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DYNAMIC ADAPTIVE POLICYMAKING FOR IMPLEMENTING MOBILITY AS A SERVICE (MAAS)

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1. INTRODUCTION

Given the global urbanisation, many cities around the world are currently facing challenges in managing their transport system. Citizens of cities suffer from its negative externalities, such as poor air quality, extended travel time, and congested road spaces (Edwards & Smith, 2008; Hayashi, et al. 2004; Taipale, et al. 2012; Zavitsas, et al. 2010). Recent trends in reduced car-ownership, the rise of sharing economy, and an introduction of digitalisation into transport sector provide an opportunity to improve the urban transport system and address its adverse effects (CIVITAS, 2016; Holmberg et al., 2015). In this paper, we focus on a specific innovative transport concept: Mobility-as-a-Service (MaaS). MaaS combines different transport modes to offer a hyper-convenient and tailored-made transport solution for its user.

MaaS is a concept, formally initiated within the information technology sector. It denotes an ability to set up a large scale information system through a virtual network, evading the necessity to invest in capital-intensive infrastructure, while enabling users to customise network parameters to their needs (Baliga et al., 2011). In the field of transportation, the concept implies a different meaning. Hietanen (2014) is one of the first to provide a comprehensive definition of MaaS in a transportation context. He describes MaaS as a transport distribution model that combines a range of transport modes and services to provide a user-orientated transport solution via a single interface, in exchange for a pay-as-you-go fee or a monthly subscription, similar to a mobile phone service.

MaaS presents a potential paradigm shift in the transport system. It offers a change from the current ownership-based transport system towards a consumption based one (Holmberg et al., 2015). It liberates the users from any potential mode-specified sunk costs, such as car ownership or annual public transport subscription fees, that potentially 'lock' users to certain modes. Instead, under MaaS users can flexibly combine the available modes to fit their changing needs best, through a digital platform, a virtual



marketplace that mediates mobility supply and demand (Meurs & Timmermans, 2016). Also, MaaS is different to the other transport concepts, such as integrated transport or multimodal mobility in its emphasis on the use of digitalisation and the 'business dimension' or opportunity to connect transport service with services from other sectors, such as tourism and entertainment. (Finger et al., 2015).

As MaaS is still in its developing phase, a number of organisations are competing to offer different interpretations and supplements to the concept. For example, MaaS Alliance, a public-private partnership founded to provide a standard approach to MaaS, describes MaaS as an integration of transport services to provide on-demand transport through a single mobility platform (MaaS Alliance, 2017). The Mobility as a Service for Linking Europe (MAASiFiE), a pan-European MaaS project, adds to the above concept by emphasising the importance of environmental aspect and shared mobility (Karlsson, Sochor, Aapaoja, Eckhardt, & König, 2017). Others sources build on these concepts by inserting elements such as personalisation (ATKINS, 2015), technology (Nemtanu, Schlingensiepen, Buretea, & Iordache 2016), or Big Data (Xerox, 2015) as additional aspects of MaaS. (See Jittrapirom et al.(2017) for a review on definition of MaaS). In addition to these definitions, several actors have also presented their White Papers on MaaS, such as Comtrade (2017), travelspirit (2017), and TSSG (2017). If the concept of MaaS attracts further interest, its definition will continue to evolve.

The implementation of MaaS is likely to have positive and negative, uncertain effects. Proponents believe that the shift away from an ownership-based to a use-based transport system in MaaS has a potential to increase public transport use through a provision of a high-level of convenience that persuades drivers to give up their private vehicles. Additionally, it can contribute to the transport system performance by increasing its efficiency, reducing congestion, decreasing the need for parking space, and enhancing the level of accessibility (European Commission, 2016). It also provides an opportunity to offer a guaranteed door-to-door multimodal transport service, which promises customers a trip from A-to-B within a specified time frame. Such a system is likely to blur the boundary between public and private (Finger et al., 2015). However, there are also several concerns regarding the implementation of MaaS. Such as the inherent risks in the increased use of centralised, ICT-based transport services, which enable parties that have access to the data and how it is presented to users to influence the market,

affecting security risks and privacy (Finger et al., 2015). Mulley (2017) points out that such tailored mobility solutions can even lead to “more vehicles on the road” unless a sharing culture is promoted. Additionally, a trial project in Ubigo, a transport broker service in Gothenburg (Sweden), suggests a need to regulate how a platform aggregator ‘organise’ users’ trips. The results show the trial reduced the participant’s’ car use, a desirable societal goal, but this also lowered the revenue of the platform owner. For the reason that Ubigo was unable to price public transport trip higher than the market rate. Thus it relied on making profits from the utilisation of other modes in the package, such as taxi, bicycle sharing, car sharing, and car rent (Sochor et al., 2015). There is also a concern regarding equity in access to mobility that can be influenced by a platform aggregator (P Jittrapirom et al., 2017). For example, Whim employs a concept of mobility currency that gives discounted advantage to users, who can afford higher monthly package. A mobility point purchase through Whim’s most expensive subscription (€389 for 10,000 points) is more than 50% cheaper than a Whim point purchase through its most basic package (€89 for 1,000 points). Lastly, literature such as Giesecke, Surakka, & Hakonen, (2016) and Holmberg et al., (2015) emphasise the importance of configuring MaaS in a way that ensures its contribution towards the overall sustainability of the transport system.

There have been some MaaS schemes implemented around the world. Among those, are pilot projects that operated within a defined period such as Ubigo (Finland), SMILE project (Austria), and Katsuplus (Finland). Others are ongoing operational schemes, such as Tuup and Whim (Finland), Hannover Mobility Shop (Germany), and MyCicero (Italy). The operationalised of these pilot and schemes have facilitated a quantification of their impacts. However, there still are a limited number of these projects. For this reasons, there are still several unknown elements that may restrict MaaS widen implementation, such as the preferences of public transport operators, travellers’ acceptance, liability in case of malfunctioning, concerns about privacy and security, and the contributions of MaaS towards the transport system as a whole.

To cope with these uncertainties and to enhance the likelihood of success of future MaaS projects, we put forward an adaptive approach to implementing MaaS system for an urban area of Nijmegen, the Netherlands. The approach allows policymakers to create policies that are more robust for future situations and can adapt as the future unfolds and uncertainties resolve. The application of DAP to this case study should demonstrate its implementation

within transport policy making, in particular, implementation of MaaS. In section 2, we present a framework for policy analysis and provide a classification of uncertainty associated with each entity in the framework. We then describe the DAP framework that supports decision makers in dealing with high level of uncertainty in section 3. We apply the framework to our case study in section 4 and conclude the paper in section 5.

2. A FRAMEWORK FOR POLICY ANALYSIS AND UNCERTAINTY

Policymaking, in essence, involves identifying a set of measures or interventions to a system, with an aim to gain desirable outcomes. In Figure 1 a framework for policymaking based on this view is presented (Walker, 2000). The core of this framework is the system domain (R), which in our case, is the urban passenger transport system. We can define the boundaries and structure within the system domain as follows: the main entities are the subjects of transportation (people), the means of transportation (vehicles), and related infrastructures (roads, rail within an urban environment). Their mutual interactions produce outcomes of interest (O), which in this case can be energy consumption, the level of emissions, the level of congestion, and the level of traffic safety (e.g. casualties, injuries). Policymakers value these outcomes based on their subjective preferences or weighing (W). Subsequently, they evaluate these outcomes against their set goals or whether the perceived problems are resolved.

Policies (P) and external forces (X) are two types of influence that act on the system domain. The policies are a set of actions policymakers control, such as the providing legislation for public transport operations or constructing additional bicycle lanes. In contrary, the external forces are beyond the reach of policymakers. Examples of such external forces in the field of urban transport are population demographics, climate change, technological developments, and economic developments.

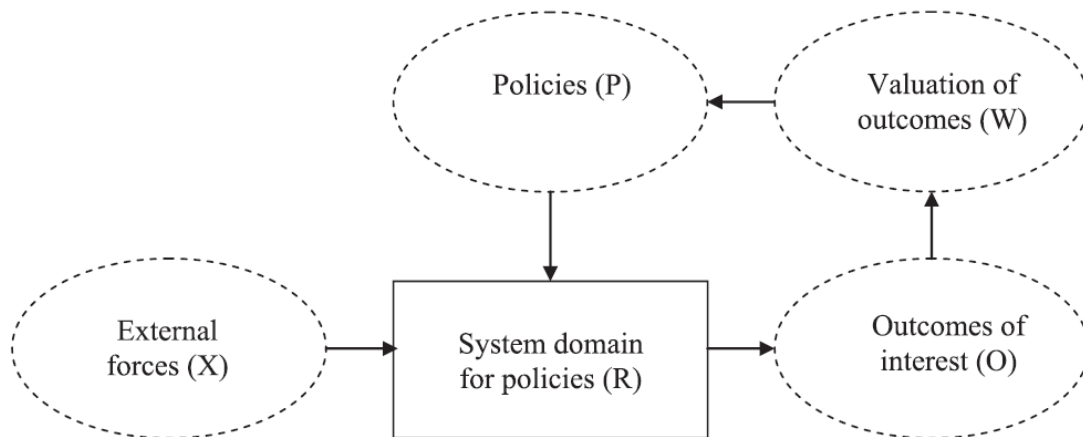


Figure 1. A Policy making framework (Walker, 2000)

In this framework, different levels of uncertainty can be distinguished per location (Walker & Marchau, 2017). For example, regarding external forces (X), the uncertainty in national economic developments (X) is considered very uncertain while ageing developments might be regarded as rather certain. Another example involves the impacts of policies (R). For some policies, the impacts can be rather well predicted (e.g. alternative parking fee schemes) while for other parking policies (e.g. Park and Ride) this seems more difficult. Walker et al., (2010) introduce a typology for uncertainty based on the levels of uncertainty. The levels of uncertainty proposed are grounded on a view that uncertainty is nonbinary. Additionally, it purports how the level of uncertainty can be classified based on how it can quantify or predicted accurately (Courtney, 2001). For instance, an entity with uncertainty on level 1 can be predicted from trend extrapolation. Level 1 uncertainty is often treated through a simple sensitivity analysis of transport model parameters, where the impacts of small perturbations of model input parameters on the outcomes of a model are assessed.

Level 2 uncertainty is any uncertainty that can be described adequately in statistical terms. In the case of uncertainty about the future, Level 2 uncertainty is often captured in the form of either a (single) forecast (usually trend based) with a confidence interval or multiple forecasts ('scenarios') with associated probabilities.

However, in level 3 and 4, it becomes difficult to predict the future using a probabilistic approach as there are a multiplicity of plausible (level 3) or even unknown (level 4) futures. Figure 2 depicts the gradual transition of a level of uncertainty from complete certainty (left) to total ignorance (right).

In case of MaaS, the level of uncertainty surrounding its implementation is high (Level 4). There are several for this. Firstly, there is still a limited knowledge about this novelty transport concept as a transport policy intervention. Several of these ambiguities have been mentioned earlier, such as the continuous evolving of the definition, its overall effects to the urban transport system, and user and stakeholders' acceptance. It may be possible to speculate likely outcomes of these concerns from lessons learnt in other sectors, such as hospitality in Airbnb or within the transport sector itself from Uber. Still, the speculation is likely to have a limited level of accuracy as well as polarised opinions from stakeholders and scientific community. The second dimension is the complexity arises from the domain of MaaS. Urban transport is known to be a highly complexed system, mainly due to the interconnectivity between the entities within it (Kölbl et al., 2008; May, 2003). Certain transport policy can bring about unintended effects that worsen the overall performance of the system (ADB, 2009; IET, 2010; Jittrapirom, Knoflacher, & Mailer, 2017). The third dimension is the valuation of the outcome by decision makers, which may be forecasted with some certainty but this subjectivity can also be influenced by other factors that have a high level of uncertainty, such as public mood at the time of valuation. The final dimension arises from the uncertainty associated with the external forces. Certain forces, such as population can be forecasted using past data with some accuracy, other forces, such as national economic development, are harder to predict accurately.

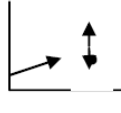
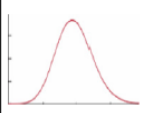
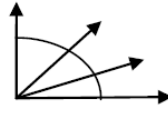
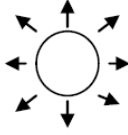
		Level 1	Level 2	Level 3	Level 4	
Complete Certainty	Context (X)	A clear enough future (with sensitivity) 	Alternate futures (with probabilities) 	A multiplicity of plausible futures (unranked) 	Unknown future 	Total ignorance
	System Model (X)	A single (deterministic) system model	A single (stochastic) system model	Several plausible system models, with different structures	Unknown system model; know we don't know	
	System Outcomes (O)	A point estimate for each outcome (with sensitivity)	A confidence interval for each outcome	A known range of outcomes	Unknown outcomes; know we don't know	
	Weights on outcomes (W)	A single set of weights	Several sets of weights, with a probability attached to each set	A known range of weights	Unknown weights; know we don't know	

Figure 2: The progressive transition of levels of uncertainty from complete certainty to total ignorance (based on (Walker, Marchau, & Kwakkel, 2013)).

3. DYNAMIC ADAPTIVE POLICY (DAP)

The key idea to cope with Level 4 uncertainties, is to move away from developing a static plan that will work well for one or more specific futures, and in its place, constructs a dynamic plan that is flexible, adaptable and perform well across the full range of plausible futures (including surprises). Based on this awareness, Walker et al. (2001) developed a Dynamic Adaptive Policymaking (DAP) scheme which was further elaborated and applied by Kwakkel et al. (2010) and Vander Pas et al. (2013). This scheme enables policymakers to deal with the uncertainties surrounding the policy formulation process. DAP is based on the recognition that perfect information about a system is unattainable. Instead, it focuses on utilising available information in making a robust policy that is prepared to cope with uncertain vulnerabilities and can capture arising benefits. Moreover, it emphasises the importance of creating a policy framework that allows policy to be adapted and changes in according to information gain and related feedbacks receive from the system as part of the process.

The DAP consists of two phases; 1) a design phase and 2) an implementation phase. In the first phase, the dynamic adaptive policy, monitoring program, and various pre- and post-implementation actions are formulated. The latter phase consists of the operationalising of the policy, the monitoring of its performance, and the implementation of (ex-ante developed) adaptation actions if necessary. The key terms of DAP are Vulnerabilities, events that can reduce the impact of a policy to a point where the policy is no longer successful, and Opportunities, events that can enhance or accelerate policy success.

The planning phase of DAP consists of five steps; the first and second steps are the identical to the traditional policy formulation, while the rest of the steps are unique to DAP. Figure 3 depicts the five steps with a summarised description below.

- Step I: Stage-setting step – this involves the traditional starting activities in policymaking, such as specifying objectives or policy goals, a definition of success, constraints that may prevent the objectives to be reached, and available policy options.
- Step II: Assembling a basic policy – this consists of selecting a preferred, initial policy to be implemented and identifying the required conditions for the basic policy to be a success
- Step III: Increasing the robustness of the basic policy – this involves identifying vulnerabilities and opportunities of the selected policy, together with their associated likelihood (i.e. certain or uncertain) and immediate actions to be implemented in conjunction with the basic policy at $t = 0$ to decrease unfavourable or amplify favourable effects. These actions can be classified as:
 - Mitigating Action (M)– actions to reduce a Certain Vulnerability
 - Hedging Action (H) – actions to reduce an Uncertain Vulnerability
 - Seizing Actions (SZ) – actions to amplify a Certain Opportunity
 - Exploiting Action (Ez) – actions to amplify an Uncertain Opportunity
 - Shaping Action (SH) - actions to reduce the likelihood of a vulnerability or an opportunity

- Step IV: Setting up the monitoring system. This step includes defining signposts to track information and associated triggers. Triggers are critical values of signpost variables beyond which actions to change the policy should be implemented to ensure that the resulting policy keeps moving the system in the right direction and at a proper speed.
- Step V: Preparing the trigger response – this comprises the specification of a set of actions to be taken when a trigger level is reached after the basic policy is implemented (at $t > 0$). The associated responsive actions are:
 - Defensive Action (DA) – an action taken after the fact to clarify the policy, preserve its benefits, or meet challenges in response to specific triggers that leave the basic policy remains unchanged
 - Corrective Action (CA) – an adjustment to the basic policy in response to specific triggers
 - Capitalizing Action (CP) – an action taken after the fact to take advantage of opportunities that further improve the performance of the basic policy
 - Reassessment (RE) – an action to reevaluate or revise the whole basic policy

After the formulation of dynamic adaptive policy is completed, the DAP proceeds from the designing phase to the implementation phase; the basic policy is implemented together with prior actions and the monitoring system. The adaptive process is suspended until a trigger value is reached and a responsive action is activated. In certain cases, the responsive actions may not be sufficient to support the basic policy and the basic policy need to be revised altogether. In such case, the experience and information gained from setting up the initial adaptive policy can be of valuable input to the subsequent process.

In the next section, this DAP scheme is applied to develop an adaptive policy for implementing a MaaS-concept in the city of Nijmegen, the Netherlands. This application is a simplified example to illustrate the potential of DAP in this context

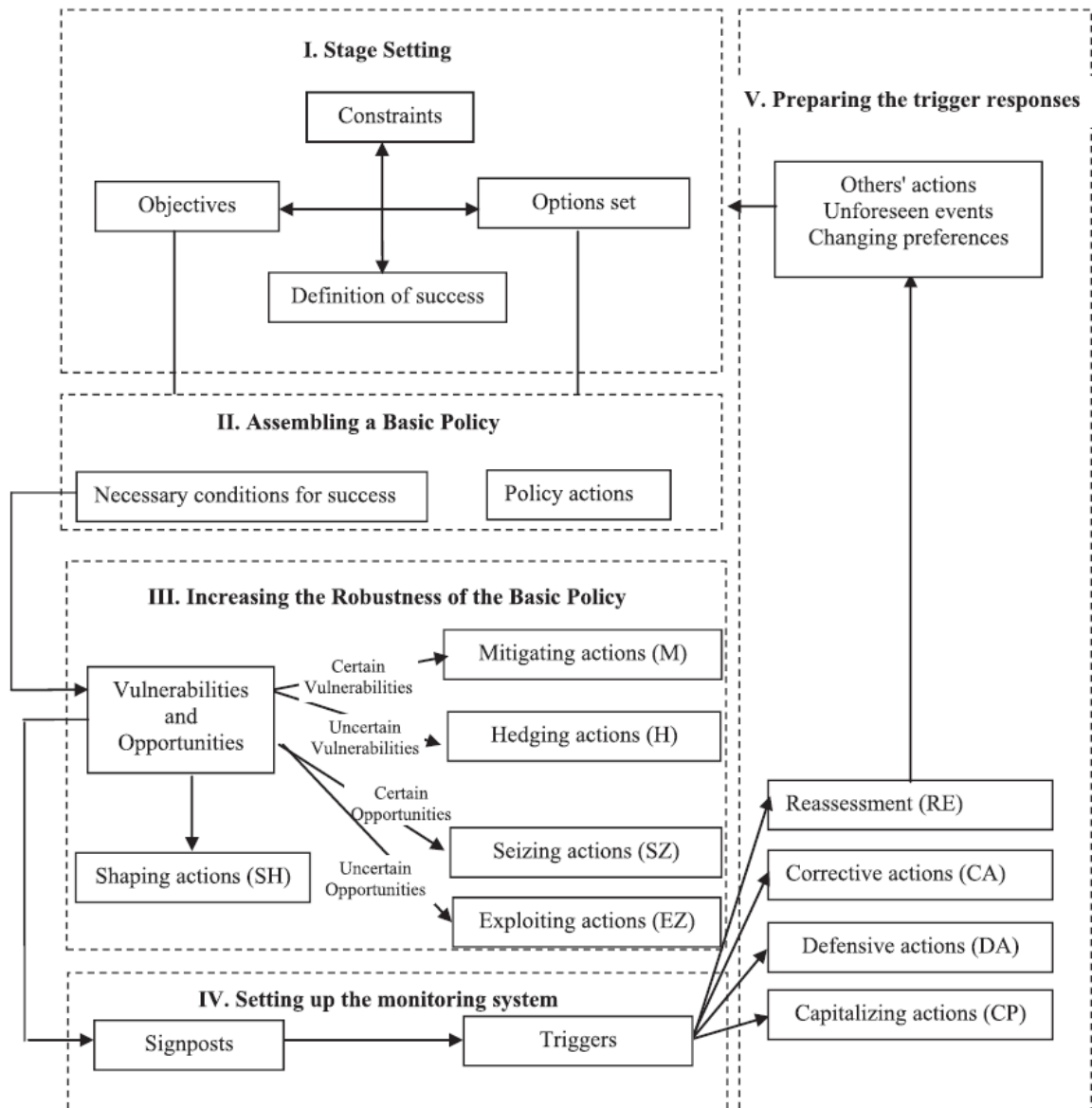


Figure 3: DAP process (Machau et al. 2017, adapted from Walker et al. 2013)

The application of DAP has been explored in various fields, such as airport strategy planning (Kwakkel et al., 2008), Innovative urban transport solutions (Marchau et al., 2008), climate change (Rahman et al., 2008) and road pricing (Marchau et al., 2010).

4. CASE STUDY: NIJMEGEN CITY, THE NETHERLANDS

4.1 Background

Nijmegen is a city in the province of Gelderland, situated in the eastern region of the Netherlands. As of April 2017, the city has about 170,000 inhabitants. Nijmegen is also adjacent to the city of Arnhem (25 kilometres), which has about 150,000 inhabitants, as of 2017. The proximity between the two cities makes them often seen as twin cities.

Nijmegen attracts a high amount of traffic, which is generated by its population and employment in the area. The major employers are academic institutions, hospitals, and industries. The daily incoming traffic consists of commuters, students, business people, hospital and city visitors. The outgoing traffic is also mainly employment and education commuters to the surrounding city and the western Dutch urban area in Randstad region (City of Nijmegen, 2016).



Figure 4: Public transport network of Nijmegen (City of Nijmegen, 2016)

Public transportation plays an essential part in the city's transport system. The main railway (Nijmegen Station) provides intercity and regional connections between Nijmegen with destinations such as Amsterdam, Schiphol, and a

border town with Germany in Venlo. It facilitates approximately 45,000 passengers on average daily. The city has four other stations, one of which serves the Heijendaal district that is largely occupied by Radboud University, Radboud UMC (academic hospital) and HAN University of Applied Sciences. Similar to other cities in the Netherlands, Nijmegen has a high proportion of cycling traffic, with over 24% of daily traffic. Nevertheless, private car has the highest trip proportion, with 41% (driver and passenger combined), whereas public transport accounts for 9% of all daily trips. This figure is slightly different if we consider only trips below 5 kilometres. Cycling trips become dominant (37%), followed by car trips (30%), and walking (28%). Public transport trips represent a meagre proportion of only 3-4%, although 88.7% of the city's population was living within 300 metres from a public transport line in 2014-2015 (City of Nijmegen, 2016).

Nijmegen city is currently experiencing increased transport congestion during rush-hours. Long queues of car traffic can be regularly observed around the two bridges that link the city to its surrounding area to the north. Additionally, there are long queues of bus and train passengers for services between the central station and Heijendaal district during the peak hours period as well. Breng, the local bus operator, has commissioned an exclusive bus rapid transit service between the station and Heijendaal district to resolve the issue but the problem persists. These congestion problems are expected to intensify, as the residential area north of the city (De Waalsprong) is further developed, and the number of students enrolled at these institutions continues to increase. Also, the low percentage of bus patronage put a strain on the bus operator to maintain the profitability of the operation of its 35 bus lines.

4.2 DAP for implementing MaaS in Nijmegen city

In this section, the DAP framework is applied to resolving the transport problems of Nijmegen. The main aim here is to demonstrate how DAP can be used to formulate an implementation plan for a MaaS scheme. This DAP is neither exhaustive or finalised. It is simplified and based on a desktop study, and only a selection of items are included here. The information presents here should be seen as a simplified first draft of the DAP plan to initiate discussion with stakeholders, who will enhance the sophistication and relevance of the plan through a participatory process.

Step I Setting the Stage

The current transport policy objectives of Nijmegen city are to maintain the levels of accessibility, reliability, and safety of its transport system from the perspectives of visitors, residents and economic vitality of the inner city. The objectives also focus on clean and sustainable transport, such as bicycle and public transport. Based on these objectives, the city aims to achieve: 1) Increase accessibility and flow, 2) Increase quality and quantity of parking facilities, 3) Increase road safety, 4) Stimulate participation public transport, and 5) Stimulate bicycle use (City of Nijmegen, 2017).

There is a number of policy options to realising these objectives; such as improving the existing public transport service, introducing an innovative demand-responsive transport service, or implementing a MaaS scheme. MaaS can be a promising policy as its operationalise can improve the efficiency of the transport system through better matching between demand and supply. Additionally, the hyper-convenient transport service in MaaS is likely to increase public transport patronage. However, there are a number of uncertainties that currently obstruct the large-scale implementation of MaaS, such as users' acceptance and the willingness of transport operators to support the implementation. The latter can be elaborated further into lack of trust, potential loss or control over their operation, and the need to adjust their business model (Finger et al., 2015; König, Eckhardt, Aapaoja, Sochor, & Karlsson, 2016; Lund, 2017). Additionally, the associated risks in the deployment of an innovative transport solution as MaaS are high. As mentioned above, MaaS is still in its early phase with a limited number of operational and pilot schemes.

Step II Assembling a basic MaaS-policy

A step forward is to start with implementing a demand-responsive shared-ride service, similar to Katsuplus or UberPool. This measure will allow actors involved to build up experience in operating this innovative transport service and gaining confidence from potential users and stakeholders.

The solution put forward by the Province of Gelderland and Breng is Breng flex, a demand-oriented, shared-ride service operating in the Arnhem and Nijmegen region. Its operation began in December 2016 for a one-year period. The service provides an on-demand connection between a preferred, existing bus stop to another preferred, existing bus stop within the area for a fixed price of €3.50 per passenger. It operates 7-day a week (weekday 06.30-24.00; Sat 08.00-24.00, and Sun 09.00-24.00) (Breng, 2017). The service

fleet consists of ten 7-seater buses, powered by eco-gas and eight electric cars. The bus has space for a wheelchair and baby carriages, which, if needed, can be indicated during the reservation. Users can order a ride via a smartphone app or by calling a dedicated phone number. Once a booking is made, the app informs the user about the driver, the type of vehicle, the license plate, the driver's phone number, the estimated time of pick up, and the total journey time. Trip cancellation is possible free of charge for up to 2 minutes after booking. After that, a 70% of the agreed fee will be charged with a maximum of €5.00. Payment can be made via electronic transfer via an app, iDeal (online transfer), credit card, debit card, or OV chip card (Dutch transport smart card), but cash payment is not accepted. The pilot is monitored and evaluated as part of the Smart Cities' Responsive Intelligent Public Transport Systems (SCRIPTS) project.



Figure 5: Breng Flex Source: left (Breng, 2017), right (author)

The definitions of success for Breng flex are related to the objectives regarding the specification of desirable outcomes (e.g. desired levels of PT use, car-ownership, and congestion, emissions). Next, we identify four necessary conditions of success: a. Sufficient supports by stakeholders, such as public transport operator, b. Sufficient demand for and acceptance of the new service, c. Reliable technology to support operation, and d. Delivery Breng flex's performance in according with general transport goals.

Step III, IV and V (Increasing the robustness of the basic policy, defining a monitoring system, and specifying responsive actions)

The immediate and future robustness of the basic policy is specified in these steps; a number of actions are put forward to improve the policy's robustness, protecting it from failing or taking opportunities. A summary of is presented in Table 1. Columns 1-4 present some clear conditions for the success of the basic policy, its Vulnerabilities (V) and Opportunities (O), and if these vulnerabilities and opportunities are certain or uncertain. Column 5 contains

the actions to be implemented together with the implementation of the basic policy ($t = 0$) to increase the basic policy's robustness. The signposts and their trigger levels, as part of the monitoring system, are shown in column 6, and the associated adaptive actions are specified in the final column.

We will highlight some elements of the table to demonstrate the essence of the DAP scheme and its application to the case study. In the first row (a. Sufficient support by local authority operators and other stakeholders), the lack of interest to participate in actors and stakeholders may be certain, as the concept is innovative and unprecedented. This potential lack of support can derail the project. A possible Shaping Action (SH) to decrease this likelihood is to secure support from critical actors and actively involve and communicate with actors and stakeholders to ensure their understanding and ownership in the project. Additionally, a Mitigating Action (M) is to secure funding that can be used to subsidise the service, thus reducing the reluctance of public transport provider to join the project. The associated signposts will monitor the level of the corporation from each actor and stakeholder (e.g. highly engaged, not interested, and hostile). Should these levels drop below expectation, the adaptive actions will be triggered. These involved intensified stakeholder engagement (CA), reducing the scope of service to minimise impacts (DA), and reassessment of the basic policy (RE).

In the next row, demand for and user's acceptance of the new innovative service is one of the highly critical conditions to its success. It is an uncertain opportunity that hinges on multiple factors. A Shaping Action (SH) to increase the likelihood of high users' demand is an effective marketing strategy that provides information and attracts users to the service. To capitalise this opportunity, we can prepare service extension plan, which increases fleet size or area of coverage. Also, the scope of the project can also be upgraded to implement a MaaS scheme by including a range of other modes of transport, such as bicycle sharing, car sharing, and public transport services. The signposts will monitor the number of users on the platform and actual service usage. These parameters will trigger adaptive actions; to implement expansion plan (CP) or in the event of the high level of demand and acceptance to reassess the plan and roll out a MaaS scheme (RE).

As of August 2017, the actors involved in the Breng flex are highly satisfied with the preliminary outcomes. The mid-term evaluation is currently ongoing and will be finalised by the end of September. The municipality of Nijmegen has initiated a follow-up MaaS pilot project in SL!M Nijmegen. The project

aims to provide a door-to-door mobility service via a platform interface of a smartphone App and website. It is a collaboration between the local steering group of Heijendaal district, the representative of the public transport provider in Breng knowledge centre, and the local authority in the Province of Gelderland. The pilot is also part of the SCRIPTS project with an operation period between 20 August 2017 and 1 March 2018.

SL!M's primary target group is the visitors to the Heijendaal district, which is home to several academic and research institutions, such as Radboud University, Radboud UMC (academic hospital) and HAN University of Applied Sciences. Additionally, it aims to benefit the residents, as well as students and employers of these institutes. Users can plan, reserve, make payment, and access their multimodal trips by the platform, which is operated by GoAbout. The pilot will offer the following transport modes:

- Bicycle sharing (SL!M Campusbike) – users can access a pool of shared bicycle using a smartphone to release a smart-lock at any time of the day.
- Public transport – users can plan and buy ticket for their public transport trip via bus and train through their smartphone
- Car sharing (SL!M Campuscar) – users can make reservations and access a pool of car sharing located on the campus using their smartphone. The additional cars will also be available for medium and long-term rental for business visit and weekend.
- On-demand shared taxi (Breng Flex) – for a fixed fee, users can travel between their bus stops of choice within the service area of Arnhem and Nijmegen
- Taxi – User can also reserve regular taxi service through the platform
- Parking and Park & Ride services- The platform also able to identify parking availability around the desired destination.

In parallel to the platform operation, the consortium will also create a physical focal point for transport service, in the form of mobility hub (SL!M Hubs) at different locations. At each of these hubs, facilities for different modes of transport, such as parking space, a pool of bike and car sharing, and public transport stop will be provided. Additionally, interactive screens for transport information and customer services will be provided. These hubs constitute points, which transfers between different modes within the transport system will occur.

Table 1: Vulnerabilities and opportunities in the basic policy to implement Breng flex

Condition for Success	Vulnerability (V) / Opportunity (O)		Certain / Uncertain	Actions taken at Time = 0 (Increase Basic Policy Robustness)	Signpost Monitoring (begins at Time = 0) and Trigger Events	Actions taken at Time > 0 (Adaptive Actions)
a. Sufficient support by crucial actors, such as public transport operator, and stakeholders, such as taxi operator.	V	Lack of willingness to collaborate due to lack of trust, efforts required to adjust services, or potential loss of operation control. Strong opposition from competing services, such as taxi.	C	(SH) Lobby supports from critical actors and actively involve relevant stakeholders and competitor from the design phase to ensure service acceptability and support (M) Secure funding to subsidise service.	Monitor: Level of Stakeholders' interest and corporation, feedback and comments Trigger: Level of participation drop below expected	(CA) Intensify and actively engaged stakeholders to reduce conflict (DA) Reduce scope of service to necessary minimal (RE) If support is in sufficient reassess basic policy
b. Demand for and acceptance of the new service continues to grow	O	Demand and user acceptance of Breng flex increases at a faster rate than expected	U	(SH) Formulate effective marketing and promotion strategy to ensure exposure and user awareness about the service; (EZ) Prepare expansion plan for Breng flex service. Prepare implementation plan for MaaS	Monitor: Number of user on the platform (potential users) and service usage (active users) Trigger: Number of potential and active user rise above threshold	(CP) Implement Breng flex expansion, increase fleet size by purchase new vehicle or includes taxis (RE) Readjust the service strategy and roll out MaaS service by include other modes of transport
c. Reliable technology to support operation	V	Technology failure	U	(SH) Deploy proven technology with high-level of technical support. Soft launch the system to iron out any possible bug, (H) Prepare non-digital contingency plans, such as call centre and manual vehicle management strategy	Monitoring: Operations report, Customer feedback; system operation status Trigger: Level of negative feedback and failure incident rise above thresholds	(CA) Conduct investigation and resolve issues (DA) Roll back to operate as DRT (non-digitalisation)
d. Delivery Breng flex's performance in according with general transport goals	V	Breng flex's performance below expected service quality	U	(SH) Understand the potential of Breng flex. Set realistic targets with a clear scope. (H) Manage expectations of stakeholders	Monitoring: Stakeholder and customer feedbacks; service performance in various aspects (e.g. efficiency, satisfaction, environment) Trigger: Levels of performance fall below thresholds	(CA) Adjust service design and implement measures to increase quality and level of service (DA) Readjust expectation of stakeholders (RE) Reassess system design

Note: (H) = Hedging Action; (M) = Mitigating Action; (EZ) = Exploiting Action; (SH) = Shaping Action; (SZ) = Seizing Action; (CA) = Corrective Action; (DA) = Defensive Action; (CP) = Capitalizing Action; (RE) = Reassessment

5. CONCLUSION / DISCUSSION

In this paper, we applied Dynamic Adaptive Planning (DAP) which focuses on addressing opportunities and vulnerabilities of implementing an initial MaaS-system for the city of Nijmegen. According to the DAP-scheme, we start with the implementation of a Breng flex system, a demand responsive taxi-bus service that aimed to replace current inefficient bus lines. The necessary conditions for success for this basic policy include sufficient support from local public transport providers and other stakeholders, the acceptance of the new transport service by the city's residents, a reliable technology for reservation and dynamic routing/scheduling is available, and the performance of the service in according with general transport goals. We then propose certain actions that should be taken right away to increase the robustness of the basic MaaS policy:

- secure support from critical actor and actively collaborate with stakeholders, such as public transport providers, governments, and citizen institutes (Shaping Action),
- develop an expansion plan in case demand increases faster than expected (Exploiting Action),
- soft launching of the system enabling the handling of any possible bug before official launch (Hedging Action).

Also, a monitoring system is specified to trigger future adaptations of the basic policy as additional knowledge, such as acceptance and performance of Breng flex, emerge. For example, the stakeholders' levels of acceptance or, the level of ridership, and cost-revenue ratio are monitored, and responsive actions are prepared to be implemented in case trigger-events occur. For example, a high level of acceptance by travellers may prompt a roll out of a MaaS scheme as a Capitalizing Action.

As of August 2017, the preliminary results of the Breng flex project indicate the project is a success. The formal evaluation process is ongoing and will be concluded by the end of September. The city of Nijmegen has initiated a MaaS pilot project together with some actors. The scheme will start its operation from 20 August 2017 to 1 March 2018.

We demonstrate in this paper how DAP can offer an alternative transport planning method, which is contrary to traditional approaches, as DAP addresses uncertainty explicitly and incorporates adaptation as part of the

process. This method assumes uncertainty is nonbinary and inevitable. It enhances the robustness of a given plan, amid surrounding dynamic changes, thus increasing the likelihood of its success.

There are however also challenges in applying adaptive planning approach in practice (Bosomworth et al., 2017). These challenges include difficulties in using DAP to deal with complex and contested issues, establish trigger points for a complex system, and to take into account the institutional and governance implications of applying DAP. Filling in these challenges can improve DAP, which to-date has been applied mostly by researchers in hypothetical case studies.

The shortfalls of DAP reported above highlight improvements needed to ensure its successful application in the real world. The simplified DAP scheme presented in this paper is a result of a desktop study. It should be seen as a starter for developing a MaaS-DAP with actors and stakeholders, rather than an implementation-ready plan. The development of such participatory MaaS-DAP will be done in future research.

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