. In the former case, only the peak-period passenger himself is affected by rescheduling; in the latter case, the whole household is affected.

In these dimensions, the most important reasons why people have time schedules that leave little leeway is that they think that rescheduling their time would force them to begin everything either too early or too late or that they could no longer punctually begin their leisure-time activities, such as running errands and shopping in the evening.

If shops were open longer, this would have little impact on whether peak-period passengers would travel at different times. It would be more effective to reduce subjective reasons for not beginning daily routines either earlier or later. In light of the high stability and routinization of the personal activity program, it would be helpful if the target persons became more conscious of the existing options open to them to reorganize their daily routines. The reorganization of the personal activity program would be simplified if externally fixed times and time limits were done away with such as the times when recreational facilities (e.g., sports arenas, restaurants, cultural establishments) open and close.

Given current conditions, the potential that can be attained by taking steps of this sort is naturally also limited. A large number of those who are not free to reschedule their daily routine due to their personal activity programs must be encouraged to willingly reschedule their routines before behavioral changes can be expected to occur.

Those persons inflexible in rescheduling their time due only to their personal unwillingness to be flexible currently account for 3.4 percent of the total. This group increases to the extent to which temporal restrictions are eliminated in other areas. This shows how important it is to take steps to convince people that they should change their behavior, irrespective of what other policies might be introduced.

Two aspects can be emphasized in approaching the foregoing group:

1. Give them information about the problem of peak-period travel, showing the extent of peak-period demand and the problems that this causes; this convinces the individual of the importance of his own personal contribution.

2. Show them how much more comfortable it would be for them to travel at other times and emphasize other advantages of their traveling either before or after the peak period.

Informing those persons with the option of traveling at another time of the advantages of traveling during off-peak hours can have a positive impact on their travel behavior.

The question of how the absolute peak demand of the VVS might be decreased will be supplemented by more far-reaching considerations at the end of this paper. The negative effect of the peak-hour demand on the public transit system is caused less by the absolute number of passengers during these times than by the highly variable demand during the day. Thus, the supply during the peak hours is also limited by the lesser demand during off-peak hours. Therefore, if it is possible to increase the number of passengers during the off-peak (later morning and evening) hours, when there are relatively few passengers, it will indirectly be easier to cope with the peak hours.

This emphasizes the importance of an integrated marketing concept. Peak-period passengers are thus

not the only target group. For this reason, information strategies and public relations measures should also be aimed at potential VVS customers using public transit for occasional trips and leisure activity trips.

Policies to increase flexibility in scheduling time can be aimed at all of the dimensions that are responsible for determining the travel situation. In Figure 2, examples of the most important policies are summarized, and a highly simplified evaluation has been made based on the following criteria:

1. Size of the potential influence of the policy,
2. Type of impact (voluntary or mandatory),
3. Degree to which conditions can be influenced by introducing the new policy, and
4. Ability of the transit authority to put the policy into effect.

MODE CHANGE

Overloading can result in switching to other modes of transportation. In order to study the impact of this problem on public transit, passengers' options of switching to other modes were determined and the probability of a change in modal choice resulting from decreased comfort during the peak hours was estimated (8).

The analysis shows that every tenth passenger basically has the option of using an alternative mode of transportation (see Figure 3). However, to a

particularly large extent, peak-hour passengers are forced to use public transit due to the travel time, that is, the speed of public transit in comparison with other modes of transportation.

If one surveys the results of the modal-split conditions for commuting and school travel, driving a car is a potential alternative mode that is mentioned relatively rarely. The bicycle and passenger in a car are modes mentioned considerably more frequently.

CONCLUSION

This study has proved that the problems resulting from peak-hour travel are complex and that there are few generally valid solutions to the problem. Although it is proper and helpful to point out the high costs incurred by the transit authority because of peak-hour travel, it must be noted that public transit is a form of transportation designed for the majority; thus, public transit is destined to cope with peak-hour volume. Furthermore, most peak-hour passengers are subject to constraints. Thus, it is frequently impossible or inconvenient for passengers to travel at those times that the public transit managers deem to be desirable.

One of the most important insights of the study is that individual activity programs are highly stable and routinized. Even if people were totally free to determine when they would start work and school, this would have only a limited impact on

DIMENSION	EXAMPLE OF POLICY	Can be Actualized			
		Effectiveness of Policies	Voluntary in Nature	Applicable	Implementable
Objectively forced to travel at a specific time	1) Changing fixed time when work begins, staggered work hours	+	-	+	-
	2) Introduction of flexi-time	+	+	0	-
	3) Changing time when school begins	+	-	+	-
	4) Improving VVS connections	-	+	+	+
Household activity program	1) Eliminating "mandatory" family lunches	0	+	0	-
	2) General Extension of time during which household activities can be participated in	0	+	-	-
Personal activity program	1) Extending closing hours for shops	-	+	+	-
	2) Pointing out existing re-organisational options	0	+	0	0
	3) Decreasing objective time barriers	0	+	0	0
Willingness to be flexible	1) Information on the problems caused by peak hour travel and demonstration of increased comfort which is possible	0/+	*)	+	+
*) In combination with other policies		+ =high 0 =medium - =low			

FIGURE 2 Policies to increase temporal flexibility and evaluation of effectiveness.

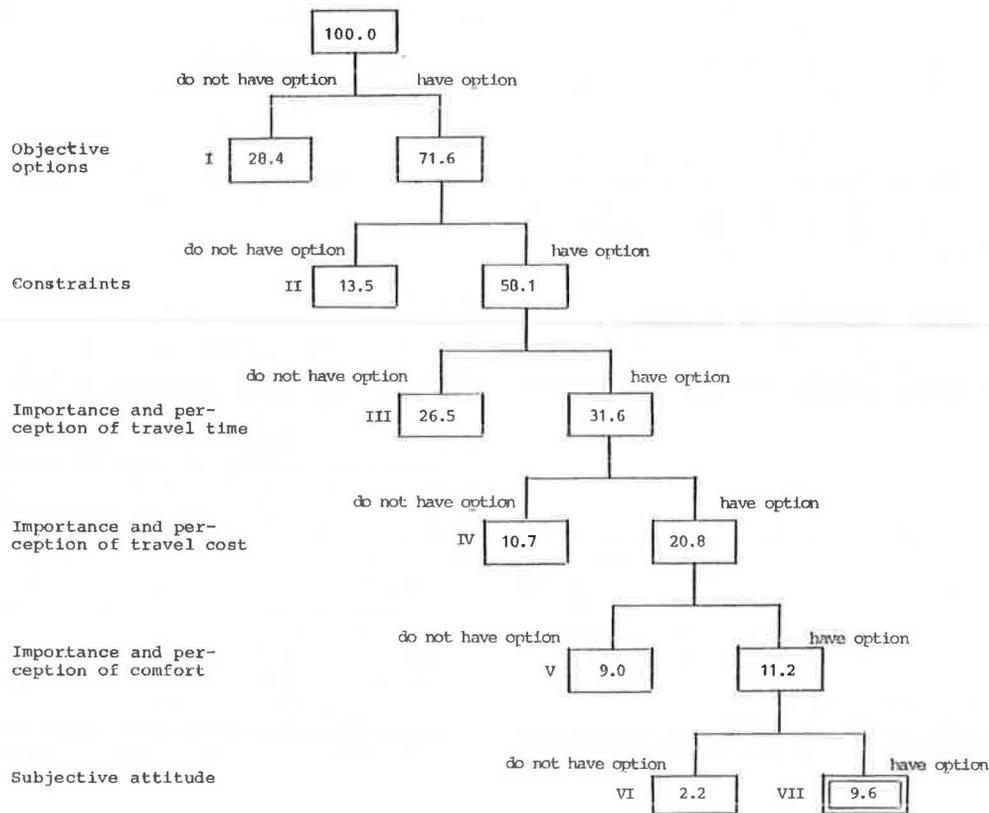


FIGURE 3 Option of changing mode of transport.

solving the problem of peak-hour travel. Furthermore, in the VVS, especially in the rapid rail transit system, the S-bahn is well frequented during the entire rush-hour period. Therefore, if the S-bahn were used somewhat earlier or later, this would simply transfer the problem from one train to the next. If the trips were postponed until after the current peak hours (about 8:00 a.m.), this would result in increased costs (especially for personnel), which could not be neutralized by cutting back on expenses elsewhere.

The capacity of the S-bahns in Stuttgart could also be increased by adding additional multiunit trains (trains with three units instead of two units). Although this involves investment costs, if the multiunit trains could make it possible to increase the capacity of the trains enough to cope with peak hours, in the long run this would probably be the most economical solution.

Decreasing the passenger load in transit vehicles by changing the times when schools start seems to be promising only when used in specific instances.

Two groups have been pinpointed who should be informed about the problems caused by peak-hour travel for the VVS and who should be encouraged to reconsider their travel behavior and possibly change their travel habits in a manner that would be positive for the public transit system. One of these groups is those passengers (10 percent) who have the basic option of not using public transit; the other group consists of those who could travel at another time.

Furthermore, businesses, public authorities, and administrations should be encouraged to introduce flexitime in order to increase the proportion of passengers flexible to travel at other times. Success is possible, if at all, only over longer periods of time; much patience is needed.

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