D6.1: Structure Design for Incentive and Adaptive Demand Modules

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This document provides:

The structure, requirements and description of mechanisms for the management of incentives and adaptive demand by the city, as possible within the PETRA platform

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Note

This deliverable is subject to final acceptance by the European Commission.

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Executive Summary

This deliverable introduces and defines the new City Management Component that will implement options for influencing incentives and adaptive demand for travellers using the PETRA App in their travel. The document analyses the requirements from earlier project documentation, reviews current state-of-the-art in dashboards and control components and provides a structure design for the new city management control dashboard.

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1 Introduction

PETRA – Personal Transport Advisor: an integrated platform of mobility patterns for Smart Cities to enable demand-adaptive transportation systems is a project funded by the Seventh Framework Programme of the European Commission under Grant Agreement No. 609042. It provides the technological foundation for developing a service platform that connects the providers and controllers of transport in cities with the travellers in a way that information flows are optimized while respecting and supporting the individual freedom safety and security of the traveller.

The current deliverable, D6.1, Structure Design for Incentive and Adaptive Demand Modules provides insight in the framework in which the functionalities for management of incentives and adaptive demand in the platform in operation will be developed.

1.1 PETRA Project Overview

The aim of the PETRA project is to develop a service platform that connects the providers and controllers of transport in cities with the travellers in a way that information flows are optimized while respecting and supporting the individual freedom safety and security of the traveller. In that respect cities will get an integrated platform to enable the provision of citizen-centric, demand-adaptive city-wide transportation services. Travellers will get mobile applications that facilitate them in making travel priorities and choices for route and modality. The work will result in a city-wide transportation system comprised of several sub-systems that involve transportation services and policies to be adaptive to the travel demand of the citizens. To achieve this, the platform will fuse different data from various city sources, travel operators and citizens, perform a broad class of predictive analytics, detect the real-time events based on the analytical information and real-time data, and provide information services to the transportation service providers and city stakeholders to optimize the transportation offerings according to the citizens' interests. The envisioned platform will address key research challenges by:

a) enabling a coherent model of mobility patterns via the capture of their multi-dimensional, collective, analytical and dynamic aspects;

b) driving the application of this model via incorporation into various transportation services and city-level policy evaluations;

c) paying specific attention to the governance aspects on how to handle the public – private and privacy issues of connecting travellers, cities and transport providers together through such a platform.

Three cities with very different use cases will implement and evaluate the platform and will host three demonstrations of a mobile Personal Mobility Advisor app.

To achieve its goals, PETRA conducts original research and applies technologies from the fields of Big Data Management, the Internet of Services, Semantic Web, AI Planning, Stream Processing, Simulation, Data Mining, and Human-Computer Interaction. For more information, please refer to the project Website at http://petraproject.eu/.

1.2 Deliverable Purpose, Scope and Context

Within this document, the functionality of incentive and adaptive demand management of PETRA is specified. The deliverable starts with the need for an adaptation of the dashboard component for this functionality and then analyses the requirements for the related set of components: Management & Control, Simulation, Gaming and Dashboard.

Section 3 defines the structure and principal mechanisms of the component, and provides some realistic examples of usage.

Then the document lists some best practises in control systems related to the city, and the theoretical foundation of Situation Awareness. It ends with technical options and conclusions.

The document is a step in the development of the platform. It does not provide actual code, but translates the thinking in the consortium into definition of functionality, structure and mechanisms.

1.3 Document Status and Target Audience

This document is listed in the Description of Work (DoW) as "public", as it provides general information about the design of PETRA and can therefore be used by external parties in order to get according insight into the project activities.

While the document primarily aims the project partners, this public deliverable can also be useful for the wider scientific and industrial community. This includes other publicly funded projects, which may be interested in collaboration activities.

1.4 Abbreviations and Glossary

A definition of common terms and roles related to the realization of PETRA as well as a list of abbreviations is available in the supplementary document "Supplement: Abbreviations and Glossary", which is provided in addition to this deliverable.

Further information can be found at http://petraproject.eu/.

1.5 Document Structure

This deliverable is broken down into the following sections:

- Section 1 provides an introduction for this deliverable, including a general overview of the project, and outlines the purpose, scope, context, status, and target audience of this deliverable.
- Section 2 positions the architecture in the context of the former related deliverables D2.1, D2.2 and D2.3.
- Section 3 defines the structure and principal mechanisms of the component, and provides some realistic examples of usage.
- Section 4 reviews relevant state of the art in dashboards and control components
- Section 5 discusses the technological implementation of the component
- Finally, Section 6 concludes the document.

2 City Management Component

As described in the Description of Work (DoW), the PETRA platform will have options for setting incentives and adaptive demand management. There are also dashboards mentioned for setting incentives, load balancing and event management.

In the DoW, the text for the dashboards mentions the availability of '*a few knobs to adjust, that will, in the back of the component, change the parameters of the travel advisor platform.*' This is in violation with the design documentation D2.2, and with the general use of the concept of a dashboard in management literature, commonly defined as '*an easy to read, real-time user interface, showing a graphical presentation of the current status and historical trends of key performance indicators to enable instantaneous and informed decisions to be made at a glance.'*

2.1 Introducing a new component

Upon further investigation of the purpose of these items, the consortium identified the need for an adaptation of the dashboard component, different from identified in the design documentation D2.1, and original D2.2. This component will be called the City Management Control Dashboard (CMCD) Component. This component will implement the functionality of influencing incentives and adaptive demand management. (D2.2 has been revised after delivery of D6.1.)

In this document, we define a structure design of the City Management Control Dashboard (CMCD) Component. This module is an addition to the Dashboard,,Simulation and Gaming modules and together form a set that have interactions with the mission control by city officials.

- The Dashboard component provides city officials information about the status of the currently sensed travel behaviour in the city, within the limits of the data processed by the PETRA platform
- The Management & Control component allows city officials to implement a set of parameters into the PETRA platform (i.e. changing travel advise)
- The Simulation component allows city officials to experiment and determine optimal settings of parameter for given goals using a simulated environment
- The Gaming component allows city officials and urban traffic controllers to assess the incentive and objective structures provided by the city stakeholders to improve the performance of the command and control room.

The City Management Control Dashboard Component will provide the functionality of setting incentives and adaptive demand options as described in the DoW, and the 'few knobs' mentioned under the dashboards. It will be the only point of setting operational parameters of the PETRA Platform from a city perspective.

In terms of interaction dynamics, the four sub-components are very different. The Dashboard component will display information permanently in (semi-) real-time. The Simulation and Gaming components will be used periodically when certain events, disruptions or new optimization goals appear and new parameter options are required. The

City Management component will be used when the decision to implement new parameters is taken.

2.2 Analysis of Requirements

This section analyses the requirements of the Dashboard, Management and Control, Simulation, and Gaming components as included in the first delivery of D2.1, 2.2 and 2.3, and analyses them for dependencies and requirements that can be moved to the City Management Component. The tables are based upon the information in D2.1, D2.2 and D2.3 as submitted within the project in their original delivery months.

2.2.1 Analysis of Simulation Component

Simulation serves as a tool for the city authorities to experiment the consequences of services of the PETRA platform. Simulation is based on an activity-based model. The validation of the simulation model is done using different sources of data.

Requirements of the simulation component (H) are described in Table 1. Specific details are provided and relations with the new City Management Control Dashboard Component are stated in the last column.

Table 1 Requirements Simulation Component

Requirements		Specific Details	Relation City Management Control Dashboard Component
	Activity driven modelling of networks dynamics		
1	Simulating the city mobility dynamics.	Using activity-based models	Outputs shall be transferable to City Management Control Dashboard Component
2	Integration with the gaming platform	The simulation has a set of changeable parameters: The parameters can be set to a value chosen by decision authorities for testing policies probably via gaming.	A mock-up city management control component can be relevant in the gaming component to allow for simulated setting of the platform parameters
3	Integration with Data Management Component	Data is an input to the simulation as well as a tool of validation and calibration	None
4	Integration with advisory platform services	not specifically via gaming first	See H1

2.2.2 Analysis of Gaming Component

Gaming can be seen as a participatory research method aimed to enrich decision-making for citizen-centric demand-adaptive sustainable transport systems by experimentation with information flows between actors in order to improve the collective and individual performance. Within the scope of PETRA, the key results of participatory experimentations are the conceptual designs of dashboards for city authorities, however other envisioned results are improved management strategies for urban transportation systems.

The requirements of the gaming are described in Table 2. Specific details are provided and relations with the new City Management Component are stated in the last column.

Table 2 Requirements Gaming Component

Requirements		Specific Details	Relation City Management Control DashboardModuleComponent
I	*Gaming Platform*		
1	Integration with the simulation platform	Simulation provides to the gaming platform the backend algorithms for predicting outcomes on the city	None
2	Setting incentives	The options for setting incentives and adaptive demand shall be available in the gaming component too.	Via a mock-up or offline version of the City Management Component
3	Load balancing	The options for load balancing and adaptive demand shall be available in the gaming component too	Via a mock-up or offline version of the City Management Component
4	Event control	To test strategies for event management, options for such control shall be available in the gaming component too	Via a mock-up or offline version of the City Management Component
5	Use Case testing	Of the dashboards	None

2.2.3 Analysis of Dashboard Component

The dashboard component shall provide city officials with the relevant data of the status of the transport system. Requirements per category of the data management component are described in Table 3. The four categories are:

1. General (J)
2. Interactive Map (K)
3. Reporting (L)
4. Management (M)

Specific details are provided and relations with the new City Management Component are stated in the last column.

Table 3 Requirements Dashboard Component

Requirements		Specific Details	Relation City Management Component
J	*General*		
40	The Dashboard shall be web based		Most likely a good choice for the City Management Component too
41	The users of the Dashboard shall have two different kinds of profiling, one read-only for the decisional level and one interactive for the operational level		The interactive functionality will be implemented in the City Management Component
K	*Interactive map*		
1	The map shall be able to represent private traffic levels in real time	Street based	None
2	The map shall be able to represent private traffic levels for a certain day of the week as an average	Street based	None

3	The map shall be able to represent crowding levels in real time	Zone or POI based	None
4	The map shall be able to represent crowding levels for a certain day of the week as an average	Zone or POI based	None
5	The map shall be able to represent PT service level in real time, showing routes, stops and positions		None
6	The map shall be able to represent the scheduled PT service, showing routes and stops		None
7	The map shall be able to represent different layers at the same time, enabling the user to show which layers he want to see		None
8	The map shall represent POIs and, clicking on a POI, it will be possible to see the current rules that apply		The City Management Component shall be able to use the same POI and rule definition
9	The map shall enable POIs editing interactively	Adding a new POI, modifying the position of a POI, changing the default attributes e.g. the name	None
11	The map shall use a cartography representing streets		The component shall use the same network definition
L	*Reporting*		
54	The dashboard shall supply real time KPIs for private and public transport		
55	The dashboard shall supply historical KPIs for private and public transport		
56	The dashboard shall supply the possibility to execute custom tabular reports		
57	The dashboard shall supply a tabular report builder to simply create new report giving the measures available for the city		
58	The dashboard shall supply a list of current rules and scenarios implementations		The scenarios will be active settings activated by the City Management Component
M	*Management*		
1	The dashboard shall let the user decide to run a scenario	For example enabling or disabling it according to the schedule	This functionality shall move to the City Management Component
2	The dashboard shall have an interface for defining new rules over existing objects		This functionality shall move to the City Management Component
3	The dashboard shall have an interface for defining scenarios picking existing rules		This functionality shall move to the City Management Component
4	The dashboard shall give the possibility to upload new objects	POIs or area in shape-file format	None
5	The dashboard shall give the possibility to enable/disable functionalities for the city		Activation on temporary travel options in the component

3 Synthesis of requirements into a structure

The analysis tables in the previous section show that the City Management Control Dashboard Component is the place for setting all options that the city official wants to influence for mitigation of travel patterns that are not optimal from a system point of view. This section continues with the identification of the options that the component can influence, the structure of the component and the modes of interaction. It ends with some realistic options for use that are enabled by the definition earlier in the section.

3.1 Options to influence within the scope of the PETRA platform and demonstrators

After analysis of the use cases and realistically available options within the three cities, there are three categories of options available for influence within the scope of PETRA. These categories are:

1. Temporary closing of particular travel options.
   This can include the closure of a road network link, taking a bus out of service, or unavailability of a part of a pedestrian foot network.
2. Temporary addition of travel options
   When for instance for certain events there is a special bus shuttle line from parking lots outside the city into the city centre that is not part of the regular bus system
3. Precautionary avoidance of certain travel options
   If delays or crowdedness are expected at certain locations or on certain link due to for instance events, weather or construction work, the travel options that are affected by this shall be updated before the delays start to occur to avoid the delays.

With this list of categories of options, a variety of objectives can be managed, like reduction of congestion, reduction of emissions, better access for emergency services, etc. These objectives fall outside the scope of the current document, but will need to be specified later, and mapped on the options for their effect.

The current list of categories does explicitly exclude adaptive pricing, that is often discussed in the literature as adaptive demand option. The reason for this is that PETRA is multimodal, and adaptive pricing in multimodal transport systems is both scientifically and practically underdeveloped as of yet. Furthermore do none of the cities involved for demonstration have adaptive pricing in place yet.

3.2 Structure of City Management Component

As a project, PETRA has the ambition to become the base platform for city management of transportation based upon data-driven approaches. This has both journey planning and activity planning aspects. Given the original focus on incentive and adaptive demand components of this deliverable, and the choices in D2.1, 2.2, 2.3 and 3.1, we choose to limit the scope of the first City Management Control Dashboard component to journey planning first. This provides already a wide range of management options, which could be extended in versions beyond the duration of the project.

The component translates the options into parameters that the journey planner can take into account. There is a remarkably simple set of parameters that need to be influenced, given the way that the journey planner works:

1. Temporary closing of particular travel options.
   This can be implemented by putting the expected travel time for the travel option to infinitely large, so that the option will never be selected, for a given duration of the closing.
2. Temporary addition of travel options
   Adding actual travel options lead to the range of options available in the platform, for a specified amount of time, so that it also becomes unavailable again after the temporary addition has ended.
3. Precautionary avoidance of certain travel options
   This can be implemented by giving the travel options higher expected travel times than the platform predicts based upon the currently sensed data, for a given duration.

The component will, for this purpose, have a user interface towards the City Official that provides the control options. Then there is the inner working of the component that translates the input to the right numbers of expected travel times and available travel options that then are pushed to the data management component.

3.3 Modes of interaction with the City Management Control Dashboard Component

Setting the parameters mentioned above means setting a relatively large amount of detailed data on links. The component will facilitate this setting by having alternative modes of input of data:

1. It will be possible to load a configuration from the Simulation component and specify the time window of implementing this configuration.
2. There will be an interface in which a set of travel options can be selected both one-by-one and batch wise, on which the city official can then apply a rule to set the new expected travel time. There will be a set of pre-defined rules available for batch processing. For one-by-one processing, the pre-defined rules and manual entry of a value will be available. For all rules and values, the time window can be set.
3. There is an option to add new travel options and their expected travel time value as well as time window.

3.4 Examples of applications of the City Management Control Dashboard Component

Based on the potential of the concept of the city management component, Venice specified four example cases of real operational interest that could be generically applicable to Rome, Tel Aviv and other cities:

1. A mass of visitors is expected to be arriving by road to the city because of a large event. To prevent that all cars get stuck aiming to the car park area near the event the City Manager wants to incentivise travellers to use the park and ride areas that are normally underused and that will have a shuttle bus service for the period of interest. This is a case of “temporary opening travel options”.
2. A mass of pedestrians wants to go to a main square because of the Pink Floyd Concert or because of the summer fireworks or the carnival. Without proper management, everybody will use the obvious and usual pedestrian routes with crowd turbulances as possible extreme result. In these cases, the City Manager shall “activate” two or three somewhat longer but less crowded routes (maybe also multimodal) and distribute the flow along all of these. Here the travel planner should suggest the routes accordingly, e.g. proposing route 1 to 50% of those using the app, route 2 to 30% of the users and route 3 to the remaining 20%. Of course there will be the police in the field that will help. Generically, the city could also figure out to use VMS in some key points but it would not be enough.
3. A mass of travellers arrives at the railway station and wants to board the public transport in front of it, and the result is the rise of long lines of people waiting to buy the tickets and then trying to get on board. A traveller unfamiliar with the city would wait one hour there, since he does not know he could use other options, e.g. go on foot and spend less time. In these cases, the City Manager would like to distribute travellers to other PT stops nearby, reachable on foot, or suggesting to arrive to destination through other paths and modes. For the travel planner it would mean for instance to lower the ranking of the railway station stops and improve the ranking of other paths and stops, until the congestion at the station goes down to normal.
4. High tide (generically: road closures in a non-Venice city, due to generic events) prevents the pedestrians to walk here and there, or that the road capacity is limited, and the Public Transport service is heavily modified since boats cannot go under the bridges being no clearance. This means that the travel planner has to work on another road network and another PT service, temporarily. In the perfect world, the network of accessible roads changes in time depending on the tide level and the travel planner negotiates it accordingly. Generically, again there is a temporary opening or closing of routes and change to the PT network.

4 Best practices in management and control components

The use of management dashboards and components for process control is already widely developed, mainly along two lines. Firstly, there are the operational control interfaces that give real-time feedback on the status of operational, here and now, processes. (Air) traffic control, surveillance rooms and the process industry are daily operating examples with extensive industrial systems in place. Secondly, there are dashboards for tactic level management, also called Business Intelligence (BI), mainly consisting of key performance indicators of the business, for corrective actions on a weekly, monthly or quarterly basis.

4.1 Typical dashboard and component uses versus PETRA

Typical for operational control interfaces is that there is an industrial implementation of the visualisation of the core process, with very clearly defined parameters and their acceptable ranges. Mitigating actions can most often be done at the level of an individual component, or by setting a integrated action plan into operation that for instance automates the closing of several pipes. Operational control of processes that are less well defined are mostly done by expert observation, like police officers monitoring cameras.

In the past, business intelligence made many promises to open up the world of Big Data including quick access to large data sets, centralized data warehouses, and advanced analytics. In reality, however, traditional BI offered limited benefits. Inability to access large data sets or even load large amounts of information without applying batch processes that could take many hours or even several days was standard. Once the data was loaded, it was often stale, and interactive analytics were limited and only available to those users with high-end computer skills and analytical capabilities.

The situation for PETRA is that the entire platform is based upon the Big Data concept, with a great variety of data inputs, and a wide process (transportation), that cannot be controlled, but only influenced. Thereby, an additional challenge is that PETRA has management at different levels of abstraction. The dashboards, as mentioned in the DoW, for Setting Incentives, Load Balancing and Event Control have different time horizons and different scopes. This makes the design of the right structure and components a non-trivial task.

4.2 Lessons from other dashboard applications

4.2.1 Preparedness in emergency management

In e-government, the digital approach to public governance, disparate public agencies have to coordinate their activities with each other horizontally and vertically[1]. Crises preparation and response are a subset of e-government, in which public organizations (i.e., police, fire department and ambulance services) need to coordinate their activities in real-time[2]. As the occurrence and evolution of a crisis cannot be predicted in advance, it is of vital importance to be prepared in order to enable rapid crisis response. This has resulted in an increasing interest in crisis preparedness of the main relief agencies,

[1] Layne, K., Lee, J.: Developing fully functional E-government: A four stage model. Government Information Quarterly 18 (2001) 122-136

[2] Bharosa, N., Janssen, M., Groenleer, M., van Zanten, B.: Transforming crisis management: field studies on network-centric operations. In: Wimmer, M. (ed.): 8th International Conference on E-Government, DEXA EGOV 2009. Lecture Notes in Computer Science, Lintz, Austria (2009)

especially since some of the major crises in the past decade (e.g., 9/11, Katrina, London, Madrid) have exhibited poor crisis preparation. Due to the impact and associated media attention, policy makers cannot afford to say “we were unprepared” anymore to victims and their families in case of a crisis[3]. Hence, relief agency managers are expected to prepare for the eventuality of a crisis by understanding the vulnerabilities of an organization, analysing the organizational capability to deal with a range of crisis scenarios, and by taking precautionary measures to mitigate the possible risks of being unable to cope with crisis events. In each of these crisis preparation processes, performance indicators (PIs) are considered of major importance[4]. Historically, relief agencies operate in an isolated manner and define and use their own set of PIs. They usually focus their PIs on internal processes, clustered in themes such as financial status, human resources, and service delivery.

In general, relief agency managers depend on governmental agencies for their financial resources. Since policy makers usually have a fixed budget for relief agencies, they need to know how to balance financial resources between agencies in order to maintain an overall level of preparedness. For policymakers, PIs are essential for planning crisis preparedness. Yet the current mono-agency sets of PIs do not show the aggregate level of preparedness of the relief services as a whole, which in turn is the criterion by which the public will judge governmental agencies.

Scholars in the domains of strategic management[5] have proposed the use of dashboards as instruments for both the clustering and visualization of PIs. Despite the advantages predicted for organizations when using dashboards[6] literature on the development of dashboards indicating the level of crisis preparedness on a multi-agency scale is scarce. Instead, most studies are concerned with the appropriateness or success of response activities. In one study investigated by one of the participating researchers[7], a set of dashboards has been defined using similar participatory methods as proposed in PETRA. The preparedness dashboards share similarities in the wide range of information that can become important depending on the contextual setting, as well as the large focus on operational control (emergency response, versus traffic control) in the context of the dashboard setting.

[3] Boin, A., 't Hart, P., Stern, E., Sundelius, B.: The Politics of Crisis Management: Public Leadership Under Pressure. Cambridge University Press (2005)

[4] Carter, N., Klein, R., Day, P.: How organisations measure success: The use of performance indicators in goverment. Routledge, Taylor & Francis Group (1995)

[5] e.g. Clarke, S.: Your Business Dashboard: Knowing When to Change the Oil. The Journal of Corporate Accounting & Finance 16 (2005) 51-54, and Adam, F., Pomerol, J.C.: Developing Practical Decision Support Tools Using Dashboards of Information. In: Burstein, F., Holsapple, C.W. (eds.): Handbook on Decision Support Systems 2. Springer Berlin Heidelberg (2008) 151-17

[6] E.g. Dover, C.: How Dashboards Can Change Your Culture. Strategic Finance 86 (2004) 43−48, and Gitlow, H.: Organizational Dashboards: Steering an Organization Towards its Mission. Quality Engineering 17 (2005) 345−357, and Resnick, M.L.: Situation Awareness Applications to Executive Dashboard Design. 47th Annual Conference of the Human Factors and Ergonomics Society (2003) 449-453

[7] Bharosa, N., M.F.W.H.A. Janssen, S.A. Meijer & F. Brave (2010): Designing and evaluating for Multi-agency Crisis Preparation: A Living Lab. In: M.A. Wimmer, J.L. Chappelet, M.F.W.H.A. Janssen & H.J. Scholl (Eds), Proceedings of electronic government: 9th International conference (pp. 180 – 191). Berlin: Springer

4.2.2 Traffic Control

In the world of traffic control, the concept of real-time data-driven control is taking off, with more and more targeted sensors being installed in the road system, as well as collection of phone, Bluetooth and social media information, for example. This results in a significant effect on urban traffic management: an increasing amount of incoming (streaming) real-time traffic data from different sources, such as sensors, new systems and services as well as the growing interaction of individual traffic "participants" both with the control systems and with each other result in a huge potential for added value creation on many levels, thus fundamentally changing traffic management. Existing approaches to intelligent traffic systems include traffic load prediction and computation, but also vehicle tracking and routing, by means such as traffic signaling dynamics, Geographical Information Systems (GIS) and dynamic messaging solutions and meta-level analyses across vast arrays of data have become possible that help generate much more precise forecasts of future developments, detect inaccuracies or abnormalities and deliver almost real-time predictions. However, many of the existing systems still feature legacy IT solutions and are unable to simultaneously connect many different data sources to one system, analyze, process and store large amounts of complex event data streams in (real) time and to derive pre-emptive measures for the traffic control system operators in near real-time.

A dominant research effort into the value of such information for traffic control was the Mobile Millenium project at UC Berkeley (2008 – 2011), after which many projects followed that aimed to get vast amounts of data into control rooms. Today, every industrial provider of control systems offers such components (i.e. Siemens, IBM, amongst others), but the way in which to effectively visualise and feed back data to operators is still a discovery process. Clearly, the evolution of Big Data necessitates a paradigm shift in control room operations, as the sheer volume of information would be daunting for control rooms using the traditional operational model, with its user-centric approach to monitoring requiring constant human supervision. A great deal of risk falls upon the operator who must be constantly tuned to all monitors and make subjective decisions based solely on visual information. Because of the limited powers of human observation, this model isn't sustainable.

As of 2014, the amount of validated studies on the effects of different modes of visualisation on effectiveness of traffic control is surprisingly limited, since most studies are focussing on the theoretical benefits of such data feeds in simulation studies[8]. The world of air traffic control is a little more advanced here, and some recent studies on train traffic control provide first insights into this effect.

4.3 Foundations of interface design: Situation Awareness

The theory in the world of process control on which to base designs of interfaces to control systems has developed immensely. Where for instance the railways up to the 1980's had interfaces mainly based upon the traditions of the lead engineers, and therefore had very different visualisation depending on whether it were the British, French or Germans who founded a system in a particular country, now design processes are built upon empirically tested theories. The main relevant theory here is situation awareness.

[8] e.g. Qi Yang, Haris N. Koutsopoulos, Moshe E. Ben-Akiva. Simulation Laboratory for Evaluating Dynamic Traffic Management Systems. TRR: 1710, pp 122-130 (2000) that is the key reference of this stream.

In the 1990s, the development and research on situation awareness made huge advances in the applied cognitive psychology and human factors field [1]. A simplified description of situation awareness (SA) is: knowing what is happening around oneself in a complex environment, in order to take an optimal decision. Nowadays, situation awareness (SA) is an accepted concept of cognition in complex, socio-technical and dynamic environments [2], as a predictor for good decision-making and indirectly of performance [3]. Loss of SA has been closely linked to performance failures, which resulted in accidents, e.g. driving accidents, operational errors in air traffic control [4] and loss of performance. As operators often need to collaborate, situation awareness can also be extended beyond the individual to a team or group level. Although the concept has been originally of interest to aviation psychologist, it is increasingly investigated across different domains, e.g. medicine, military, robotics, driving [5][6]. Due to the technological advancements in computer game development, virtual environments are also more frequently used instead of the more expensive and traditional physical full-scope human-in-the-loop simulators for investigations on situation awareness. However, in a field where psychologists developed a body of theory on how to measure SA in the as-if-real physical simulators, this change of technology requires a bridge between game designers, psychologists and computer scientists. This bridge is relatively new and underexplored in the literature, due to different disciplinary approaches and emphases.

Despite the large acceptance of and research on situation awareness across domains, the field is marked with numerous definitions of SA [14]. The discrepancy in definitions can be largely subscribed to two different schools of psychology; information processing and ecological psychology [6]. Whereas the information-processing stream of research relate situation awareness to memory, inference and knowledge, the ecological school of thought emphasize the direct perception as affordances of objects and events. One of the most accepted definitions of situation awareness is that of Endsley [15], who defines SA, based on Goal-Oriented Task Analysis, as the perception (level 1 SA), understanding (level 2 SA) and projection (level 3 SA) of elements in future states (see Figure 1), whereas the ability to project future actions of elements in a situation is the highest level of SA that can be achieved. Most of the studies on situation awareness have been using this three-level model when defining and measuring situation awareness on an individual level. However, beyond the individual as a unit of analysis, the ecological perspective receives more attention as well.

Distributed cognition and interactive team cognition (ITC) theory are both more holistic theories that recognize teams as unit of analysis [16] or the system level as a unit of analysis [17] for cognition. The ITC theory is approached from an ecological psychological perspective and argues that teams interaction and processes are they key variables for investigation as they are inextricably tied to their context. The distributed cognition theory applies concepts of the information-processing perspective, in which individuals and artefacts are part of the cognitive system.

For the PETRA project, and the current Deliverable that deals with the management components, SA is extremely important, since the dashboard, interfaces and management components will have an influence on the people that operate the PETRA platform. If this is going to be placed in a control room for traffic control, the influence of PETRA on the entire function of that control room should not be neglected. It is therefore crucial to specify an approach that takes the components of Endsley's information-processing view into account.

If the platform will be operated at more tactic levels of management of the city, Endsley's model is less relevant, and the mental models of the tactical level managers shall become the object of inference.

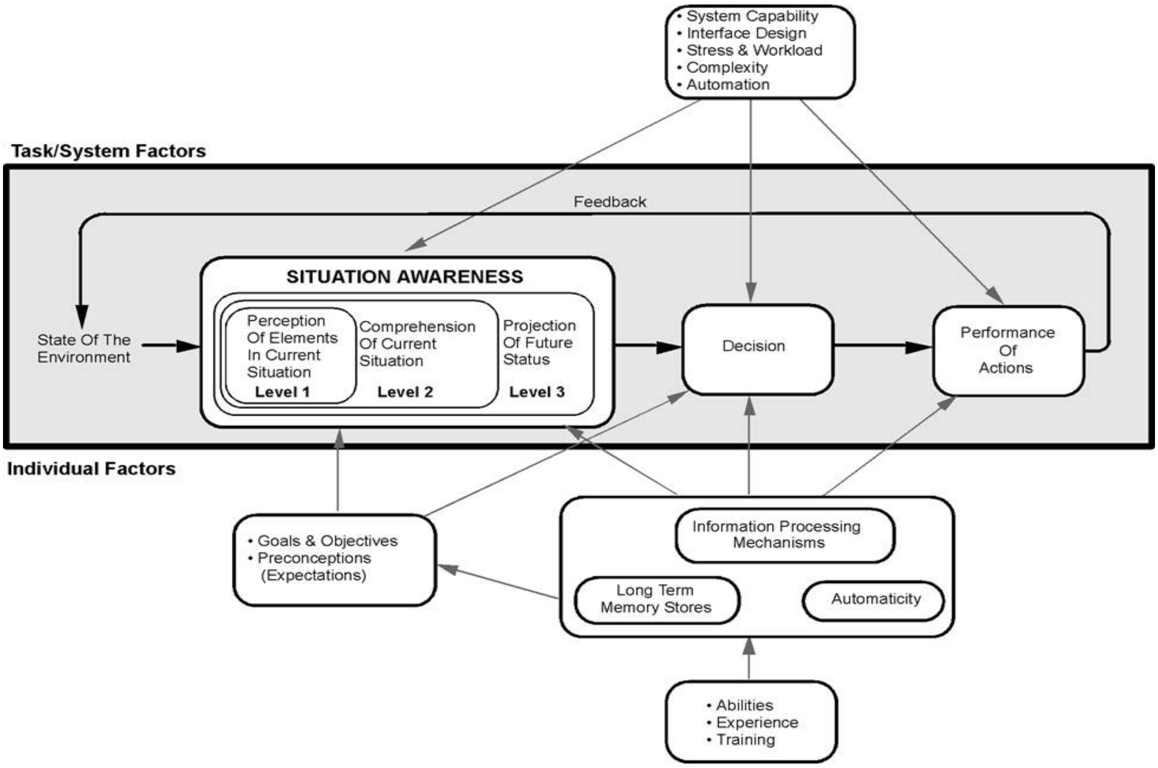

Figure 1 Information-processing perspective of situation awareness (Source: Endsley, 1995, p 35)

4.4 Consequences for City Management Component

The City Management Component implements the decision of the city official when aiming to mitigate a certain event. This decision can only be good if the perception of elements and comprehension of the current situation are good. The dashboard component of PETRA will have this role. However, the platform will be part of a larger structure in the city, like the traffic control room. It is therefore important to recognise that the PETRA dashboard will never be the only source of information and the City Management Component never be the only way to implement a decision. Modesty in claims on the effects of PETRA is therefore crucial. As the discussion on the preparedness-dashboards in emergency management showed, it is still very difficult to have the right information display when the control problem is a multi-actor and multi-level problem. PETRA has this situation, since mitigation of (larger) events goes far beyond the scope of a traffic control room, and the goals of the city will bring out tensions between operational control and strategic management.

In the steps towards good implementation of the City Management Component it is therefore essential to take into account governance aspects, and the reality of traffic control centers and effect on the city fabric and city users.

5 Technology options

Given that the PETRA platform will be deployed as a Platform-as-a-Service in the CloudFoundry framework, the most logical option is to make the component a separate component in the platform. Since each component defines its own interface, it will be possible to make a customised interface for this component to allow the city officials to interact.

As with the dashboard component, there is the desire to make this web-enabled. This does not directly mean that we are talking about a web-page, but the service should be accessible via the network, so that the dashboard and control interface can be located at a different place than the PETRA platform. CloudFoundry is facilitating such technological options by default.

More choices in the implementation will have to be made, but are dependent mostly on the full specification of the simulation component and the trip planner component.

6 Conclusions

This document, intended to provide a structure design only for incentive and adaptive demand components, defines a new City Management Component that incorporates the functionality of the components and putting them into a logical position in the PETRA platform.

The newly defined component will be one of the components in the PETRA CloudFoundry implementation and will basically influence in a use definable and temporal manner the expected travel times of various travel options. This simple mechanism gives tremendous power given the structure of the trip planner within the platform.

In future versions, the current limitations to journey planning purposes can be extended with trip planning aspects once the effects of and sensitivity to the journey planner using the current set of options are known and understood. This will also open up new discussions on the integration of PETRA in city control rooms.

The next steps in the design of the City Management Component are exact definitions of the rules by which to influence the expected travel times in a realistic way, so that the behaviour of travels is adjusted according to the goals that the city has.