MEASURING PERFORMANCE OF KNOWLEDGE TECHNOLOGIES THAT AIM TO SUPPORT STRATEGY MAKING

Case of Urban Strategy

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1. INTRODUCTION

There are a large number of computer based systems that aim to support integrated land use and transport planning; more than 100 in the Netherlands alone (Al 2005). These so-called Planning Support Systems (PSS) have been developed since the 1970s and are still continuously improved. In a recent survey among land use and transport planners in the Netherlands we found that, just as in almost all planning fields, these instrument fail to support an important phase of planning where land use and transport should come together; the strategic planning phase (Te Brömmelstroet 2010). Figure 1 lists the reasons that were found to block the widespread use of these tools in daily practice of integrated land use and transport strategy making.

Figure 1 Bottlenecks for PSS in integrated land use and transport strategy making (% of respondents (124) that think it is a (highly) problematic.

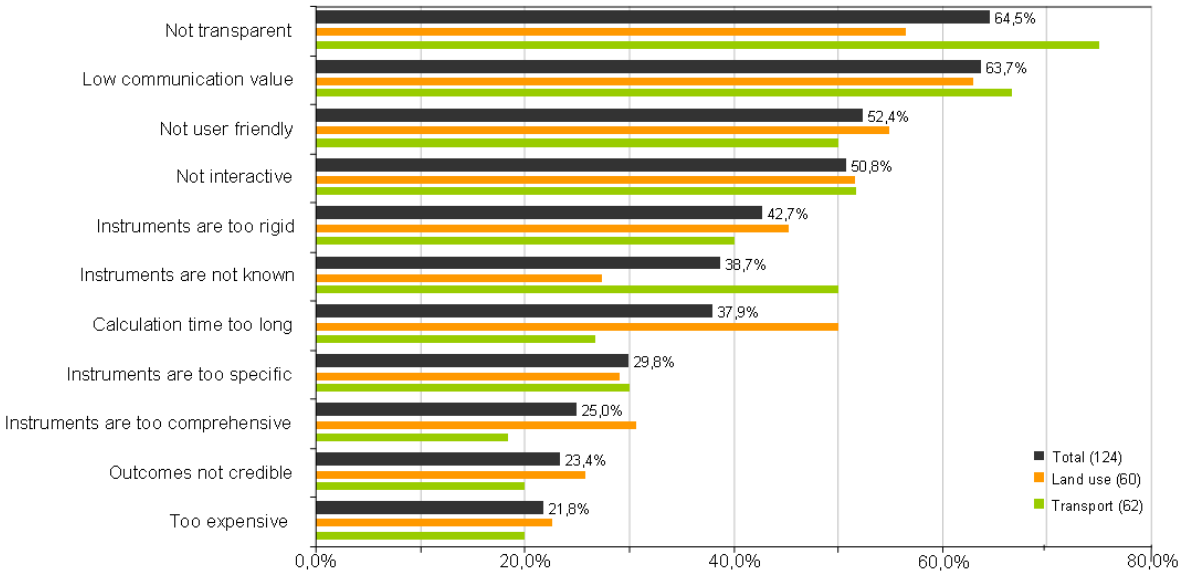


Figure 1 shows that it are mainly soft characteristics that hamper widespread use of PSS. Transparency, low communication value, user friendliness and interactiveness are seen as (highly) problematic by more than half of the respondents. There is no shortage of ideas to bridge what has been coined the implementation gap. Some of these focus on improving PSS software by adding new functionality: PSS that are more integrated (i.e. What If developed by Klosterman 1999), more interactive (i.e. Urban Strategy developed by TNO 2011) or more user-friendly (i.e. UrbanSim developed by Waddell 2002, 2011). Others focus more on the hardware, such as Maptables (see Vonk & Ligtenberg 2009) and other visual gadgets. Then there is the process-oriented line that focuses on bridging the human gap between the potential end-users and the PSS developers with more participative, iterative PSS development structures (i.e. Lee 1973; 1994; Te Brömmelstroet & Schrijnen 2010; Vonk 2006).

In this publication we report on the first family of solution strategies; a more interactive PSS software package. We have experimented with a state-of-the-art PSS called Urban Strategy that has been developed in the Netherlands in recent years. The goal of this experiment was to find out if urban Strategy enabled a bridge over the PSS implementation gap. To do so, we first need to define how we measure usability or use of a PSS (section 2). Then, we describe the set up of the experiment (section 3). Before concluding the report and discussing implications of our findings in section 5, we report the outcomes of the experiment (Section 4).

2. ASSESSING USABILITY OF PSS

Recently we have developed a instrument that enables us to structurally test if improvement strategies for PSS are successful (Te Brömmelstroet, 2011). It is based on the idea that PSS have (one of) two main goals: First, improving planning *processes* by structuring them better and/or making them more interactive, integrative and participatory. Next to that PSS aim to improve the *outcomes* of these processes (e.g. strategies, plans and projects) by providing relevant knowledge and facilitating a design-analysis loop: 'linking knowledge to actions in the public domain' (Friedmann 1987). Especially in strategic planning this link is particularly problematic. Couclelis asserted that strategic planning

> "is a hopelessly complex human endeavour. It involves actions taken by some to affect the use of land controlled by others, following decisions taken by third parties based on values not shared by all concerned, regarding issues no one fully comprehends, in an attempt to guide events and processes that very likely will not unfold in the time, place, and manner anticipated" (Couclelis, 2005; p. 1355).

The subject of strategic planning is often referred to as 'wicked problems' (Rittel and Webber, 1984), for which there are no clear-cut answers or solutions. It is the development of the capacity to deal with these problems, rather than final solutions that is the general aim of strategic planning. Planners here (should) aim to become aware and learn to cope with complexity and the "unknown unknowns" (Taleb, 2007) instead of collecting knowledge to reduce it/them.

Both aims of PSS are being translated into a multidimensional framework. Based on academic literature on ideational output (e.g. Dean et al. 2006) we operationalise the quality of the outcome in the dimensions *novelty*, *workability*, *relevance* and *specificity*: i.e. a good planning outcome is novel, workable, relevant and specific. Based on academic work on Group Model Building (Rouwette et al. 2002) we operationalise the quality of the process in the dimensions *reactions*, *insight*, *commitment*, *behavioural change*, *communication*, *shared language*, *consensus*, *system changes*, *further use of modelling* and *efficiency*.

The dimensions are then translated into statements. The once for process are presented in table 1 and are rated by the participants themselves. The once for outcome are presented in table 2 and are rated by external raters.

Table 1 Dimensions of outcome and their operationalisation

Dimension	Operationalization	Measure statements (9-point Likert scale, asked to external raters)
1. Novelty	1a. Originality	The strategy is ingenious. The strategy is imaginative. The strategy is surprising. The strategy is novel
	1b. Paradigm relatedness	The strategy is radical. The strategy is transformational.
2. Workability	2a. Implementability	The strategy can be easily implemented.
	2b. Acceptability	The strategy is socially acceptable. The strategy is legally acceptable. The strategy is politically acceptable.
3. Relevance	3a. Applicability	The strategy clearly applies to the stated problem.
	3b. Effectiveness	The strategy will solve the problem. This is an effective strategy

4. Specificity	4a. Completeness	The strategy can be decomposed into independent subcomponents. The strategy covers who The strategy covers what The strategy covers where The strategy covers when The strategy covers why The strategy covers how
	4b. Implicational explicitness	There is a clear relationship between the recommended action and the expected outcome.
	4c. Clarity	The strategy is clearly communicated with regard to grammar and word usage. The strategy is easy to understand

Table 2 Dimensions of process and their operationalisation

Dimension	Operationalization	Measure (statements on Liker scale; asked to participants)
5. Reaction (I)	5a. Enthusiasm	I have a good feeling about the session The session resulted in valuable results
	5b. Satisfaction	The session was successful. I am satisfied with this session. I am confident that the group solution is correct
	5c. Credibility	The results of the session offer real solutions for the problem The results of the session are based on correct assumptions on the underlying system
6. Insight (I)	6a. Insight in problem	My insight into the problem has increased. The session has given me more insight into the relations between the elements that compose the problem. It is clear to me what the causes of the problem are. I now have more insight into the processes that play a role in the problem. The session has given me insight into the possibilities that my organisation has in 'steering' the problem. The session resulted in new insights.
	6b. Insight in assumptions	My understanding of the opinions of the other participants about the problem has increased. I understand how other participants in the session perceive the problem. I better understand the proposed solutions of other participants in the session.
7. Commitment (I)		I support most of the results that were drawn during the session. I will communicate the results of the meeting in front of other members of my organisation. I will try to convince others in my organisation of the importance of the results.
8. Behaviour (I)		I will use insights from the session in my daily planning practice
9. Perception of Communication (G)		The process has given me insight into the opinions and ideas about the problem of other participants.
10.Perception of development of shared language (G)		During the sessions we have developed a shared professional language During the sessions a platform emerged that supported the sharing of ideas
11. Perception of consensus (G)	11a. On problem	We have reached a shared vision of the problem. The results integrated diverse opinions and ideas of the

		participants. We were able to reach a consensus on the problem.
	11b. On goals	We have reached a shared vision on the goals
	11c. On strategies	We have reached a shared vision on the possible solutions
12. Perception of cohesion (G)		I had a strong sense of being part of a group The session brought me closer to the other participants We experienced conflict during the session There was conflict about the task we had in the session
13. Efficiency gains over traditional method		The session was time efficient We were able to perform the work with less effort than in regular sessions We were able to perform the work in less time than in regular sessions We were able to do more in the same time compared to regular sessions

3. SETUP OF THE EXPERIMENT

3.1 Intervention: Urban Strategy PSS

TNO started around 2005 with the development of a PSS – Urban Strategy (Borst et al. 2007; 2009a; 2009b) – specifically aiming to bridge the existing flexibility- and communication bottlenecks. Urban Strategy aims to improve complex spatial planning processes on the urban- and regional level. To do this, different computer models are linked to a central database and interface to provide insights in a wide area of urban indicators and maps. The effects of interventions in infrastructure, land use, build objects and their functions can be calculated and visualized. Because the PSS is able to calculate fast and present the results in an attractive 1D, 2D and 3D visualisation this can be used in interactive sessions with planning actors.

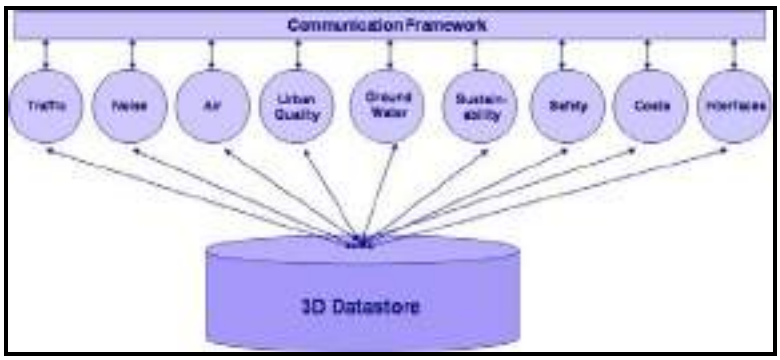
Starting point for Urban Strategy is the use of existing state-of-the-art and legally accepted models. To link these existing models a number of new elements were developed:
- a database with an uniform datamodel;
- interfaces that show a 3D image of the modeled situation, indicators and that offer functionality to add interventions;
- a framework that structures the communication between the models and the interfaces.

3.2 Mechanisms: how does Urban Strategy bridge the PSS implementation gap?

The goal of Urban Strategy is to enable planning actors in workshop sessions to communicate their ideas and strategies to the PSS and to learn from the effects that are shown. This interactivity calls for fast calculations of all the model and fast communication between all elements. For this, the models were enabled to respond on *events* (urban interventions from the participants in the workshops. A new software architecture was developed to have all these elements communicate (figure 2).

Through this increases speed and the wide variety of models that are linked together, the PSS aims to be highly flexible in offering answers to a large number of questions that a group of urban planning actors can have.

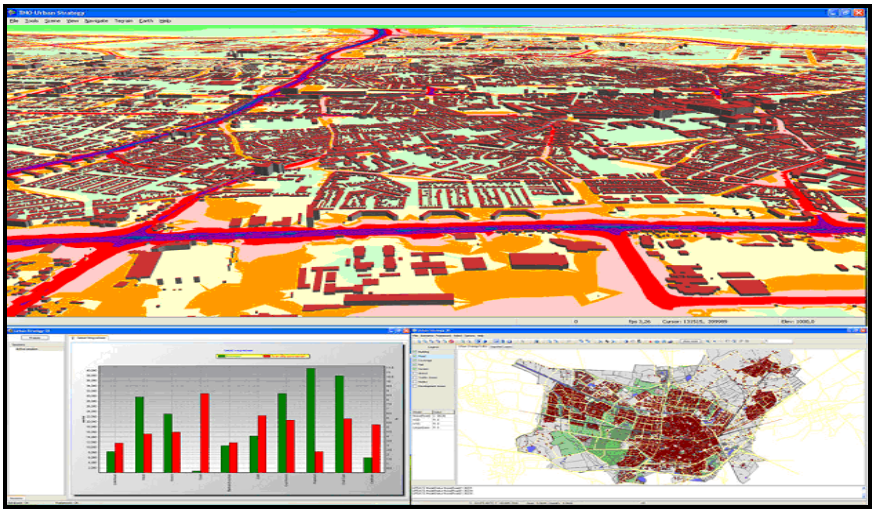
Figure 2 Schematic overview of communication architecture of Urban Strategy.



The 3D interface generates, based on objects in the database, a 3D digital *maquette* of the urban environment. To this, different information layers can be addes, such as air quality contours, noise contours and groundwater levels. Also, the objects can be colored according to their characteristics (function, energy use, CO2 emissions, number of inhabitants, etc). The 2D interface can be used by the end user (or operator) to add changes to the database. Objects can be added or removed, their location can be changed and the characteristics of the object can be changed. The 1D interface shows

indicators that are calculated by all the models that are included. Examples are the percentage of noise hindrance, group risk in an area or the contribution of types of objects to CO2 emission.

Figure 3 The three interfaces of Urban Strategy



3.3 A two group treatment experiment

Together with TNO we organized two sessions in which the usability of Urban was tested. For this we set up a typical urban planning problem: where to allocate a large number of new houses and jobs from an accessibility point of view in the western part of Rotterdam (appendix I). The groups were told that their results would be assessed on novelty, workability, relevance and specificity (the dimensions of table 1).

We invited seven second year Urban Planning students from the University of Amsterdam based on their excellent performance in the course '*Planning voor Ruimte en Mobiliteit*' in 2010. They represented future planning practitioners that deal with planning challenges such as the abovementioned. The seven students were randomly split into two small groups. Each group was then asked to find the best solution for the proposed urban planning problem.

Both groups were treated in a similar way. They each got 70 minutes to process the information n on the problem, get acquainted with Urban Strategy and then come up with a solution for the planning problem. First they were asked to individually read the assignment. After they signaled that they read it, Ralph Klerkx started to introduce Urban Strategy to the group. In 10 minutes, he showed the functionality of the instrument and what can and cannot be done with it. After this introduction Ralph guided the groups in finding solutions for the planning problem. A TNO colleague did the hands-on work of translating the interventions of the students into Urban Strategy and starting the calculations to show the effects of certain interventions.

After a small number of iterations (planning interventions and seeing their effects) both groups had to draw up an integrated land use and mobility strategy for the region

Next to the support by Urban Strategy (the PSS and the support by Ralph and his TNO colleague) the groups had pens and paper to their disposal. Also, a number of maps of the area were printed on A3 size and positioned on the table. Both groups used these maps to present their strategy and added a written explanation to it.

4. TWO SESSIONS OF STRATEGY MAKING

The two groups applied a different strategy making style. In this section we will shortly describe the most notable differences and similarities

4.1 Group 1 (4 persons)

The first group consisted of four male urban planning students with a background in land use and mobility studies. The group started with an introduction to Urban Strategy by Ralph. 1 of the participants asked questions about the OD matrix and the network that is used to calculate effects.

The strategy making started from a bottleneck point of view (the bridges are congested, this needs to be solved). There is one person that takes the lead in the process while another responds to the ideas of this person. The response is mostly done based on information in the maps (by pointing to them). When the group wants to start testing the first idea of a housing strategy they ask if they can see the zones that are used to calculate the effects because they want to use this as their scale of reference (i.e. 25.000 new houses in one zone, more detailed allocation not a question in these kinds of strategic questions). Urban Strategy is adapted to show these zones. The group then asks many questions about what they exactly see in the maps. They keep a very analytical stance in the process. They keep asking questions about the limits of the models behind the results. Although they test some of their assumptions and share their tacit knowledge, they are showing a lack of confidence in the results. They only used Urban Strategy to look at traffic intensities (mainly on the bridges) and stayed on a very abstract level of detail. In general this group followed a design – evaluate – design – evaluate approach.

4.2 Group 2 (3 persons)

The second group consisted of three male urban planning students with a background in land use and mobility studies. During the introduction of Urban Strategy one participants asks clarification on the legend that is used in the traffic intensity map. Another participant asks questions relating to the borders of the model: what can(‘t) it do?

The strategy making is started as an individual exercise. The participants started to individually think, look and draw. The first idea that is put to the test is the extension of the road network to connect the new tunnel. With this, the group hopes to solve some of the congestion and externalities of the east-west corridor through the city. During the drawing of this new road in Urban Strategy, the system created several errors. In the end, the system had to go back to the starting position, because the network was not functioning properly any longer.

5. OUTCOMES

5.1 Quality of outcome

The total number of participants (7) and groups (2) are too small to make significant statements about the effects of Urban Strategy. We also did not have a control group of students that dealt with the planning problem in a business-as-usual scenario (i.e. no support from a PSS). However, the results are still offering valuable insights.

Three experts (PhD students in the area of integrated land use and transport planning) were asked to rate the outcomes of the two groups (the two integrated land use and transport strategies). They were asked to rate the statements in table 1 on a seven point Likert scale. Table 3 shows the average of the six scores (three raters times two strategies) on all statements and on the four dimensions.

Table 3: Quality of the outcome

	Score	**Group 1 (4p)**	**Group 2 (3p)**	**N**
Novelty	**3,6**	**3,4**	**3,7**	
Originality	**3,0**	**2,5**	**3,6**	
The strategy is ingenious	*2,8*	*2,5*	*3,0*	*4*
The strategy is imaginative	*3,5*	*3,0*	*4,0*	*4*
The strategy is surprising	*3,2*	*2,7*	*3,7*	*6*
The strategy is novel	*2,7*	*1,7*	*3,7*	*6*
Paradigm relatedness	**4,2**	**4,3**	**4,0**	
The strategy is radical	*3,7*	*4,0*	*3,3*	*6*
The strategy is transformational	*4,7*	*4,7*	*4,7*	*6*
Workability	**3,9**	**2,9**	**4,2**	
Implementability	**3,4**	**3,0**	**3,7**	
The strategy can be easily implemented	*3,4*	*3,0*	*3,7*	*5*
Acceptability	**4,1**	**2,8**	**4,3**	

The strategy is socially acceptable	~~*3,0*~~	~~*1,0*~~	~~*4,0*~~	*3*
The strategy is legally acceptable	*4,3*	*3,5*	*5,0*	*4*
The strategy is politically acceptable	*4,0*	*4,0*	*4,0*	*4*
Relevance	**3,1**	**2,5**	**3,8**	
Applicability	**3,4**	**3,3**	**3,5**	
The strategy applies to the stated problem	*3,4*	*3,3*	*3,5*	*5*
Effectiveness	**2,9**	**1,8**	**4,0**	
The strategy will solve the problem	*3,0*	*2,0*	*4,0*	*4*
This is an effective strategy	*2,8*	*1,5*	*4,0*	*4*
Specificity	**2,9**	**2,5**	**3,4**	
Completeness	**2,9**	**2,6**	**3,2**	
The strategy can be decomposed.	*4,8*	*4,0*	*5,5*	*4*
The strategy covers who	*1,0*	*1,0*	*1,0*	*6*
The strategy covers what	*4,3*	*3,7*	*5,0*	*6*
The strategy covers where	*5,3*	*5,3*	*5,3*	*6*
The strategy covers when	*1,2*	*1,3*	*1,0*	*6*
The strategy covers why	*1,7*	*1,0*	*2,3*	*6*
The strategy covers how	*1,8*	*1,7*	*2,0*	*6*
Implicational explicitness	**2,5**	**1,3**	**3,7**	
There is a clear relationship between the recommended action and the expected outcome.	*2,5*	*1,3*	*3,7*	*6*
Clarity	**3,3**	**2,7**	**3,8**	
The strategy is clearly communicated	*2,8*	*2,0*	*3,7*	*6*
The strategy is easy to understand	*3,7*	*3,3*	*4,0*	*6*

* The statements that were rated by half of the (*grey*) are (less than) raters from the excluded calculations.

In a lack of a control group the only reference point that we have is an expected average. Following this, we could state that each score under 3,5 is relatively bad and above 3,5 is relatively good. The average aggregated score for the quality of the outcome is 3,3. However, there is a large difference between the two groups (resp. 2.8 and 3.8).

The dimensions novelty and workability are rated as good, although only slightly above average (resp. 3,6 and 3,9). There are also a very limited number of statements that score relatively good. On average the two strategies are rated as relatively radical (3,7) and transformational (4,7) legally and politically acceptable (4,3 and 4,0) and decomposable (4,8), especially into what (4,3) and where (5,3)

The lowest scores are related to the sub dimensions originality (3,0), effectiveness (2,9), completeness (2,9) and explicitness (2,5). The expert raters have low rates on the statements for ingeniousness (2,8), novelty (2,7) and effectiveness (2,8). They also think that there is too little information in the strategies on who (1,0), when (1,2), why (1,7) and how (1,8).

5.2 Quality of process

To assess the quality of the process the seven participants were asked to rate the statements from table 2 on a seven point Likert scale. This again means that an average score above 3,5 equals a relatively good score and below 3,5 a relatively bad one. Although the number of participants is too

low to show significant patterns, all dimensions show a positive result. The overall aggregated average for the quality of the process is 4,0.

Table 4: Quality of the process

	Score	Group 1 (4p)	Group 2 (3p)	N
Reaction	**3,6**	**3,1**	**4,3**	
I have a good feeling about the session	5,3	4,5	6,3	*7*
The session resulted in valuable results	2,7	1,8	4,0	*7*
The session was successful	4,3	3,3	5,7	*7*
I am satisfied with this session.	4,6	4,3	5,0	*7*
I am confident that the group solution is correct	3,1	1,5	5,3	*7*
The results of the session offer real solutions for the problem	2,3	2,0	2,7	*6*
The results of the session are based on correct assumptions on the underlying system	2,6	2,8	2,3	*7*
Insight	**4,2**	**4,2**	**4,3**	
My insight into the problem has increased	4,7	4,8	4,7	*7*
The session has given me insight into the possibilities that my organisation has in 'steering' the problem	5,0	5,0	NoData	*1*
It is clear to me what the causes of the problem are.	4,0	3,3	5,0	*7*
I now have more insight into the processes that play a role in the problem	4,5	5,0	4,0	*6*
The session has given me more insight into the relations between the elements that compose the problem.	4,3	4,5	4,0	*7*
The session resulted in new insights	4,7	5,0	4,3	*7*
My understanding of the opinions of the other participants about the problem has increased	3,8	3,7	4,0	*6*
I understand how other participants in the session perceive the problem	4,3	4,0	4,7	*6*
I better understand the proposed solutions of other participants in the session.	3,6	3,0	4,0	*5*
Commitment	**4,4**	**3,3**	**5,0**	
I support most of the results that were drawn during the session	4,4	4,0	5,0	*7*
I will communicate the results of the meeting in front of other members of my organisation	4,5	4,5	NoData	*2*
I will try to convince others in my organisation of the importance of the results	1,5	1,5	NoData	*2*
Behaviour	**5,0**	**5,0**	**5,0**	
I will use insights from the session in my daily planning practice	5,0	5,0	5,0	*6*
Perception of communication	**4,0**	**3,3**	**4,7**	
The process has given me insight into other people's opinions and ideas about the problem	4,0	3,3	4,7	*6*
Perception of development of shared language	**4,1**	**4,1**	**4,2**	
During the sessions we have developed a shared professional language	3,9	3,8	4,0	*7*
During the sessions a platform emerged that supported the sharing of ideas	4,4	4,5	4,3	*7*
Perception of consensus	**5,1**	**4,5**	**5,8**	
We have reached a shared vision of the problem	5,3	5,0	5,7	*6*

The results integrated diverse opinions and ideas of the participants	4,4	4,0	5,0	*7*
We were able to reach a consensus on the problem	5,3	5,0	5,7	*7*
We have reached a shared vision on the strategic goals	5,1	4,3	6,3	*7*
We have reached a shared vision on the possible solutions	5,1	4,3	6,3	*7*
Perception of cohesion	**4,9**	**3,7**	**4,1**	
I had a strong sense of being part of a group	5,7	5,3	6,3	*7*
The session brought me closer to the other participants	4,7	4,0	5,7	*7*
We experienced conflict during the session	(-) 2,6**	(-)2,5	(-)2,7	*5*
There was conflict about the task we had in the session	(-) 2,4	(-)3,0	(-)1,7	*7*
Perception of efficiency gains	**3,9**	**4,6**	**4,3**	
The session was time efficient	3,9	4,3	3,3	*7*
We were able to perform the work with less effort than in regular sessions	*3,3*	*6,0*	*2,0*	*3*
We were able to perform the work in less time than in regular sessions	*5,0*	*4,0*	*6,0*	*2*
We were able to do more in the same time compared to regular sessions	*4,7*	*4,0*	*6,0*	*3*

* The statements that were rated by less than half of the participants (*grey*) are excluded from the calculations.

** The statements with a minus are negative statements (the lower the rate, the better the score).

Of the dimensions, the perception of consensus has the highest score of 5,1. However, there are large differences between the two groups. In the first group of four persons this was rated with 4,4 and in the second 5,8 The participants were especially content with the shared vision (5,3) and consensus (5,3) on the problem. If we look to the separate statement, it is noteworthy that the participants rate the "sense of being part of a group" highly (5,7).

On the negative side, the participants think that the sessions do not offer real solutions for the problem, rate the value of the results fairly low and also doubt if the results are based on correct assumptions about the land use and transport system.

6. CONCLUSIONS AND IMPLICATIONS

Although these two treatment groups only give us some first insights, we can already identify some interesting directions. It seems that Urban Strategy in its current form has difficulties in supporting integrated land use and transport strategy making on the urban scale.

6.1 Conclusions relating to the measurement framework

In this report we have operationalized the goals of PSS (to improve planning) into a measurement framework of two multidimensional concepts: the quality of the outcome (rated by external experts) and the quality of the process (rated by the participants). All parameters were measured on a 7-point Likert scale.

Since we have not yet measured a control group, it is difficult to state what the value of the framework is. The differences that occur between the two groups (both underwent the same treatment) might hint to the fact that the reliability of the indicators is weak. It can also indicate that the composition of the group of participants has a strong influence on the measured indicators.

Especially in some of the statements that were rated by the external experts, a high standard deviation was found, indicating that measurement validity can be weak. We will have to do a more in-debt analysis on these specific indicators and see where this lack of agreement comes from.

6.2 Conclusions relating to Urban Strategy

From the first results of this experiment, it seems that Urban Strategy in its current form has very little positive effect on the quality of the outcome (3.3) and quality of the process (4,0) of integrated land use and transport strategy making. Observations of the sessions strengthened this finding. It seemed that the scale and level of detail are currently not well tuned to the demands of the land use and transport strategy makers. Also, the kind of indicators used (IC maps, noise areas) are not well suited for the kind of questions that are asked in this planning domain.

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APPENDIX I

Vervoersplanologische uitdaging

Rotterdam West (zie kaart 1) kent tot 2030 een grote ruimtelijke- en mobiliteitsopgave. Zo moeten er in het gebied ruimte worden gevonden voor een groot aantal nieuwe inwoners en banen. Ook de omgeving van het gebied is vol in ontwikkeling, met als voornaamste verandering de aanleg van de Tweede Maasvlakte in het westen. Deze opgave resulteert in een enorme druk op het wegennetwerk van de stad, omdat goederen moeten worden afgevoerd en tegelijkertijd de inwoners en arbeidsplaatsen bereikbaar moeten blijven.

Strategie rondom nieuwe oeververbinding

De Stadsregio Rotterdam denkt momenteel aan het creëren van een nieuwe oeververbinding in het gebied als oplossingsrichting voor dit complexe vraagstuk, waarbij er 2 mogelijke varianten worden onderzocht (zie kaarten 2 (verkeer), 3 (lucht) en 4 (geluid)). Dit is ook het startpunt van jullie opdracht. Jullie worden als vervoersplanologisch team gevraagd om een integrale ruimte- en mobiliteitstrategie te maken voor het gebied. De opgave dient met de volgende zaken rekening te houden:

- Er moeten 25.000 nieuwe inwoners en 25.000 nieuwe banen worden toegevoegd aan het gebied
- De strategie moet ervoor zorgen dat het mobiliteitssysteem goed blijft functioneren, ook na uw interventies.
- Bij het maken van de strategie moeten jullie rekening houden met leefbaarheidsaspecten (met name geluid en luchtkwaliteit)