

## The Impact of Intelligent Transport Systems on Office Location Attractiveness: Testing the Predictive Validity of a Location Choice Model

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In recent years, a model was developed describing effects of Intelligent Transport Systems (ITS) on location preferences of office-keeping organisations in urbanised. The model is based on a Hierarchical Information Integration Approach, using Stated Preference data. The model indicates that ITS significantly contribute to office location preferences. This article presents an analysis of the predictive validity of that model. Office keeping organisations in two medium-sized Dutch cities (Nijmegen and Arnhem) were asked to evaluate existing office locations assuming different ITS scenarios. The analyses show that the model systematically underestimates the attractiveness of office locations. However, the part worth utility scores, describing the contribution of ITS to location preferences, appeared to be good estimators of the added value of ITS. Moreover, the ranking position that responding organisations give to the office locations in their cities is estimated properly by the model.

*Keywords:* Intelligent transport systems (ITS), Office location choice, Hierarchical information integration model, Stated Preference.

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## 1. Introduction

Due to changes in the accessibility levels of regions, cities and specific locations, many questions arise about the nature of the causal relationship between new transport infrastructure services and spatial patterns of location development (see e.g. Vickerman et al., 1999; Meurs & Haaijer, 2001; Banister, 2002). These questions intensify since many innovations are to be expected in the next decades due to the increased implementation of information and communication technology (ICT) in transport systems (Nijkamp et al., 1996), resulting in what is called Intelligent Transport Systems (ITS). ITS include a wide range of in-vehicle and/or infrastructure based electronic devices, which seem to hold many keys to improve the performance of the transport system. Consequently, ITS receives much interest from governmental bodies since they could contribute significantly to transport policy goals. However, many uncertainties about the nature and effects of implementation do exist (Van der Heijden & Marchau, 2005) and one of them concerns the spatial impacts of ITS (see e.g. Miller et al., 1997, Johnston & Rodier, 1999, Janelle & Gillespie, 2004). In a recent academic study, therefore, the question was tackled whether and how the spatial distribution of office locations will change in case ITS-based transport concepts are deployed at a large scale (Argioli, 2008). The aim was to develop a model for location choice behaviour of offices under different ITS conditions. The model specification and calibration have been published in another article (Argioli et al., 2008).

A morphological analysis (see e.g. Zwicky, 1967) was applied, including the identification of key variables from literature, the systematic combination of different values of these variables and the elimination of inconsistent and non-plausible combinations. This resulted in three rather different ITS concepts (see text box 1): (1) a concept stimulating regional/inter-city accessibility by creating a network of automatic car lanes, comparable to the concept that was studied in the USA in the nineties (see Ioannou, 1997), (2) a concept stimulating intra-urban accessibility by creating a network of automatic bus lanes (for example the Phileas concept as applied in the Dutch City of Eindhoven; see Van der Heijden et al, 2006), and (3) a concept improving local access of business areas by introducing a connecting automated people mover service from Park & Ride facilities along motorways. E.g. in the Dutch city of Rotterdam, a comparable people mover concept has been implemented in the past decade, connecting a railway station to an office business area. To model the potential impact of these ITS concepts on business (re)location choices, a model was estimated based on the Hierarchical Information Integration (HII) approach proposed by Louviere (1984) using stated preference data (e.g. Timmermans, 1982). To collect SP data hypothetical profiles of office locations were specified including attributes of ITS-related transport concepts. More details will be described in the next section.

The results of the estimated SP/HII model (Argioli, 2008; Argioli et al., 2008) can be considered as promising for at least the scope of the conducted study: Dutch medium-sized cities. It was found that ITS concepts do significantly contribute to total accessibility and that, at its turn, accessibility of an office location does significantly contribute to the overall preferences for office locations. According to these findings we expect a change in location preferences of office-keeping organisations for specific locations in a medium sized city region in case ITS-related transport services, based on the three concepts mentioned above, would be implemented in that city region. These findings, however, do not guarantee that the model also has a good predictive validity. It was not tested whether the model predicts the changes in attractiveness of office locations and preferences of business managers for these locations well in case certain ITS facilities and services in the neighbourhood of these locations are implemented.

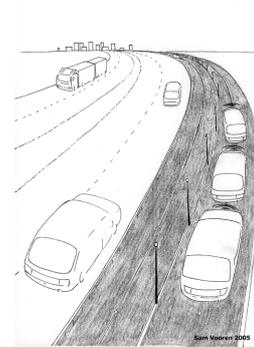
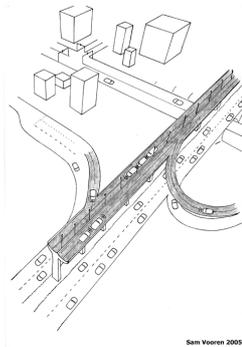
The debate on validating SP models with regard to predictability is not new (e.g. Van der Heijden & Timmermans, 1988; Slovic, 1995) and linked to the use of experimental designs. Although overall SP models can provide a reasonable account of individual's later choices (Wardman, 1988), the predictive validity is a common concern. For instance Wardman (1988) found that

some stated choice models did not predict actual choices in travel behaviour very well. A study by Couture & Dooley (1981) also showed a considerable bias between the stated use before and the actual use after the introduction of a new fixed-route bus system. Chatterjee et al. (1983) reported a high number of non-commitment bias in studies on bus user services. It was found that people were not consistent when stating a use before and the real use after introduction of a bus. The use was overestimated. In general it is observed that actual behaviour in some cases differ from intentions and modelled expectations (Warshaw & Davis, 1985). The predictive validity of SP/HII models is influenced by issues such as the relevance of the situation to individuals, the extent of realism in the design and the lack of incorporation of situational factors in the model (Bradley, 1988). In order to increase the predictive validity of SP models, customisation of profiles by the use of real-world situations has been suggested (Polak & Jones, 1991).

### Text Box 1. Descriptions and artist impressions of the three ITS-related transport concepts as used in the HII study

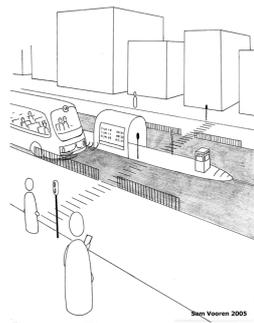
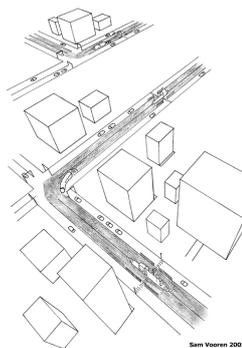
#### Automatic car lane

The *automatic car lane* involves one dedicated lane per driving direction added to the existing motorway. Cars equipped with a so-called *Autopilot* are enabled to drive fully automated on this lane. The *Autopilot* guarantees that the car keeps automatic distance to the proceeding vehicle (longitudinal control) and that the car keeps driving within the lane (lateral control). Due to automatic guidance by traffic management the travel time on this lane is guaranteed. To use the lane, drivers need to pay a fare. The automatic car lanes connect major parts of an urbanised area.



#### Automatic bus lane

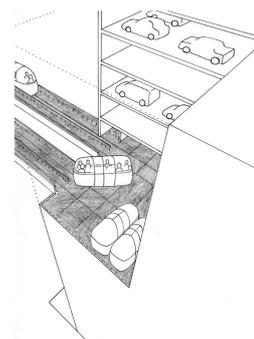
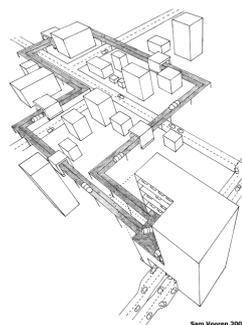
The *automatic bus lane* consists of a semi-electric driven bus which uses a dedicated lane. The bus has right of way at crossings. The bus timetable is based on high frequencies of bus departure and arrival. The bus drives fully automated and does not need a chauffeur. Instead, a supervisor is present on the bus for control of the vehicle and passengers. Passengers receive real time information on departure and arrival times of the bus. Further, the passenger is guaranteed that the bus sticks to the time schedule. The *automatic bus lanes* connect important activity centres within a city region.



#### People Mover from Park and Ride

The *People Mover from Park & Ride* offers car drivers the possibility to park the car on a Park and Ride facility and to finish the trip by using a People Mover vehicle. The People Mover is a small ( $\pm 15$  passengers) vehicle which is fully automated. Car drivers that want to use the *People Mover from Park and Ride* are already informed in the car about available parking places. The People Mover departs with a high frequency.

The *People Mover from Park and Ride* has an unlocking function for e.g. office parks.



The aim of the article is to describe three predictive validity tests for our SP/HII model on the impact of ITS on office choice behaviour: does the model consistently and sufficiently predict changes in attractiveness of office locations in case the transport accessibility of these locations changes due to the implementation of ITS facilities and services?. Section 2 first summarises the developed SP/HII model, which is crucial for understanding the remainder of the article. Section 3 describes the set up and execution of the data collection to enable the predictive validity tests of the model. Section 4 describes the results of these tests. Finally, section 5 draws some conclusions.

## 2. Summary of the HII model describing office location choice behaviour

### 2.1 *The structure of the model*

As mentioned, a model based on Stated Preference data was developed. The selection of relevant attributes to be included in the model was based on a literature review. Empirical studies of Louw (1996), Van Dijk et al. (1999) and Pen (2002) indicate the relevance of attributes describing the accessibility of a location and features of the office real estate, such as the age, floor space or price. The attributes representing the ITS concepts are of a lower hierarchical level, as they influence the value of the construct variable *accessibility*. Consequently, a straightforward application of the standard SP approach was not possible. Therefore, we assumed that firms apply a hierarchical evaluation procedure in evaluating the total attractiveness of an office location. This implies that the contribution of different factors, including ITS, to the aggregate level of accessibility is assumed to be evaluated before a trade off is made between the aggregate level of accessibility and the levels of other important features of a location. To model this hierarchical decision problem, we adopted the Hierarchical Information Integration (HII) approach suggested by Louviere (1984).

Two experiments were developed for collecting data to calibrate the hierarchical stated preference model: one for measuring the relative impact of different variables on accessibility of potential office locations, and one for evaluating the total quality of these locations. In the first experiment, respondents were asked to trade-off a set of accessibility attributes. For example nearness to a train station might be valued less than nearness to a motorway on/off ramp. In the second experiment, respondents had to trade-off attributes describing the total quality of the office location of which one attribute refers to the aggregate value of accessibility. The predicted scores of the first experiment determine the aggregate accessibility levels in the second model for the specified location profiles. This allows the indirect estimation of effect of accessibility attributes from the first experiment on the overall location preference in the second experiment.

### 2.2 *Data collection*

Referring to details in Argiolu et al. (2008) we only summarize the mainlines in this subsection. The data for calibrating the model was collected by a questionnaire among office keeping organisations in the Netherlands. As mentioned, the SP/HII model consists of two submodels. The *first* submodel measures the influence of attributes describing the accessibility of office locations: these attributes are the three ITS related transport concepts described in section 1 and two conventional transport modes (train and motorway). The *second* submodel measures the influence of the attributes describing the overall office location on location preferences where the '*accessibility*' decision construct is included as one single attribute. Apart from that, the attributes '*building type*', '*internal space use*', '*rental costs*' and '*parking availability*' were included in the measurement. The levels of the attribute '*accessibility*' refer to a ten-point school report scale (from 1 to 10), being widely used in the Netherlands, and are fixed to be 4 (*relatively bad*), 6 (*sufficient or average*) and 8 (*relatively good*). Data for determining the levels of the other attributes

were deduced from different studies and data bases describing the situation of the Dutch office real estate market.

The combination of the attribute levels into different profiles used for collecting the SP data was performed by using a so-called 'smallest orthogonal fraction' (Addelman, 1962). Regression analysis was used to estimate two main-effects preference model, using effect coding (see e.g. Molin, 1999). According to Addelman, the smallest orthogonal fraction of the full factorial design was chosen for the two experiments, implying that none of the interaction effects could be estimated. The design included 8 profiles for the accessibility experiment (5 attributes, each 2 levels) and 18 profiles for the second experiment on the overall evaluation of office locations (5 attributes, each 3 levels). For each experiment we added one example profile and two hold-out profiles. Hold-out profiles are randomized profiles, not used for model calibration but for testing the internal validity of the model. Consequently, respondents had to judge 11 profiles for the first experiment and 21 profiles for the second experiment. Respondents were asked to evaluate the attractiveness of each profile by rating on a ten-point scale under the assumption that they would have to (re)locate the organisation.

In order to select an appropriate sample, potential respondents were selected from a large database of organisations based on three criteria. The first criterion was that organisations had to be located in five selected Dutch medium-sized (according to Dutch standards) cities (130.000 – 200.000 inhabitants). The second criterion was that only organizations with a minimum of four employees were considered as potential respondents, since smaller organisations are too often located at private home addresses. Thirdly, only office-keeping organisations within the service- and non-profit-sector were selected. These three criteria lead to a sample of 4808 appropriate organisations.

All these 4808 organisations were approached. A questionnaire was sent directly to the (board of) director(s) assuming that this would provide more reliable and valid results. The data were collected in June 2005. In total, 404 questionnaires returned (response of 8%), of which 372 were useful for further analysis. Although the response rate is low, it is an 'average' rate given the main characteristics of the questionnaire: its length, complexity and the fact that only one mailing without sending a reminder (see for example Dennis, 2003). No further checks were performed on whether the response group is to some extent biased. It might e.g. be the case that our respondents attach more weight to transport accessibility than non-respondents. Given the explorative nature of our study however, we considered not further investigating such biases acceptable.

The questionnaire started with some general questions to measure the quality of the response group. The answers reveal that regarding aspects as office types, organisation sectors and organisation size, a heterogeneous group was reached. Further, almost every respondent indicated to have a large influence on the decision making process in case the organisation would (re)locate. It was therefore considered valid to assume that information on the organisations' location preferences can be based on only one respondent per organisation.

### *2.3 Main results*

Table 1 summarizes the main results of the model specification based on the collected data.. The intercept of the regression equation is equal to the average rating whereas the regression coefficients represent the part-worth utilities of the attribute levels as deviations from this average rating. The R square indicates the descriptive power of the model, and indicates the variance in individual ratings.

Table 1 shows that the part-worth utilities are in expected directions giving at least face validity to the estimated model. The two conventional transport concepts were considered by the respondents to have the largest influence on the accessibility level of an office-location. The part-

worth utilities indicating the effects of these conventional concepts of transport are substantially higher than the contributions of the ITS-related transport concepts. Nevertheless, each of the ITS-related transport concepts appears to have a significant contribution to the perception of accessibility of office locations. Of the three ITS-related transport concepts, the automatic bus lane has the largest influence in the preference model while the People Mover from the P&R facility and the automatic car lane are roughly considered to have an equal impact.

**Table 1. Estimated parameters for HII model (n=372)**

Accessibility experiment	Part-worth utility	Total office location evaluation	Part-worth utility
Average utility (intercept)	5.802	Average utility (intercept)	4.939
Motorway on/off ramp		Parking Space (per 100 employees)	
1,5 km	0.678*	10	-0.705*
6 km	-0.678	30	0.050
		50	0.655
Train station		Accessibility judgement (10-point scale)	
250 meter	0.560*	4	-0.624*
3 km	-0.560	6	0.017
		8	0.607
Automatic Bus Lane		Rental-/purchase cost per m <sup>2</sup> /year	
250 meter	0.382*	€ 90	0.493*
None	-0.382	€ 130	0.058
		€ 170	-0.551
People Mover from P&R		Type of internal space use	
250 meter	0.269*	Closed interior spaces	-0.282*
None	-0.269	Flexible spaces	0.175*
		Different rooms + office garden	0.107
On/off Ramp Automatic Car lane		Office building appearance	
1,5 km	0.266*	Old mansion within respectable neighbourhood	-0.009
None	-0.266	'Functional' building in residential neighbourhood	-0.108*
		Modern building on office park or boulevard	0.127
R <sup>2</sup> = 0.244		R <sup>2</sup> = 0.208	

\* sign. at 0.000 level

From the information on the overall location evaluation model in Table 1 we learn that the respondents consider the availability of parking space to be the most important attribute in location evaluations. As the second part-worth utility is not significant, the utility function can be considered to be linear, meaning that an increase in the number of parking lots per 100 employees from 10 to 30 increases the utility to the same amount as an increase from 30 to 50 parking lots. Both the attributes accessibility (secondary importance) and rental purchase costs (third in importance) should be interpreted as linear functions as well. We memorize that the accessibility attribute was designed as a construct and consequently was linked to the first submodel: interpretations regarding (the level of) this attribute should be based on the findings in column 1. The attributes internal space use and the type of building were found to be of relatively low importance for the overall attractiveness of office locations.

In the next sections we will describe the set up and results of the follow up study to test the predictive validity of this model in accordance to the aim mentioned in section 1.

### 3. Testing predictive validity: experimental design and data collection

#### 3.1 Set up of the predictive validity test

Ideally the predictive validity of the specified model is tested by comparing predicted choices (based on the preferences predicted by the model) with actual (re)location choices of office-keeping organisations under different conditions regarding the implementation of ITS. However, such an approach would be unfeasible, since none of the three ITS related transport concepts have been implemented yet in Dutch medium-sized cities in the Netherlands at a substantial scale. Consequently, a more experimental approach has to be followed. The approach applied in our study is based on the collection of location attractiveness evaluation data. The hypothetical location profiles used in the SP/HII experiments for model specification are translated into profiles of real world, existing office locations in a Dutch city region. For these real-world locations attractiveness in the present situation (without ITS) can be determined. Next, by assuming some implementation scenarios of the three ITS related transport concepts in this region, changes in attractiveness can be predicted by the model as well as measured from evaluation scores by office location choice managers. Observed and predicted attractiveness scores can be compared before and after hypothetical implementation of the ITS concepts.

To execute this strategy, first it was decided to focus on an urban region that was *not* included in the data collection for the model specification in order to enable the predictive context to be independent from the model calibration. It was chosen to focus on the Dutch city region Arnhem-Nijmegen. Arnhem and Nijmegen are two interrelated medium sized cities of about 160.000 inhabitants each, at a mutual distance of about 15 km. Together with the suburban villages surrounding both cities, the city region counts about 600.000 inhabitants.

Next, it was decided to approach office keeping organisations in this Dutch region by a questionnaire. In that questionnaire, five presently existing office locations were presented for both Nijmegen and Arnhem described by their locally known name, a geographical map indicating the precise location and a profile description using the models' attributes with values describing as precisely as possible the current situation. Further, different hypothetical scenarios for changes in transport conditions were introduced. These conditions were related to four different ITS scenarios, inspired by the ITS concepts described in the first section and in text box 1:

- a 0-scenario, representing the status quo and assuming no specific ITS concept to be implemented (autonomous development);
- a scenario where an automatic car lane is implemented on certain parts of the motorway network connecting the selected cities to other cities;
- a scenario where an automatic bus lane is implemented in the city, connecting selected major parts of the city;
- a scenario where at selected links of the urban road network a People Mover from P&R service is implemented.

In the three non-autonomous development scenarios, a spatial implementation of the scenarios was presumed in such a way that only a few existing office locations would directly profit from the implementation. These implementation scenarios were discussed with municipal policy makers to make them as realistic as possible.

In the questionnaire, organisations were asked to give an evaluation (in terms of a 10-point scale) of the five existing office locations in their home city for each of the four distinguished scenarios. In the questionnaire we followed the same hierarchical measurement approach as applied for the construction of the SP/HII model described in section 2. Respondents first evaluated the

locations' accessibility profile expressed in terms of distance to the motorway, train station and bus services. Next, the respondents evaluated the total profile of the location, including the attribute accessibility, for which the respondents were requested to fill in the score resulting from the first part of the evaluation. Using the scenarios, all selected office locations could be interpreted in terms of the hypothetical SP/HII profiles underlying the preference model: either as a location with a profile without ITS (0-scenario) or as a location with a profile including the presence of some ITS concept (the other three scenarios) (see subsection 3.2).

To analyse the predictive validity of the SP/HII model, three tests were performed. The first test compares evaluation scores for the existing office locations, given the available attributes and their levels, with the predictions of evaluation scores using the SP/HII model. To test whether deviations between predicted and observed scores are significant, a 'one sample t-test' was used.

The second test compares the observed change in location accessibility scores between the 0-scenario and each of the three other scenarios. According to the SP/HII model ITS services have a significant added value on accessibility. Consequently, the evaluation scores for accessibility of the locations situated close to one of the three ITS related transport concepts should be (significantly) higher than in case of the autonomous development without any specific ITS concept implementation. To test whether differences between predicted and observed scores are significant, t-tests were used.

The third test investigates the ability of the SP/HII models to predict the organisations' ranking in order of attractiveness of the mentioned office locations. The questionnaire included a location ranking task for each of the four scenarios. The model predicts that locations where ITS transport facilities and services in the direct neighbourhood are offered, are relatively more attractive than locations that do not know such facilities and services. This might even result in a better ranking position than in case such an ITS transport service is not introduced in the neighbourhood. The (changes in the) ranking scores predicted by the model were therefore compared to the rankings provided by respondents.

### *3.2 Attribute levels of the selected office locations*

In Table 2 the accessibility of the five selected and well-known office locations in each of the cities of Arnhem and Nijmegen is described in terms of the five attributes used in the SP/HII model. The values of these attributes are based on the actual distances between each office location and the various transport facilities, either existing or presumed: for the conventional public transport this concerns the distance to the nearest station, for the conventional car infrastructure the distance to the nearest on/off ramp of a motorway and for the three ITS transport facilities the distance to the planned stops of the automatic bus lane, to the planned stops of the People Mover from P&R and to the planned on/off ramps of the automatic car lane.

**Table 2. Accessibility profile of selected office locations in Arnhem and Nijmegen**

	Local name	0-scenario		ITS 1	ITS 2	ITS 3
		Train	Motorway	+Automatic bus lane	+People Mover from P&R	+Automatic car lane
Nijmegen						
Location 1	Heyendaal	500 m.	6 km.	250 meter		
Location 2	Oranjesingel	1 km.	5 km.	250 meter		
Location 3	Energieweg	2.5 km.	2 km.	250 meter	100 meter	
Location 4	Groenestraat	1.5 km.	3 km.			
Location 5	Brabantse Poort	500 m.	500 m.			500 meter
Arnhem						
Location 1	Stadssingels	500 m.	6 km.	250 meter		
Location 2	Park/Rijntoren	50 m.	6 km.	250 meter		
Location 3	Business Park	2.5 km.	6 km.			
Location 4	Schuytgraaf	500 m.	3 km.	250 meter		
Location 5	IJsseloord II	6 km.	500 m.		100 meter	500 meter

Realistic attribute levels for the profiles for the overall location characteristics are derived from regional data bases on prices and available parking spaces. The result of this attribute specification is provided by Table 3. Note that the column 'accessibility profiles' refers to profiles described in Table 2.

**Table 3. Selected office locations in Arnhem and Nijmegen described in attributes**

	Local name	Building Type	Internal Space Use	Price per (m <sup>2</sup> /year)	Number of Parking lots per 100 employees	Accessibility profiles
Nijmegen						
Location 1	Heyendaal	Modern	Flexible	130 euro	30/100	Table 2
Location 2	Oranjesingel	Old Mansion	Different rooms + garden	140 euro	20/100	" "
Location 3	Energieweg	Functional	Flexible	90 euro	50/100	" "
Location 4	Groenestraat	Functional	Rigid	130 euro	30/100	" "
Location 5	Brabantse Poort	Modern	Flexible	130 euro	50/100	" "
Arnhem						
Location 1	Stadssingels	Old Mansion	Different rooms + garden	130 euro	20/100	" "
Location 2	Park/Rijntoren	Modern	Flexible	210 euro	30/100	" "
Location 3	Business Park	Functional	Flexible	90 euro	50/100	" "
Location 4	Schuytgraaf	Functional	Flexible	130 euro	30/100	" "
Location 5	IJsseloord II	Modern	Flexible	130 euro	30/100	" "

### 3.3 Questionnaire: set-up, distribution and response

The questionnaire started with the introduction and illustration of the three ITS concepts as described in section 1 and text box 1. The introduction of these ITS concepts was the same as in the HII experiment (see Argiolu et al., 2008) to enable a valid comparison. In line with the HII experiment respondents were asked for each of the three ITS concepts to indicate whether they consider them to be realistic and to give their opinion on the concepts' potential to improve the accessibility in the city region. The goal of the latter two questions is twofold. Firstly it triggers the respondents to study the text on the concepts carefully. Secondly the answers give a first indication of the appreciation of the concepts, which might be helpful in explaining possibly very

positive or negative evaluations of locations subject to the implementation of specific ITS concepts.

Next in the questionnaire, maps of the cities including the office locations and the ITS transport facility (with stops and on and off ramps) were presented to the respondent (see for examples Figure 1 and Figure 2). The maps show the structure of the city (Nijmegen respectively Arnhem) including its main rail lines and roads and the five selected office locations. In the 0-scenario no ITS related transport concept is shown. In scenario 1 an automatic bus lane (the track) and its stops are visualised. Scenario 2 shows the People Mover from P&E and its stops. Scenario 3 finally shows the automatic car lane and its on/off ramps. To perform the first and second test described in subsection 3.1 respondents were asked to rate the locations 1 to 5 for each scenario on a 10-point scale. Finally to perform the third test respondents were asked to rank the same locations from most preferable to least preferable.

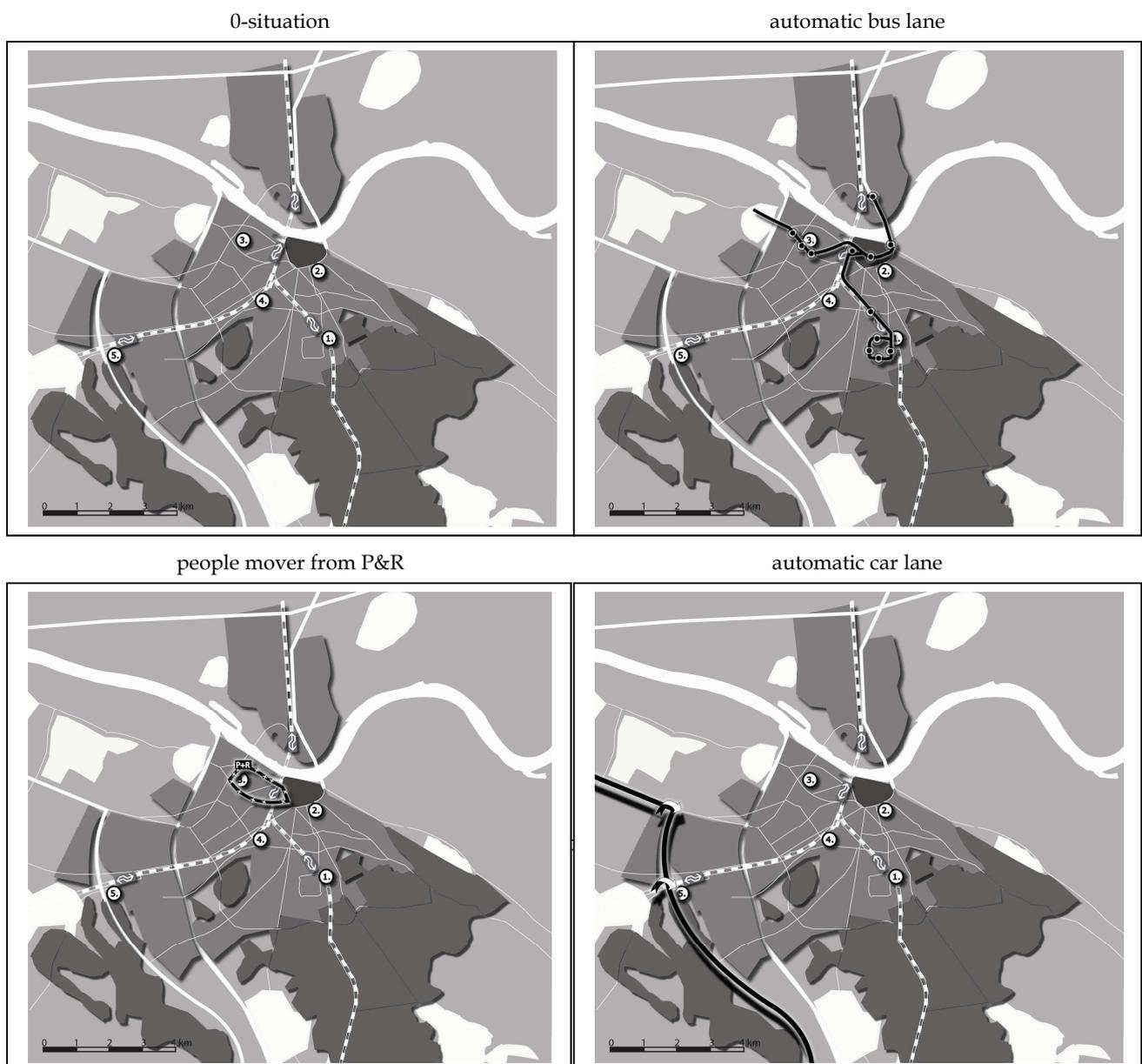


Figure 1. ITS scenarios visualized for the city of Nijmegen

Numbers in maps: five most important office locations in Arnhem

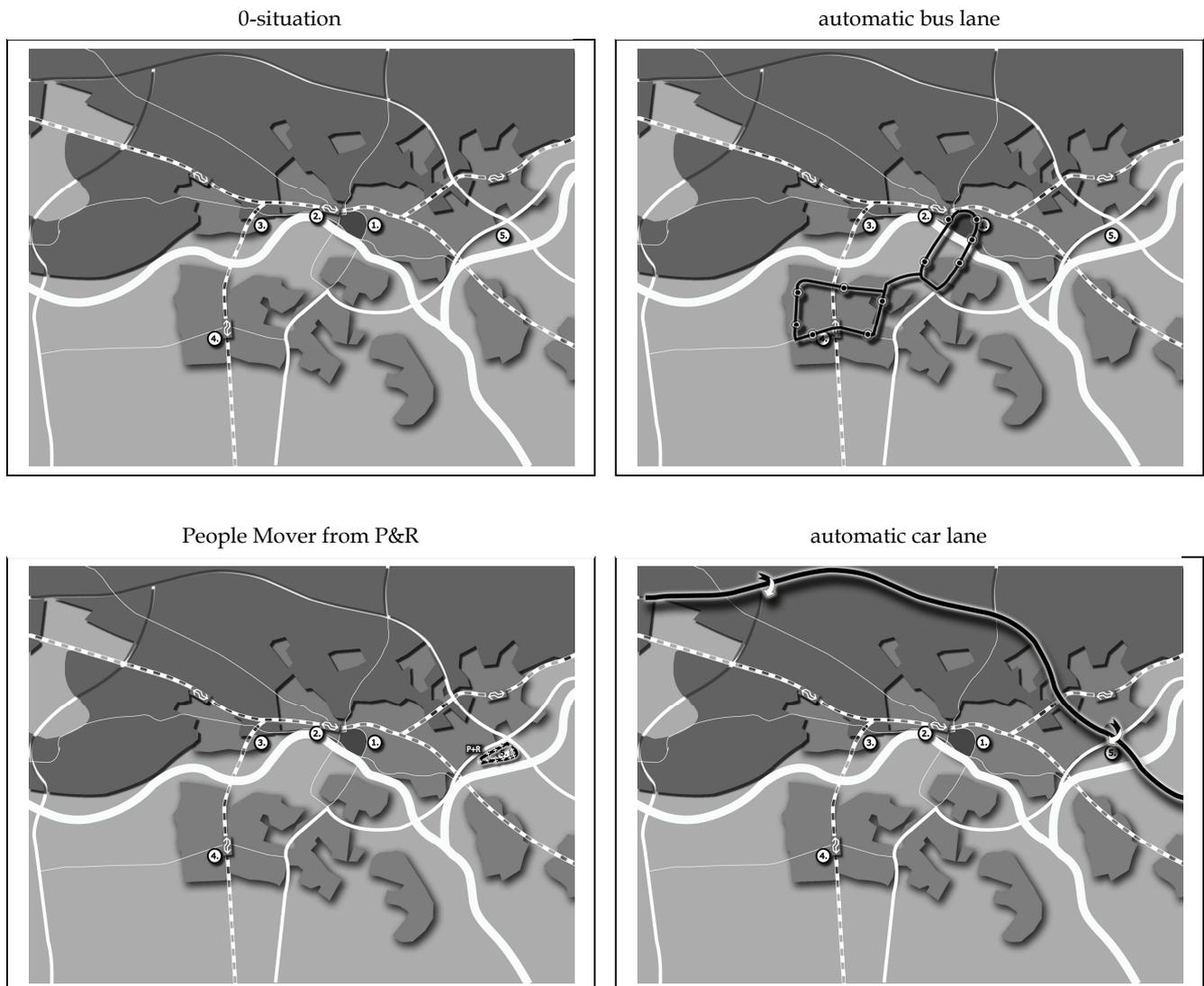


Figure 2. ITS scenarios visualized for the city of Arnhem

Numbers in maps: five most important office locations in Arnhem

The questionnaire was sent by mail to a total of 1151 selected office keeping organisations in Nijmegen and Arnhem based on a sample procedure equal to that of the data collection in the context of model building (see section 2.1). In total 123 questionnaires (11%) returned of which 98 (9%) were completely useful for analysis (52 respondents from Arnhem and 46 from Nijmegen). Overall, 49% of the respondents represent a company with a size between 4-10 employees, 42% a company size with 11-50 employees and the rest is larger than 50 employees. Half of the companies deal with advisory services, almost a quarter in financial services and the rest focuses on non-profit and facilitating services. The response group include responses from a variety of branches. The (non-) response rate is in the order of what is usual for the kind of data collection applied in this study (Dennis, 2003); the selection of the sample for the questionnaire anticipated this rate. Based on organisation type, branch type and company size it was concluded that the response group represented the sample characteristics well. Also the indicated high influence of the respondents on the companies' (re)location process (an average score of 4.7 on a scale of 1 = minimal influence to 6 = maximum influence; median score of 6; no significant differences between Arnhem and Nijmegen) gives confidence in the reliability of the given answers.

## 4. Results

### 4.1 Test 1: Comparing model predictions and observed scores

The first predictive validity test concerned the comparison between the predicted scores provided by the SP/HII models and the observed scores for the five office locations in Nijmegen and Arnhem for each of the four scenarios.

A first analysis showed that for all cases the observed scores for the profiles are higher than the scores predicted by the model. The model appeared to systematically underpredict the utility score for almost every profile. This triggered the question on the explanation for the differences between the model outcomes and observed evaluation scores. As the SP/HII experiment underlying the model has been performed for 5 different city regions and differences between these cities were few and not significant, it is not plausible to explain these differences in the validation test by geographical differences between these selected city regions on the one hand and the study area Arnhem-Nijmegen on the other hand. Therefore, other reasons should explain the differences.

A first explanation is the possible influence of extrapolation, which is less reliable than interpolation. Linear extrapolation was needed to obtain a few part-worth utilities for attribute levels describing the five office-locations for Nijmegen and Arnhem. Secondly, the systematic deviations might be caused by non-linearity in observed scores but not predicted by the models. A third explanation is that the interaction effects between attributes might be stronger in the validity study than in the SP/HII study. This might be caused by the fact that realistic locations are used, which most probably import context knowledge, owned by respondents, regarding these locations. This knowledge is not included in the experimental design in the SP/HII study, but can in reality be important to the valuation of the realistic locations. An example is the distance to important clients or living areas of employees or the image of certain neighbourhoods. Finally, a fourth explanation concerns the assumption of the applicability of an additive model, which is the case in the SP/HII model, where the multiplicative model has not been tested. The additive model offers the possibility to compensate a low score for one attribute level by a high score for another attribute level, which might not hold for all respondents. It is plausible that for some respondents a low score on some attributes, for example the building type and its site within the urban area, cannot be compensated by a high score on any of the other attributes, and vice versa. This might for example be the case for large companies: the space offered by old mansions in respectable neighbourhoods is in many cases not sufficient to accommodate all employees. Consequently, they are possibly not interested in certain locations, which results in a low attractiveness score for these locations, and vice versa: they attach high values to certain other locations.

Although the predictive validity of the SP/HII models concerning absolute evaluation scores is thus weak, the other validity tests put more emphasize on (changes in) relative evaluation scores. To perform these tests, correcting the predicted evaluations for this systematic underestimation was assumed to enable a more fair comparison. The systematic underestimation has been calculated as deviation averages for the accessibility and overall location predictions for Nijmegen and Arnhem each. These deviation averages were treated as the values of a relevant, unknown and therefore not in the model anticipated factor, and should consequently be added to the evaluation scores resulting from the predictive model to get corrected final evaluation scores. This resulted in the following corrections for all predicted evaluation scores, based on the average deviation scores: for the accessibility of all the office-locations in Nijmegen with +0.8 and for the accessibility of the office-locations in Arnhem with +1.6; for all the overall scores for the office-locations in Nijmegen with +0.9 and for all the overall scores for the office-locations in Arnhem with +2.0. Table 4 shows the resulting corrected predicted (pred.) scores as well as the

observed (obs.) scores for accessibility and the overall attractiveness of the five office-locations in Nijmegen respectively Arnhem for each of the four ITS scenario's. The observed scores that deviate from the predicted scores significantly on a 0.05 level are marked with an asterisk.

**Table 4. T-test for model validity based on corrected scores (averages)**

	0-Scenario No investments			Scenario 1 Automatic Bus Lane			Scenario 2 People Mover from P&R			Scenario 3 Automatic Car Lane		
	Pre.	Obs.	Sign.	Pre.	Obs.	Sign.	Pre.	Obs.	Sign.	Pre.	Obs.	Sign.
<b>Nijmegen N=44</b>												
Accessibility												
1	5.4	6.1	0.004*	6.2	7.0	0.001*	5.4	6.0	0.018*	5.4	6.0	0.037*
2	5.5	5.7	0.567	6.3	6.6	0.182	5.5	5.9	0.091	5.5	5.5	0.929
3	5.8	5.6	0.396	6.6	6.3	0.197	6.4	6.9	0.043*	5.8	5.7	0.565
4	5.8	5.1	0.001*	5.8	4.9	0.000*	5.8	5.0	0.001*	5.8	5.1	0.006*
5	7.0	7.2	0.318	7.0	7.0	0.932	7.0	6.8	0.380	7.6	7.6	0.878
Overall												
1	5.6	6.1	0.069	5.8	6.0	0.387	5.6	6.0	0.146	5.6	6.0	0.156
2	5.0	5.9	0.010*	5.2	6.0	0.020*	5.0	5.9	0.009*	5.0	5.8	0.016*
3	6.7	6.0	0.024*	6.8	6.3	0.098	6.8	6.3	0.070	6.6	6.1	0.065
4	5.0	5.0	0.828	5.0	5.0	1.000	5.0	4.9	0.760	5.0	4.9	0.529
5	6.7	6.6	0.816	6.7	6.7	0.867	6.7	6.4	0.274	6.9	6.7	0.549
<b>Arnhem N=41</b>												
Accessibility												
1	6.2	5.6	0.072	7.0	6.4	0.051	6.2	5.9	0.333	6.2	5.9	0.405
2	6.4	6.8	0.311	7.2	7.6	0.477	6.4	7.1	0.049*	6.4	6.9	0.164
3	5.3	5.3	0.659	5.3	5.3	0.667	5.3	5.2	0.822	5.3	5.2	0.876
4	7.1	6.3	0.004*	7.9	7.1	0.001*	7.1	5.9	0.000*	7.1	6.1	0.001*
5	5.7	6.3	0.070	5.7	6.1	0.313	6.3	7.4	0.002*	6.3	7.6	0.000*
Overall												
1	6.2	6.5	0.349	6.4	6.7	0.454	6.2	6.7	0.109	6.2	6.7	0.097
2	5.9	6.1	0.510	6.1	6.3	0.404	5.9	6.2	0.288	5.9	6.2	0.324
3	6.5	6.7	0.729	6.5	6.9	0.238	6.5	6.6	0.766	6.5	6.7	0.723
4	6.9	6.1	0.000*	7.1	6.1	0.000*	6.9	6.3	0.002*	6.9	6.1	0.000*
5	6.6	6.4	0.324	6.6	6.5	0.640	6.8	6.7	0.435	6.8	6.6	0.326

\* sign. at 0.05 level

Based on Table 4, the following observations are made. Most differences between (corrected) predictions and observed evaluation scores are not significant. However, the accessibility of location 1 in Nijmegen is systematically underestimated by the SP/HII model for all ITS scenarios. It concerns the large office, medical and university location Heyendaal, which has good public transport accessibility but relatively weak car accessibility. It concerns a booming business area where several plans have been announced to improve the accessibility by car and public transport. The booming nature and plans make the location potentially very attractive. Location 4 in Nijmegen, location Groenestraat, is systematically overestimated by the SP/HII accessibility model. In reality the location has a rather weak car and public transport accessibility (as it not close to any important transport facility). Its image of a relatively badly accessible location might be stronger than the actual distances suggest. The general office location profile of location 2 in Nijmegen (Oranjesingel), is systematically underestimated by the SP/HII general model. This location concerns a rather prestigious and central area close to the ancient city centre.

In the city of Arnhem location 4, Schuytgraaf, systematically receives higher predicted than observed scores both in the accessibility model as in the general location model. A possible

explanation is that it concerns a new office location in a new city area under construction and might therefore lack the image of an important office location.

Concluding, the findings regarding this validation test suggest that unique factors, notably the public image, of certain locations do play a significant role in location evaluations, irrespective the implementation of certain ITS. This notion was not included in de SP/HII model because of the difficulty of operationalization and measurement.

#### 4.2 Test 2: The impact of the four ITS scenarios on accessibility scores

The SP/HII model predicts that all ITS concepts have a significant impact on the evaluation scores for the accessibility: the model predicts higher scores. Whether this is confirmed by this validation experiment has been tested by comparing the 0-scenario with the other three ITS scenarios with regard to the increase of change in evaluation scores for the five existing office locations per city due to the (hypothetical) implementation of an ITS related transport concept.

First, Table 5 summarizes the, for the intended analysis, relevant scores from Table 4. The data in the Table informs on the change in observed scores due to the introduction of an ITS related transport concept for the locations that are expected to benefit. The other scores are not expected to deviate significantly, because there is no expected benefit from the ITS concepts (the distance between the location and the added ITS service is too large, see Figures 1 and 2), and are therefore left blank in Table 5. As expected, all realistic locations that lie close to a presumed introduction of a ITS related transport facility receive higher accessibility scores than in case of the 0-scenario. Except for the automatic car lane in location 5 of Nijmegen and the automatic bus lane in location 1 and 4 in Arnhem, these changes in observed evaluation scores are significant.

**Table 5. Observed accessibility scores for the ITS scenarios compared to the 0-scenario**

	0-scenario	Scenario 1 Automatic Bus Lane	Scenario 2 People Mover	Scenario 3 Automatic Car Lane
<b>Nijmegen (N=44)</b>	<b>Scores</b>	<b>Scores / significance</b>	<b>Scores / significance</b>	<b>Scores / significance</b>
Accessibility 1	6.1	7.0 (sign 0.013)*		
Accessibility 2	5.7	6.6 (sign 0.010)*		
Accessibility 3	5.6	6.3 (sign 0.028)*	6.9 (sign 0.000)**	
Accessibility 4				
Accessibility 5	7.2			7.6 (sign 0.267)
<b>Arnhem (N=41)</b>	<b>Scores</b>	<b>Scores / significance</b>	<b>Scores / significance</b>	<b>Scores / significance</b>
Accessibility 1	5.6	6.4 (sign 0.069)		
Accessibility 2	6.8	7.6 (sign 0.047)*		
Accessibility 3				
Accessibility 4	6.3	7.1 (sign 0.066)		
Accessibility 5	6.3		7.4 (sign 0.020)*	7.6 (sign 0.005)**

\* sign. at 0.05 level \*\* sign. at 0.01 level

Secondly, the observed increase in evaluation scores due to the assumed implementation of the three ITS concepts can be compared with the change in score predicted by the P/HII model. This predicted change is determined as follows. The basic utility score is the observed score for a location in the 0-scenario, indicated in the second column in Table 5. From Table 1, we can determine the difference in part-worth utility according to the SP/HII model between 'being close to' (250 m) and 'having no access' (none) for the three ITS concepts, being respectively 0.76 for the Automatic Bus Lane, 0.54 for the people Mover from P&R and 0.53 for the Automatic car Lane. These values are to be interpreted as the predicted increase in the accessibility value due to implementation of the concepts as compared to the 0-scenario. This results in the predicted

values included in Table 6, that can be compared to the observed scores for the three ITS scenarios. Table 6 also presents the outcomes of the one-sample t- tests on the differences between predicted and observed scores.

**Table 6. Predictions for accessibility scores for ITS concepts**

	0- situation	Scenario 1 Automatic Bus Lane			Scenario 2 People Mover			Scenario 3 Automatic Car Lane		
<b>Nijmegen N=44</b>	<b>Scores</b>	<b>Pre.</b>	<b>Obs.</b>	<b>Sign.</b>	<b>Pre.</b>	<b>Obs.</b>	<b>Sign.</b>	<b>Pre.</b>	<b>Obs.</b>	<b>Sign.</b>
Accessibility 1	6.1	6.9	7.0	0.735						
Accessibility 2	5.7	6.5	6.6	0.585						
Accessibility 3	5.6	6.4	6.3	0.706	6.1	6.9	0.005*			
Accessibility 4										
Accessibility 5	7.2							7.7	7.6	0.268
<b>Arnhem N=41</b>	<b>Scores</b>	<b>Pre.</b>	<b>Obs.</b>	<b>Sign.</b>	<b>Pre.</b>	<b>Obs.</b>	<b>Sign.</b>	<b>Pre.</b>	<b>Obs.</b>	<b>Sign.</b>
Accessibility 1	5.6	6.4	6.4	0.906						
Accessibility 2	6.8	7.6	7.6	0.884						
Accessibility 3										
Accessibility 4	6.3	7.1	7.1	0.927						
Accessibility 5	6.3				6.8	7.4	0.122	6.8	7.6	0.016*

\* sign. at 0.05 level

It appears that the predicted scores for accessibility is close to the observed scores. In only two cases the predicted scores significantly differ from the observed scores, implying that the model underestimates the increase in accessibility value due to the implementation of the particular ITS service at that location. In case of location 3 in Nijmegen the model predicts an increase in the score of 0,54 in scenario 2, whereas an increase of 1,3 is observed. A similar effect is visible for location 5 in Arnhem for scenario 3. A possible explanation for the observed doubling of the effect in location 3 in Nijmegen is that in the validation measurement the assumption was made that differences in (very) nearness to an ITS concept receive the same part worth utility, whereas in reality respondents attach different utility values to these differences in even near distance. In the SP/HII model a close distance of 250 meter was used, whereas the profiles for location 3 in the validity study indicate a distance of 100 meter. Both distances were assumed to be regarded as 'close to' and predicted to receive the same part worth utility. The doubling of the effect for location 5 in Arnhem may also be explained by a difference between distance levels in this study and the used model. In the SP/HII model a distance up to 1.5 km to the automated car lane is used, whereas the profile of this location in this validity study used a distance level of 500 m. A second possible explanation for the observation regarding location 5 in Arnhem might be the current high congestion level on the nearby motorway in Arnhem close to location 5. Several respondents of the Arnhem questionnaire explicitly complained about this problem in the open comments section of the questionnaire. Respondents apparently presume a large problem solving power of the automated car lane in that specific situation.

The conclusion from this test is that the SP/HII model predicts an added value of the ITS concepts on an improvement of accessibility, that largely corresponds with the observed increase in evaluation scores. Again, unique circumstances seem in certain cases to have significant additional effects.

#### *4.3 Test 3: Comparison of rankings of office locations in terms of attractiveness*

In the third step the assumption was tested whether organisations rank office locations that lie close to an ITS related transport concept higher in terms of attractiveness than in case no ITS concept is implemented. Table 7 shows the frequency of the observed ranking position (1 to 5) per location. The locations marked bold represent the locations that, according to predictions by the SP/HII model, are expected to become relatively more attractive, thus higher scores, and as such improve their relative ranking position among the 5 locations per city.

For Nijmegen, in scenario 1 the locations Oranjesingel, Heyendaal and Energieweg are expected to be chosen more frequently as the preferred location due to the proximity of an automatic bus lane. However this cannot be convincingly confirmed by the observed ranking. It can only slightly be confirmed by the fact that the location BP is losing a share in the top rank 1 position, which corresponds with the fact that this location is not benefiting from the automatic bus lane. In scenario 2 only the location Energieweg is, according to the model, expected to benefit from the introduction of the People Mover from P&R. This is indeed confirmed by the increase of its share in ranking position 1 and 2. In scenario 3 location BP is expected to benefit from the near distance to the automatic car lane. The increase in share of the rank 1 position is also clearly visible in the observed scores for this location in this scenario.

For Arnhem, in scenario 1 the relative attractiveness of the locations P/R Toren, Stadssingels and Schuytgraaf is expected to improve due to the proximity of an automatic bus lane. This can only partially be confirmed by the increase in share of the rank 1 position for the location Stadssingels. The location Business Park also benefits from this scenario, whereas the remaining two locations lose some attractiveness. In case of scenario 2, the location IJsseloord II is expected to benefit from the introduction of the People Mover from P&R close to that location. Table 7 confirms this prediction: the share of IJsseloord II in ranking 1 and 2 positions becomes larger whereas the other locations are stable or lose some attractiveness. In case of scenario 3, according to the model the location IJsseloord II should benefit from the introduction of the automatic car lane which has an on/off ramp close to that location. Table 7 confirms this prediction by showing a large increase in popularity for that location.

Overall, it is concluded for both Nijmegen and Arnhem that especially the locations which were already favoured in the present situation, benefit most from the scenario of an automatic car lane. This is plausible given the fact that the automatic car lane implies a change for improvement within the domain of the dominant travel mode, which is car driving.

**Table 7. Frequency of ranking office-locations in Nijmegen and Arnhem**

<b>Nijmegen (N=44)</b>		<b>% of total</b>			
<i>0</i> -situation	BP	Oranjesingel	Heyendaal	Energieweg	Groenestraat
Position 1	43%	25%	25%	8%	0%
Position 2	14%	20%	20%	27%	18%
Position 3	14%	12%	33%	14%	27%
Position 4	14%	14%	10%	25%	37%
Position 5	14%	31%	12%	27%	16%
Scenario 1: Automated Bus Lane	BP	Oranjesingel	Heyendaal	Energieweg	Groenestraat
Position 1	33%	27%	29%	8%	4%
Position 2	16%	29%	20%	22%	12%
Position 3	16%	8%	27%	25%	25%
Position 4	16%	12%	16%	25%	31%
Position 5	18%	25%	8%	20%	29%
Scenario 2: People Mover from P&R	BP	Oranjesingel	Heyendaal	Energieweg	Groenestraat
Position 1	29%	29%	22%	16%	4%
Position 2	18%	22%	16%	31%	12%
Position 3	10%	10%	35%	18%	27%
Position 4	18%	16%	16%	16%	33%
Position 5	25%	22%	10%	18%	25%
Scenario 3: Automated Car Lane	BP	Oranjesingel	Heyendaal	Energieweg	Groenestraat
Position 1	51%	20%	16%	10%	2%
Position 2	16%	18%	29%	22%	14%
Position 3	12%	18%	27%	14%	29%
Position 4	10%	14%	18%	27%	31%
Position 5	10%	29%	10%	29%	22%
<b>Arnhem (N=41)</b>		<b>% of total</b>			
<i>0</i> -situation	IJsseloord II	P/R Toren	Business Park	Stadssingels	Schuytgraaf
Position 1	33%	18%	10%	25%	15%
Position 2	15%	25%	15%	20%	25%
Position 3	8%	30%	38%	15%	10%
Position 4	18%	20%	23%	20%	20%
Position 5	28%	8%	15%	20%	30%
Scenario 1: Automated Bus Lane	IJsseloord II	P/R Toren	Business Park	Stadssingels	Schuytgraaf
Position 1	23%	13%	15%	35%	15%
Position 2	18%	25%	15%	23%	20%
Position 3	13%	38%	35%	8%	8%
Position 4	15%	23%	18%	18%	28%
Position 5	33%	3%	18%	18%	30%
Scenario 2: People Mover from P&R	IJsseloord II	P/R Toren	Business Park	Stadssingels	Schuytgraaf
Position 1	33%	15%	13%	28%	13%
Position 2	23%	23%	23%	20%	13%
Position 3	10%	35%	23%	18%	15%
Position 4	15%	25%	20%	20%	20%
Position 5	20%	3%	23%	15%	40%
Scenario 3: Automated Car Lane	IJsseloord II	P/R Toren	Business Park	Stadssingels	Schuytgraaf
Position 1	45%	15%	10%	25%	5%
Position 2	13%	20%	20%	23%	25%
Position 3	8%	40%	30%	13%	10%
Position 4	25%	20%	13%	23%	20%
Position 5	10%	5%	28%	18%	40%

## 5. Conclusions

This article described the results of a study to test the predictive validity of a SP/HII model describing organisations' evaluations for office-locations in a context of the hypothesized introduction of ITS based transport facilities and services. The validity analyses are based on observed ratings and rankings of real world office locations under the presumed influence of different ITS scenarios. The predictive validity is analysed in three steps. From the first test, it is concluded that the constructed SP/HII models do not accurately predict the actual evaluations for the real world accessibility and location profiles, although the location model seems a bit more accurate than the accessibility model. There appears to be a rather systematic difference between the predicted and observed evaluations. This systematic difference might be explained by model characteristics as well as location specific context knowledge not included in the SP/HII model but significantly influencing the relative image of the locations. It seems worthwhile to further investigate the causes of these differences: what is the nature of the unknown factor(s) that should be included in the model to become a more appropriate model? Such analyses should not only be based on quantitative data collection and statistical models (e.g. based on geo-information and historical relocation choices). To really understand decision making processes of office location managers, the use of qualitative research methods, notably interviews with office location managers and case studies, are considered to have at least as much added value.

The results of the second validity analysis are more promising. The test showed that the contributions, in terms of the change in the evaluation scores for accessibility, of the three ITS related transport concepts are close to what is predicted by the SP/HII model. Therefore, it can be concluded that although the mode is a weak predictor of absolute evaluation scores, the part worth utility scores for the ITS attributes are strong predictors for the relative contribution of the three ITS related transport concepts to accessibility in real world situations. Finally, the third validity test reveals a trend of increasing general attractiveness of office locations that lie close to an ITS related transport concept. This trend corresponds with the predictions from the SP/HII models. The main conclusion from these tests is therefore that the approach described in Argiolu et al. (2008) is promising regarding the quantitative modelling of possible effects of introducing ITS related transport facilities and services in the direct environment of office locations.

The present study was dominated by an explorative modelling approach. This is because there is a lack of powerful and useful theoretical and methodological perspectives in ITS-literature on the geographical impacts of ITS implementation. Our study is an attempt to (at least partially) fill in this gap by performing empirical analyses. However, various operational decisions in our explorative approach, like the choice for the included attributes and the attribute levels or the validation tests, as well as the set up of the predictive validity tests might be subject of debate. Apart from the interesting results, therefore, our study has made clear that more research should be performed to further elaborate on the model and on testing its value for understanding the potential consequences of a large scale implementation of ITS on spatial patterns of office locations. Given the gradually increasing implementation of ITS concepts, it must be possible in the near future also to measure impacts in reality, preferably in before-after studies, which will help to validate models of the kind discussed in this article. Such models are considered important tools to improve the quality of decision making in long term spatial and transport planning.

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## References

- Addelman, S. (1962). Orthogonal main-effect plans for asymmetrical factorial experiments. *Technometrics*, 4, 21-46.
- Argioliu, R. (2008). *Office location choice behaviour and Intelligent Transport Systems*. TRAIL PhD Thesis series No. 2/08, Delft, The Netherlands.
- Argioliu, R., Van der Heijden, R., Bos, I. and Marchau, V. (2008). Intelligent transport systems and preferences for office locations. *Environment and Planning A*, 40, 1744-1759.
- Banister, D. (2002). *Transport Planning*. SPON, London.
- Bradley, M. (1988). Realism and adaptation in designing hypothetical travel choice concepts. *Journal of Transport Economics and Policy*, 22, 121-137.
- Chatterjee, A., Wegman, F. and Adams, M. (1983). Non-commitment bias in public opinion on transit usage. *Transportation*, 11, 347-360.
- Couture, M. and Dooley, R. (1981). Analyzing traveller attitudes to resolve intent and actual use of a new transit service. *Transportation Research Record*, 794, 27-33.
- Dennis, W. (2003). Raising response rates in mail surveys of small business owners: results of an experiment. *Journal of Small Business Management*, 41(3), 278-295.
- Ioannou, P. (ed.) (1997). *Automated Highway Systems*. Plenum Press, New York.
- Janelle, D. and Gillespie, A. (2004). Space-Time constructs for linking information and communication technologies with issues in sustainable transportation. *Transport Reviews*, 24, 665-677.
- Johnston, R. and Rodier, C. (1999). Automated highways, effects on travel, emissions, and traveller welfare. *Journal of Transportation Engineering*, 125( 3), 186-192.
- Louviere, J. (1984). Hierarchical information integration: a new method for the design and analysis of complex multiattribute judgement problems. *Advances in Consumer Research*, 11, 148-155.
- Louw, E. (1996). *Kantoorgebouw en Vestigingsplaats*. Delft University Press, The Netherlands (In Dutch).
- Meurs, H. and Haaijer R. (2001). Spatial structure and mobility. *Transportation Research Part D*, 6, 429-446.
- Miller, M., Bresnock, A., Shladover, S. and Lechner, E. (1997). Regional mobility impacts assessment of highway automation. In: Ioannou, P. (ed.) *Automated Highway Systems*, Plenum Press, New York, pp. 293-311.
- Molin, E. (1999): *Conjoint approaches for residential preferences*. PhD Thesis, Bouwstenen 53, Eindhoven University of Technology
- Nijkamp, P., Pepping, G. and Banister, D. (1996). *Telematics and Transport Behaviour*. Springer, Berlin.
- Polak, J. and Jones P. (1993). The acquisition of pre-trip information: a stated preference approach. *Transportation*, 20, 179-183.
- Pen, C-J. (2002). *What moves companies? Decision making processes at relocated firms*. Netherlands Geographical Studies 297, Groningen University, the Netherlands.
- Slovic, P. (1995). The construction of preference. *American Psychologist*, 50, 364-371.

Timmermans, H. (1982). Consumer choice of shopping centre: an information integration approach. *Regional Studies*, 16, 171-183.

Van Dijk, J., Pellenbarg, P. and Van Steen, P. (1999). Determinants of firm migration in the Netherlands, an exercise in the demography of firms approach. In: Van Dijk, J. and Pellenbarg, P. (eds.) *Demography of Firms, Spatial Dynamics of Firm behaviour*, Netherlands Geographical Studies 262, Utrecht/Groningen, The Netherlands, pp. 87-121.

Van der Heijden, R. and Timmermans, H. (1988). The spatial transferability of a decompositional multi-attribute preference model. *Environment and Planning A*, 20, 1013-1025.

Van der Heijden, R. and Marchau, V. (2005). Advanced driver assistance systems: behavioural implications of some recent developments. *European Journal for Transport and Infrastructure Research*, 5, 239-252.

Van der Heijden, R., Argioli, R., Bos, I. and Marchau, V. (2006). Innovating urban public transport: some recent developments in the Netherlands. In: Basbas (ed.) *Advances in city transport: case studies*, WIT Press, Southampton, pp. 47-74.

Vickerman, R., Spiekermann, K. and Wegener, M. (1999). Accessibility and economic development in Europe. *Regional Studies*, 33, 1-15.

Wardman, M. (1988). A comparison of revealed preference and stated preference models of travel behaviour. *Journal of Transport Economics and Policy*, 22, 71-91.

Warshaw, P. and Davis, F. (1984). Disentangling behavioural intention and behavioural expectation. *Journal of Experimental Social Psychology*, 21, 213-228.

Zwicky, F. (1967). *Discovery, invention, research, through the morphological approach*. The Macmillian Company, Toronto.