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1.0	22/11/2011	P. Dihé	Update after final review + additional visualisation requirmeents

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Glossary

Information product	Raw data, such as the results of mathematical modelling, and the analysis thereof, will often need to be packaged in such a way as to be accessible to the various stakeholders of an analysis. The medium can be one of a wide variety, such as print, photo, video, slides, or web pages. The term *information product* refers to such an entity.
Model	A *model* is a simplified representation of a system, usually intended to facilitate analysis of the system through manipulation of the model. In the SUDPLAN context the term can be used to refer to mathematical models of processes or spatial models of geographical entities.
Profile	Within SUDPLAN a *profile* is a set of configuration parameters which are associated with an individual or group, and which are remembered in order to facilitate repeated use of the system.
Report	A *report* is a particular type of information product which is usually static and might integrate still images, static data representations, mathematical expressions, and narrative to communicate an analytical result to others.
Scenario	A *scenario* is a set of parameters, variables and other conditions which represent a hypothetical situation, and which can be analysed through the use of models in order to produce hypothetical outcomes.
Scenario Management System	*Scenario Management System* is synonymous with SUDPLAN platform
SUDPLAN application	A *SUDPLAN application* is a decision support system crafted by using the SUDPLAN platform and integrating models, data, sensors, and other services to meet the requirements of the particular application.
SUDPLAN platform	The *SUDPLAN platform* is an ensemble of software components which support the development of SUDPLAN applications.
SUDPLAN system	*SUDPLAN system* is synonymous with SUDPLAN application

User	The term *user* refers to people who have a more or less direct involvement with a system. Primary users are directly and frequently involved, while secondary users may interact with the system only occasionally or through an intermediary. Tertiary users may not interact with the system but have a direct interest in the performance of the system.
Web-based	Computer applications are said to be *web-based* if they rely on or take advantage of data and/or services which are accessible via the World Wide Web using the Internet.

Acronyms

CL/DoW	The Call and the Description of Work for SUDPLAN
CS	Combined Sewer
CSO	Combined Sewer Overflows
CSV	Comma Separated Values
ESRI	Environmental Systems Research Institute
LT	The literature
OASIS	Organization for the Advancement of Structured Information Standards
OGC	Open Geospatial Consortium
ORCHESTRA	Open Architecture and Spatial Data Infrastructure for Risk Management
PI	The four pilot applications
PR	Other projects
SANY	Sensors ANYwhere
SISE	Single Information Space in Europe
SOS	Sensor Observation Service
SULFV	Stockholm - Uppsala Air Quality Management Association
SW	General software engineering principles
W3C	World Wide Web Consortium
WFS	Web Feature Service
WMS	Web Map Service

1. Management Summary

This document has been produced by the consortium of the European Project FP7-247708 Sustainable Urban Development Planner for Climate Change Adaptation (SUDPLAN). It is the second deliverable of Task 3.1 - Requirements Specification, and contains the updated requirements of the second requirements analysis phase and is considered to be the final and stable version of the SUDPLAN requirements.

1.1. Purpose of this Document

The purpose of this document is to establish the requirements of the Scenario Management System of SUDPLAN, sometimes referred to herein as the SUDPLAN platform.

In order to understand the high level requirements of SUDPLAN, one must first understand SUDPLAN as a fundamentally interactive system. The entire purpose of the system is to support human decision makers. While this point might seem obvious and not worth mentioning, it is important to understand that many (if not most) decision support systems fail because they fail to focus on the humans who are part of the system.

In SUDPLAN we are determined not to make this mistake. We have focused on the human users of the system as the most important source of information – a perspective described in the literature as user-centred design. The requirements described in the present document derive in great part from a thoughtful and systematic process by which the needs of the users were elicited and transformed into requirements. While some requirements come from other sources, none are more important than those of the users, who are understood to be integral elements of the system. For the system to succeed, the users must succeed. For this reason, SUDPLAN is a user-driven system, and its requirements, as elaborated in the present document, are intimately connected with the anticipated users of its applications.

In work package 3, the Scenario Management System is to be developed based on the

- high level objectives of the project
- requirements contributed by the pilots
- development visions contributed by the IT developers

The present document serves as a compilation of the consolidated requirements resulting from the analysis of the interviews and discussions with the key people from the pilot sites and from WP4 (Common Services), as well as from an analysis of previous relevant projects, the literature, common software engineering practice, and the Description of Work.

This document is to be used as a guideline for all development tasks of WP3 and WP4. Moreover, this document is the basis for the multi-cycle validation process described in D2.1 (Validation Plan) by providing the necessary input for the design of questionnaires containing questions that allow determination of whether the software developed in SUDPLAN satisfies the requirements elaborated herein.

Obviously, we do not expect the final pieces of software to satisfy each and every requirement stated in this document as some of them are quite visionary or simply are not feasible within the scope of the project. We therefore expect that the respective development leaders (WP3, WP4) will include a prioritisation of requirements in their individual development plans. This prioritisation has to be discussed and agreed upon in the course of the regular project meetings to ensure that all high priority objectives of the project can be fulfilled.

1.2. Intended Audience

This document targets all SUDPLAN partners. Partners involved in the implementation of the Scenario Management System and the Common Services must pay special attention to this document as it represents their primary source of requirements for software development. Moreover, partners involved in the validation process need this document as an essential basis for their work.

1.3. Document Structure

This document is divided into two main parts:

1. The first part explains the methodology of the requirements engineering approach and briefly presents the various sources for requirements. Special attention is paid to the user needs analysis, which involved both technical and end users of the SUDPLAN platform.

2. The second part consists of the actual SUDPLAN platform requirements which are logically organised into four categories.

This document has 6 appendices which provide amongst others documentation of the interim results of the requirements engineering approach, such as pilot specific requirements that underwent a generalisation process, and several trace matrixes which map pilot and initial DoW requirements to SUDPLAN platform requirements.

1. Appendix A provides a listing of each SUDPLAN platform requirement within the structure of the requirements taxonomy.

2. Appendix B contains draft requirements distilled from the four SUDPLAN pilot applications.

3. Appendix C contains the pilot requirement to pilot use-cases requirement trace matrix.

4. Appendix D contains the platform requirements to pilot requirements trace matrix.

5. Appendix E contains the trace matrix that maps User Requirements (REQ-USR), Technical Requirements (REQ-TEC) and Developer Requirements (REQ-DEV) to DoW and ICT Requirements (REQ-DoW).

6. Appendix F provides an overview on the updates compared to the initial requirements specified in the previous version of this document.

1.4. Changes compared to the first version of the deliverable

The changes compared to the revised version of this deliverable (D3.1.1 V1.4) encompass an update of the requirements according to the Product Validation Reports of the 4 Pilots (D[5-8].3.1), the overall validation and evaluation report D2.2.1 as well as the Pilot Definition Plans (D[5-8].2.2) for the second year of the projects. In total all DoW & ICT requirements were updated, several descriptions and the sources of nearly all User- , Technical requirements were updated, six new requirements were added and seven obsolete requirements were deleted. A detailed list of changes can be found in Appendix F of this document.

2. Methodology

The methodology for user needs analysis and requirements engineering that was followed in the SUDPLAN project is based on the standard methodology of needs assessment and requirements delineation, such as suggested by Preece *et al* (2007), and also uses the results of the requirements gathering methodologies which were developed and used in the ORCHESTRA (RM-OA, 2007) and SANY (SANY, 2009) projects.

2.1. Scope of the Requirements Document

As already mentioned before, the scope of the requirements defined in this document is the SUDPLAN platform. Figure 1 shows the relation of the SUDPLAN Platform to a SUDPLAN System.

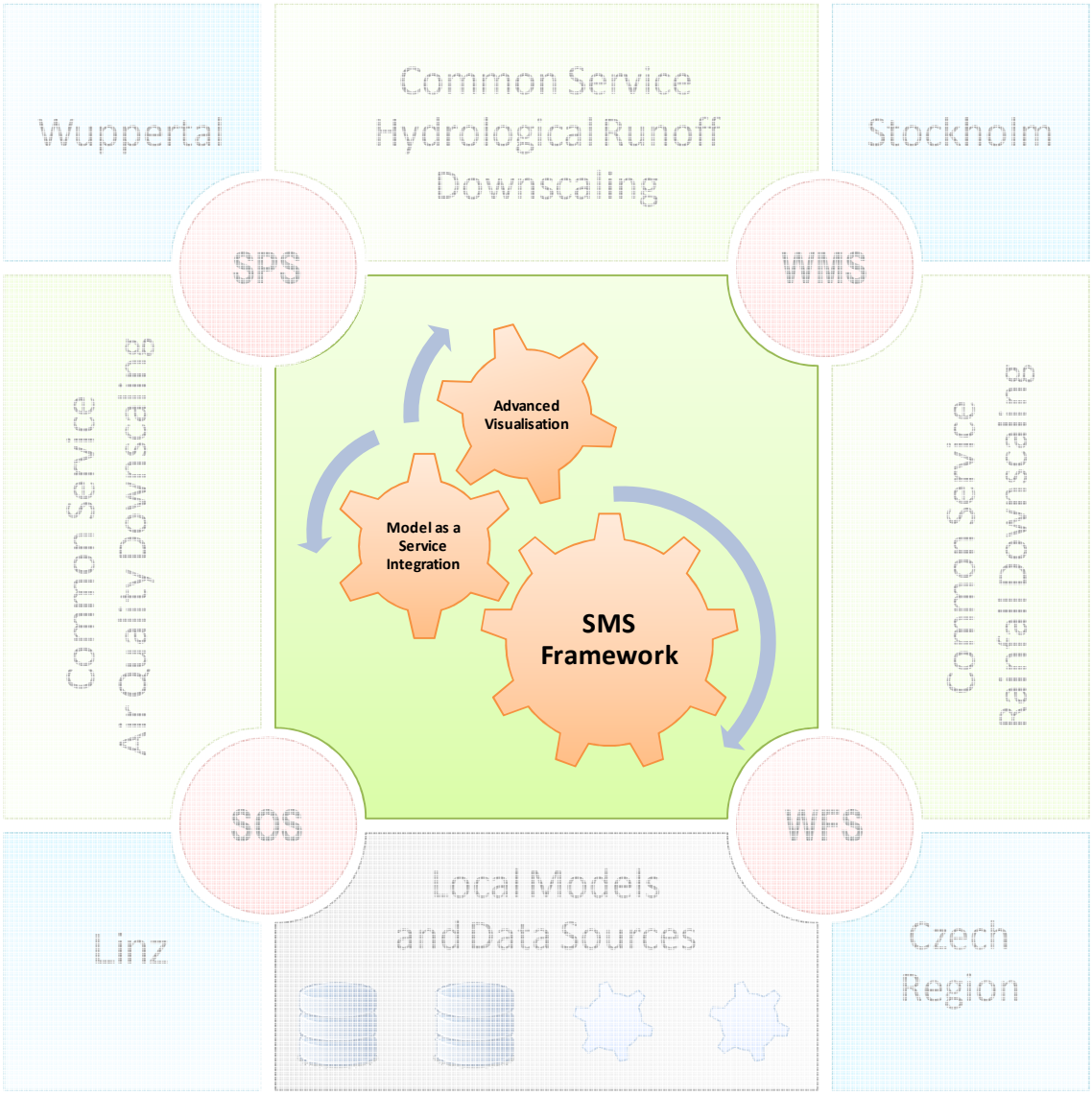

Figure 1: SUDPLAN System and Platform

The SUDPLAN platform is defined as an ensemble of software components which support the development of SUDPLAN system (or SUDPLAN application), while a SUDPLAN system is defined as decision support system crafted by using the SUDPLAN platform and integrating models, data, sensors, and other services to meet the requirements of the particular application. Thereby each SUDPLAN pilot application can be considered as distinct SUDPLAN system.

The core of the SUDPLAN platform is the Scenario Management System which is composed of a SMS Framework, a Model as a Service Component and an Advanced Visualisation Component as can be seen in Figure 1. The SMS and its constituting components are described in detail in the companion reports to the deliverables *D3.2.1 - Product Implementation V1* and *D3.3.1 Integrated Scenario Management System V1*. The SMS is supported by three Common Services providing climate downscaling for rainfall, hydrological runoff (river flooding) and air quality. More information on those services can be found in the deliverable *Common Services: Concerted Approach Report V1* and the related service specification documents.

Since those services can be considered as models (wrapped as services), they are represented in the SMS by the Model as a Service Component. Consequently, general requirements on Common Services are also covered by requirements on the SMS. The relation between the SUDPLAN platform requirements specified in this document and the other types of requirements are shown in Figure 2 which provides also a first impression of the requirements gathering process described in more detail in section 2.3.

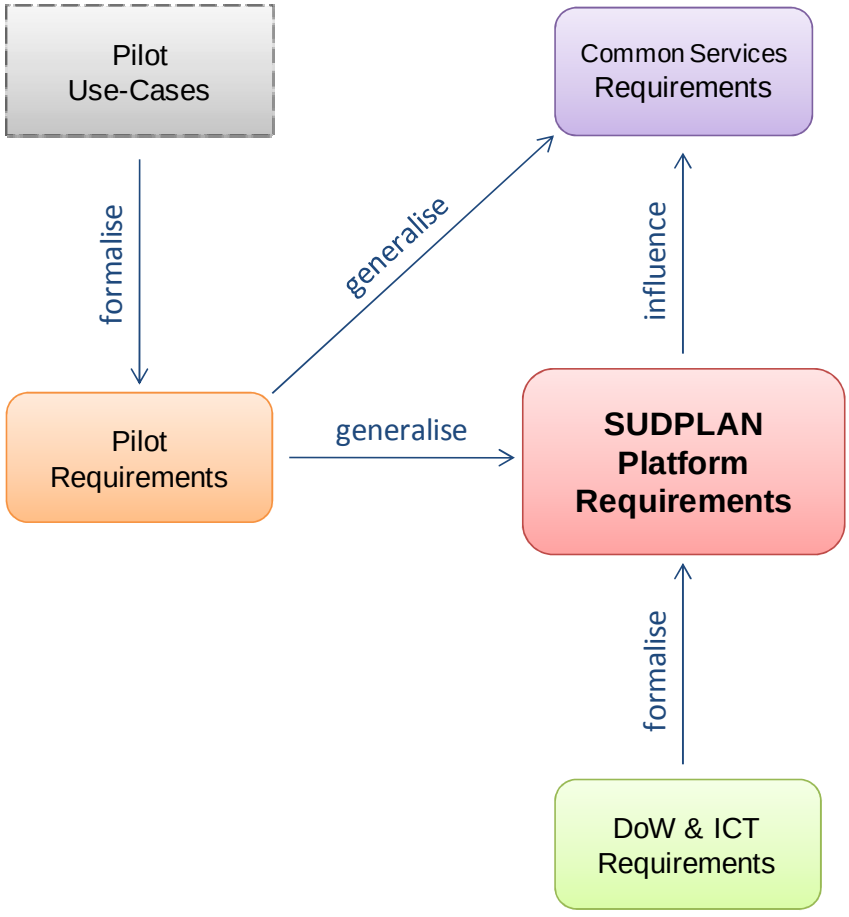

Figure 2: Relations between Requirements

Since the SMS and the SUDPLAN platform respectively shall be conceived as generic integration platform that will be able to facilitate climate change induced urban development planning in any city in Europe, requirements on that platform have to concentrate on common and generic functionalities that allow the development of a wide variety of different applications. Generalised SUDPLAN Platform requirements are therefore in large part derived from the specific requirements of the four representative pilot applications (SUDPLAN validation scenarios).

Requirements on Common Services are not addressed directly in this document, but in the deliverable *Common Services: Concerted Approach Report V1*. Although Common Services requirements are partially covered by several platform requirements, they are in some cases too model-specific to qualify as requirement on a generic integration platform.

2.2. Overview and Documents involved

As shown in Figure 3, the initial definition of requirements of the SUDPLAN platform that was carried out in the first requirements analysis phase required input from several activities in the overall project. The project plans have been developed in such a way that the input into the product requirements is generated by means of workshops, interviews and a set of documents, including existing sources of requirements.

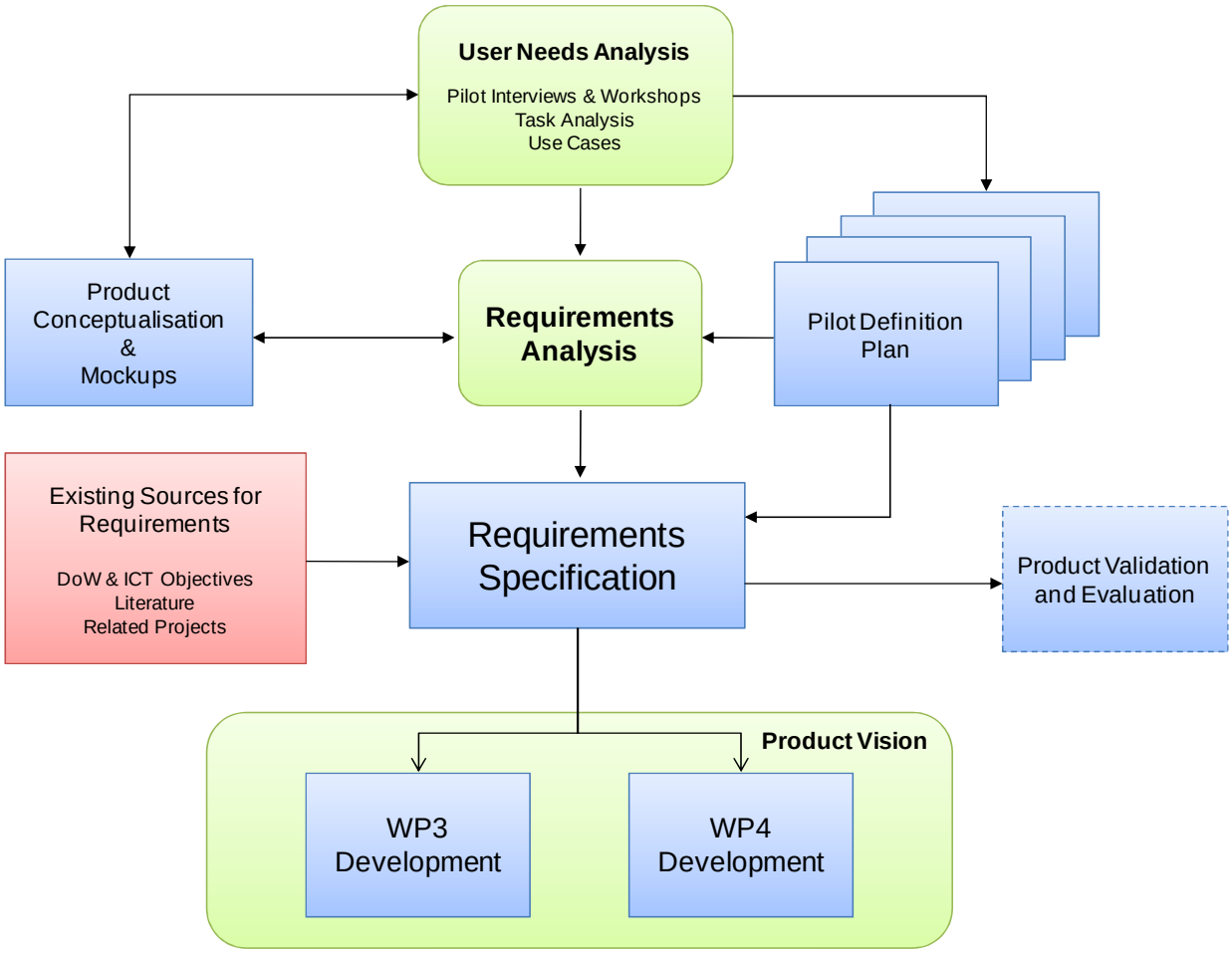

Figure 3: Requirements Specification Process

The most important source of requirements for the user-centred design process of the SUDPLAN platform was the user needs assessment, which itself provided direct feedback to the product conceptualisation and product prototyping tasks and also contributed to first the pilot definition plans.

The initial requirements specification did not only take the needs of people involved in the pilot applications into account. It also adhered to the requirements delineated in the DoW and the Call for Proposals, as the SUDPLAN platform has to satisfy the objectives and the expected impacts of the call for proposals. This ensures that the SUDPLAN platform can be validated, according to the validation plan, with special regard to the impacts expected by the call. Thus, this document provides major input to the D2.1 Product Validation Plan, which describes the validation process on the basis of the requirements established herein.

Additional requirements came from experience in related projects, the literature and general software engineering practice.

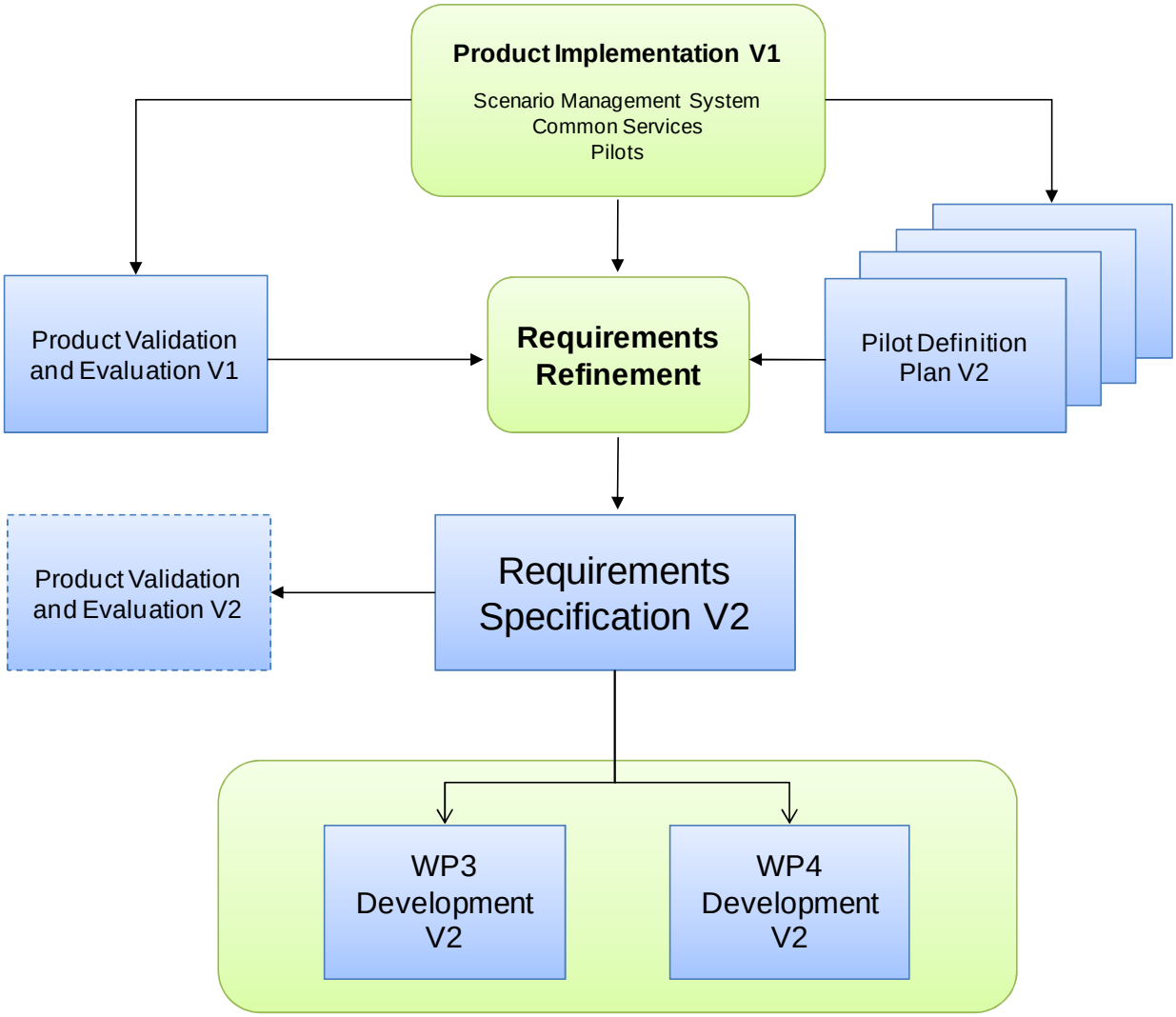

Figure 4: Requirements Refinement Process

Figure 4 shows the requirement refinement process carried out in the second phase.

Requirements identified and documented in V1 of this document were refined on basis of the findings of first implementation and validation phases as well as on updated uses-cases of the pilot definition plans for V2. The requirements refinement phase showed, that the set of the initial identified requirements can be considered already fairly complete. In order to avoid the introduction of completely new requirements which would overlap with several existing requirements, the refinement concentrated mainly on the further improvement and clarification of requirement definitions, source tracing and explanations.

Figure 5 provides an overview of SUDPLAN deliverables which serve either as immediate sources for the requirements document or refer directly or indirectly to the requirements document. The SMS and its components (D3.2.x and D3.3.x) are being developed on basis of the requirements defined in this document. The same applies in principle for the Common Services (D4.2.x – D4.4.x) whereby more concrete requirements are specified in the WP4 Concerted Approach Report (D4.1.x) that take the specific properties of the Common Services and the underlying models into account.

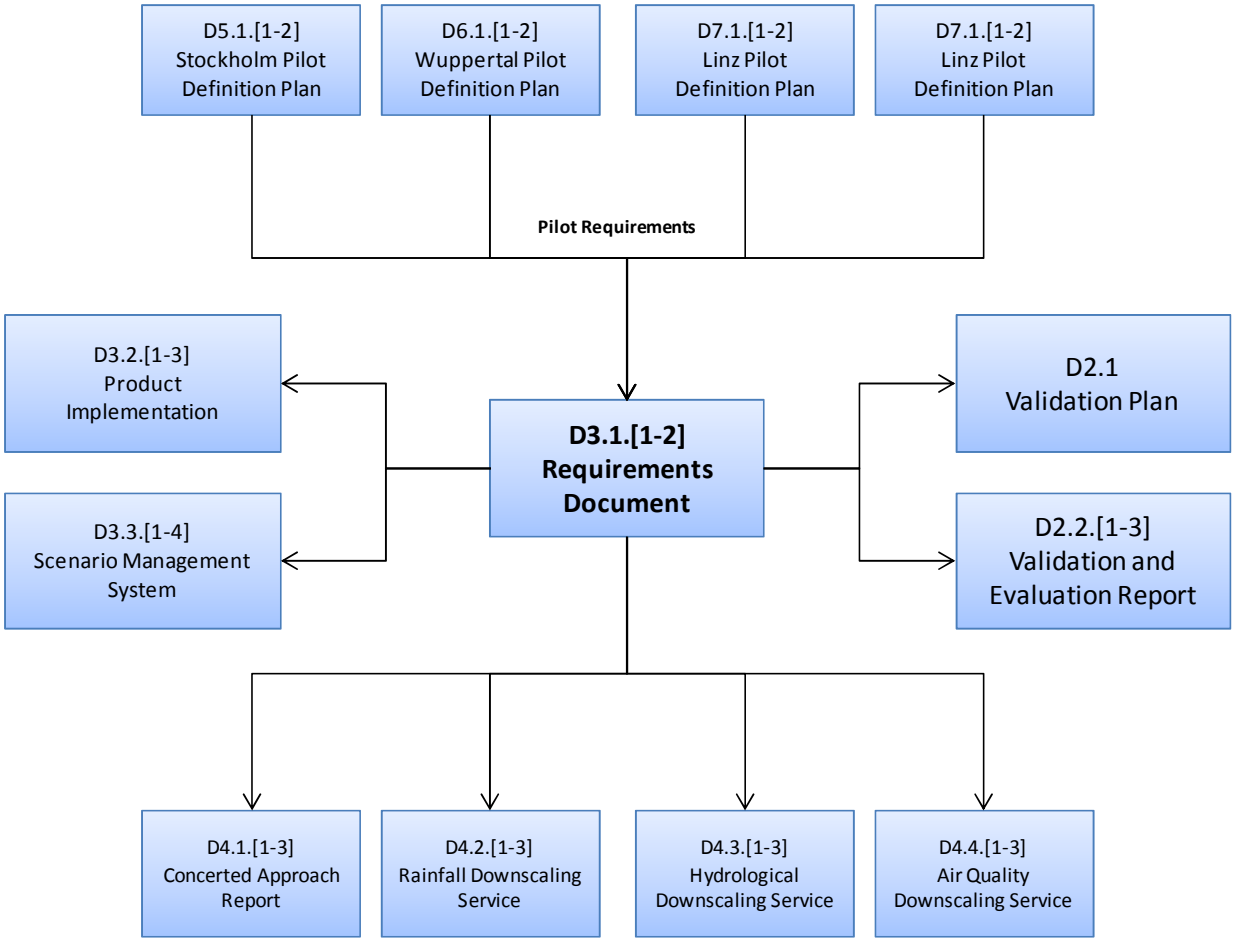

Figure 5: Documents involved

Deliverables based on the Validation Plan (D2.1) also refer directly to the requirements defined in this document. For reasons of readability, they are not shown completely in Figure 5 but in Figure 6.

Figure 6 shows the relations between the two iterations of the requirements document and the various evaluation and validation deliverables. D2.1 defines the validation methodology to assess the level of fulfilment of the requirements. The first Validation and Evaluation Report (D2.2.1) is based on pilot's Product Validation Reports (D5.3.1 – D8.3.1) and provides input to the Requirements Document V2.

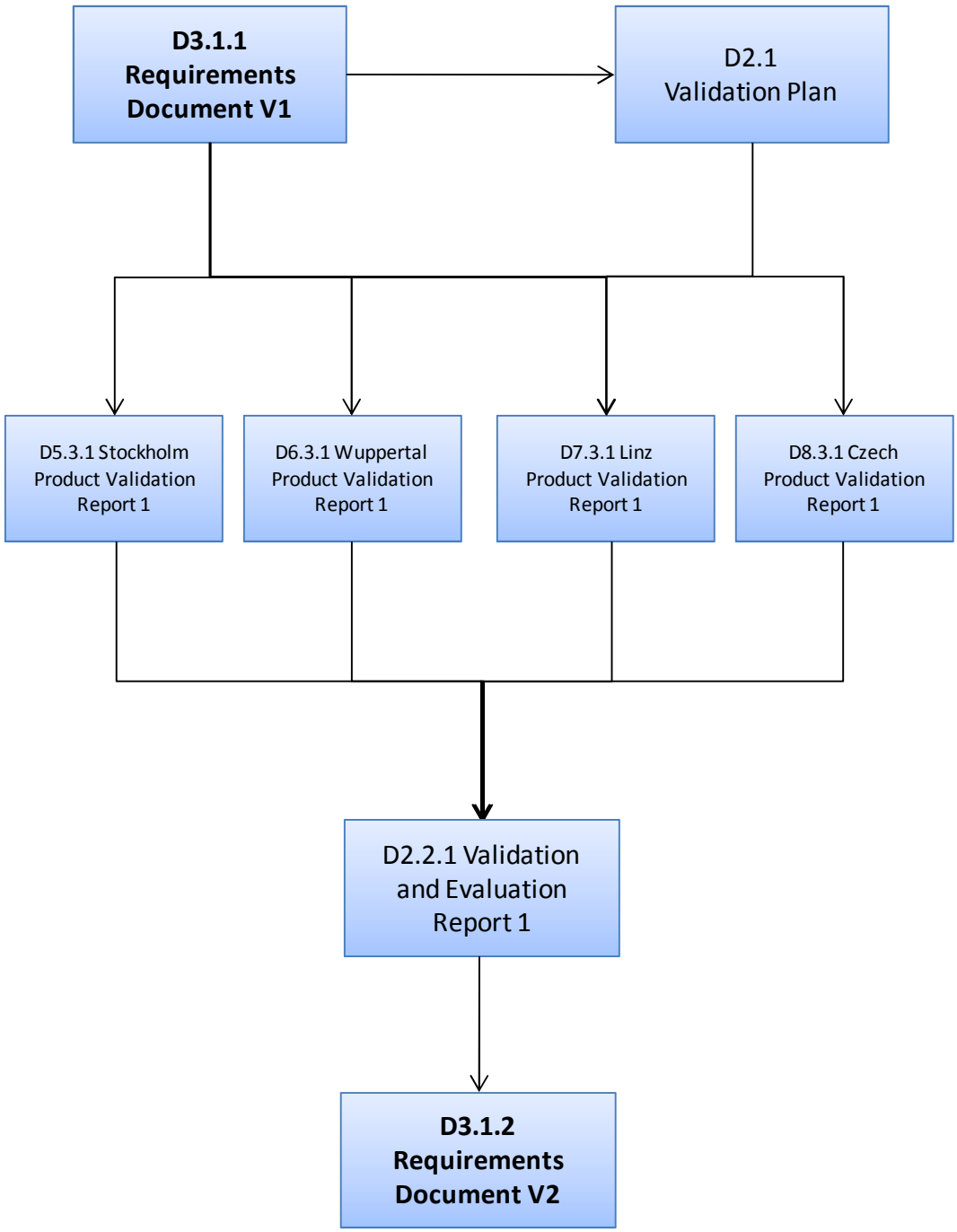

Figure 6: Validation Documents involved

2.3. Requirements Gathering

This section presents the sources of requirements, and explains how those sources were used during the requirements gathering process carried out in the first requirements analysis phase and which structured methodology was applied.

2.3.1 DoW Objectives and ICT Expectations

The first step towards the requirements specification consisted of the analysis of the Description of Work (DoW) objectives and the ICT expectations of the call. As shown in Table 1, these expectations were already taken into account when defining the project and are documented in the SUDPLAN DoW.

No.	Objective	Relevance to ICT-2009-6.4
Scenario management system for climate change adaptation		
A.	Scenario management, execution, visualization, documentation and training environment for scientific users and city managers	"Scenario-based prediction, damage assessment, planning and training"
a.	Better preparedness, decision support and mitigation of climate change impact on population, utilities and infrastructures	"Systems for better preparedness, decision support and mitigation of climate change impact …"
b.	What-if scenarios to model impacts of decisions	"decision support", "3D/4D modelling and simulation"
c.	Highly interactive 3D/4D visualisation	"Easy to use…", "3D/4D visualization"
d.	Seamlessly integrate with existing models, from European to local level	"Easy-to-use, web-based systems …"
e.	Seamlessly integrate with existing distributed infrastructures	"Easy-to-use, web-based systems …" … "… as well as sensor networks", "taking full advantage of recent advances in miniaturisation of sensors, wireless communications and increased computation power and data storage capacity"
f.	Usable, adaptable, flexible, not hard wired	"Easy-to-use, web-based systems …"
Improvement of service quality		
B.	Improve information and service quality in the area of risks for flooding, heavy rain falls and severe air pollution (in urban areas)	"better preparedness, decision support and mitigation of climate change impact on population, utilities and infrastructures"
Urban risk services		
C.	Services to quantify, report and visualise future risks over urban areas	"better preparedness, decision support and mitigation of climate change impact on population, utilities and infrastructures"
Seamless integration		

No.	Objective	Relevance to ICT-2009-6.4
D.	… in a way, that services can easily collaborate with existing systems and established infrastructures	"Easy-to-use, web-based systems …", "taking full advantage of recent advances in miniaturisation of sensors, wireless communications and increased computation power and data storage capacity"
Validation in four very diverse applications		
E.	To validate in four different, diverse urban pilot applications: Stockholm (SE), Wuppertal (DE), Linz (AT), Czech Regional Pilot (CZ)	"Integrated solutions shall be validated in the urban context including for natural disasters" (see pilot descriptions for details)

Table 1: Mapping of the SUDPLAN objectives to ICT-2009.6.4 expectations

Those requirements listed in Chapter 3 of this document that are based on DoW objectives and ICT expectation have as their source "CL/DoW." They are mainly categorised as DoW and ICT Requirements (REQ-DoW), but where DoW objectives and ICT expectation are also considered in the other three platform requirements categories, these are also indicated with "CL/DoW" in the source field. The requirements stemming from this source are generally related to the high level objectives of project and thus define the boundary conditions for the SUDPLAN platform development. Those requirements are especially relevant for the validation and evaluation of the overall project results regarding the fulfilment of the project objectives. Therefore, a trace matrix that maps User Requirements (REQ-USR), Technical Requirements (REQ-TEC) and Developer Requirements (REQ-DEV) to DoW and ICT Requirements (REQ-DoW) is presented in Appendix E and can be used in the preparation of the second iteration of validation plans.

2.3.2 Literature and Related Projects

Several SUDPLAN platform requirements contained in this document are derived from experience gained in other projects, relevant literature, and proven software engineering practice.

More concretely, the Reference Model of ORCHESTRA (RM-OA, 2007) and SANY (SANY, 2009) provide valuable requirements in a spatial decision support context, especially regarding maximising flexibility, interoperability, transferability and the ability to adapt to changing technologies and workflows. Those high level requirements are naturally overlapping with the requirements obtained by the requirements gathering process of the SUDPLAN project described in Chapter 3, and can therefore mostly be considered as high level and technical requirements applying to the SUDPLAN product.

Further requirements, mainly related to good software engineering practice and general interactive system design, have been taken from relevant literature, such as Buschmann and Henney (2010) and Preece *et al* (2007). The state of the art of interactive systems engineering has become focused on user-centred design, and this approach has been adopted for the SUDPLAN project.

2.3.3 User Needs Assessment

The most specific requirements for the SUDPLAN product, the user and developer requirements, were derived from the user needs assessment, a process that was driven by the product conceptualisation task (T2.2) and involved more than 40 people (26 people alone in both project conceptualisation workshops) from the technical and pilot work packages with backgrounds covering many IT disciplines, environmental sciences and modelling, as well as end users bringing in aspects of urban planning, management and decision making.

Figure 3 provides an overview of the user needs assessment process, also showing how the results are related to the first versions of the four Pilot Definition Plans (D5.1.1, D6.1.1, D7.1.1, D8.1.1) and the Requirements Document.

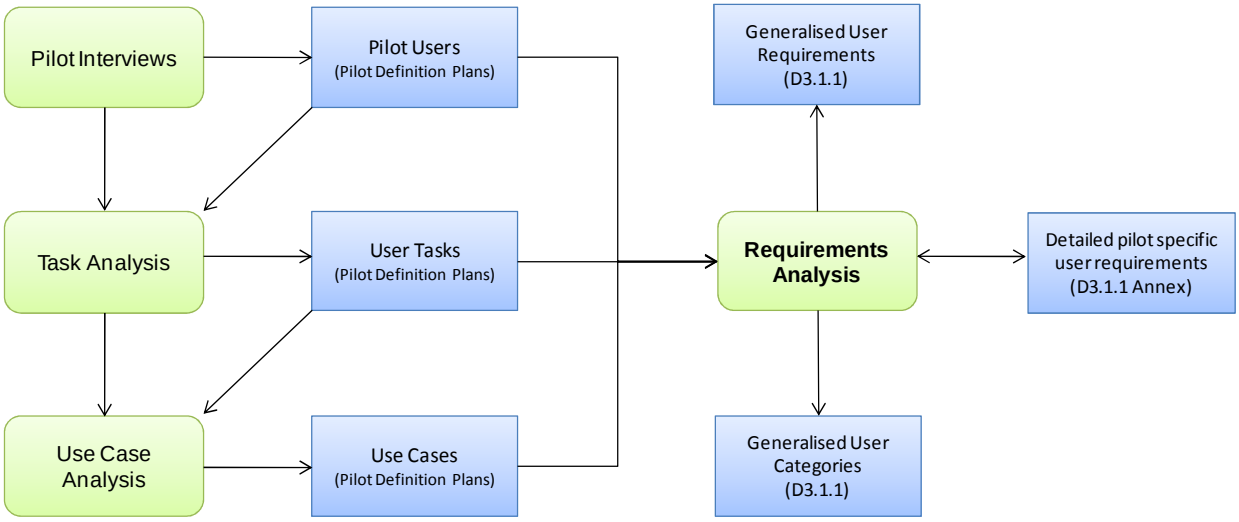

Figure 7: User Needs Assessment in V1

The first step in this process was to conduct interviews with the people involved in the pilot applications. The interviews were carried out with a strong focus on the identification of

- the users involved in each pilot's decision process and their role (e.g. direct or indirect users of the system);
- decisions the pilot application must support;
- information and data required (amount, representation, flow);
- visualization and interaction capabilities required; and
- available subsystems.

During this step, a refinement of the initial user categories described in the DoW also took place. It turned out that the initial user categories did not cover all aspects of the management, administration and decision making processes reported by the interviewed pilot users. The resulting generalised user categories as well as their relationship to the initial DoW categories are presented in Chapter 2.4.

The second main step of the needs assessment consisted of the identification of the tasks the previously identified real-world user(s) of the SUDPLAN applications must be able to perform. The identified tasks were decomposed into a hierarchy of sub-tasks simple enough to enable identification of the resources (data and services) needed to perform the lowest level tasks. This hierarchical task analysis (HTA) was performed consistently with Diaper (2003) and Hackos and Redish (1998) during dedicated workshops with pilot users and technical partners. It helped technical partners to better understand the domain context of the pilot and to identity developer requirements for the design of the scenario management system. This step resulted in the documentation of the identified tasks of the pilot users. Furthermore, it served as the basis for a more detailed use case analysis.

The third step consisted of the definition of representative use cases of the scenario management system from the pilots' point of view. The use cases are described in detail in the Pilot Definition Plans (D[5-8].1.[1-3]) and serve, together with the description of the users' tasks, as a primary basis for the requirements analysis.

The last step of the requirements analysis was itself divided into two distinct increments. The goal of the first was to formulate detailed and pilot-specific requirements for concrete functionalities of the pilot applications. Those pilot specific requirements are documented in Appendix B, Draft Pilot Requirements; their relationship to the specific use cases of the Pilot Definition Plans is indicated in Appendix C, Pilot Requirements Trace Matrix. The second increment performed a transformation of detailed functional pilot specific requirements into generalised requirements on the SUDPLAN platform. This step was necessary to ensure that the SUDPLAN product can be used by any European city, not only by the four pilot cities. The idea and methodology used for the requirements generalisation goes back to the ORCHESTRA project (RM-OA, 2007), where requirements for a generic risk management and decision support infrastructure were to be derived from requirements of very specific pilot scenarios. The pilot users were also involved in the requirements generalisation to check whether their specific application requirements are properly reflected by the more general SUDPLAN platform requirements.

Requirements coming from the user needs assessment are generally categorised as User Requirements (REQ-USR) and Developer Requirements (REQ-DEV). When derived from a pilot specific requirement, the source of a User Requirement refers to Appendix B, Draft Pilot Requirements.

2.4. Requirements Organization

In this document no fundamental distinction is made between user requirements and technical (software) requirements. Recognizing that the user is part of the system, this document addresses the SUDPLAN platform requirements comprehensively, defining them in a uniform manner. That is, while these requirements are addressed in separate sections for clarity, the same approach will be taken in their definition.

2.4.1 Requirement Categories

SUDPLAN requirements are encoded in a clear project-wide taxonomy intended to facilitate both comprehension and conciseness. In this taxonomy, the requirements are divided into four general categories:

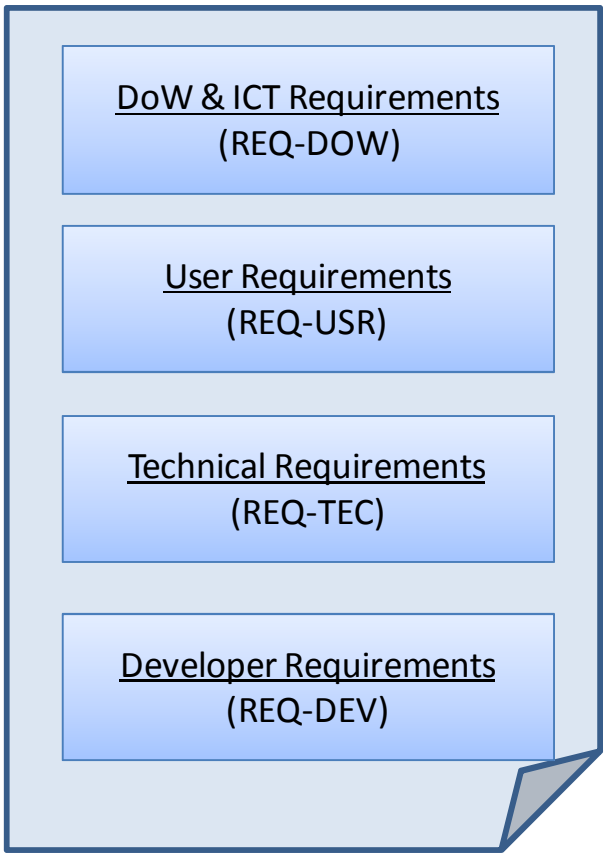

Figure 8: Requirements Categories

- DoW and ICT Requirements (REQ-DoW) are those reflecting the high level objectives of the project as expressed in the Description of Work and the expectations of the Call for Proposals.
- User Requirements (REQ-USR) are those reflecting the needs of the expected users of SUDPLAN applications, especially as exemplified by the pilot applications.
- Technical Requirements (REQ-TEC) are those which govern the non-human aspects of the SUDPLAN platform.
- Developer Requirements (REQ-DEV) are those which reflect the needs of anticipated SUDPLAN application developers, including but not limited to the pilot developers.

2.4.2 Requirement Sources

The source of each requirement is given in the requirements description. Requirements may come from

- CL/DoW: the call and the Description of Work
- PI: the four pilot applications
- PR: other projects
- LT: the literature
- SW: general software engineering principles

Furthermore, three trace matrixes that show the sources of the pilot and platform requirements are provided in Appendix C, Appendix D and Appendix E of this document.

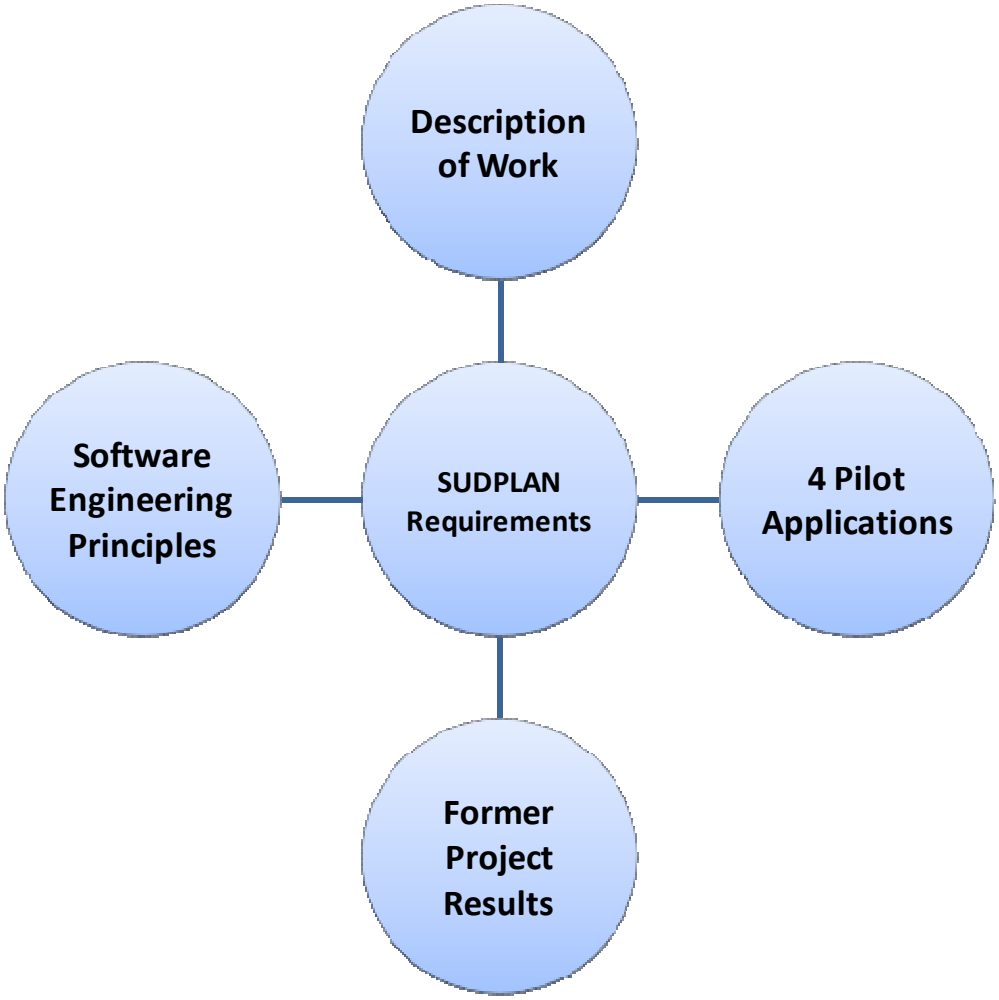

Figure 9: Requirement Sources

The SUDPLAN platform requirements are presented in Chapter 3. That chapter provides a structural organization of the requirements, decomposing the four overall categories in a logical fashion and then concisely expressing each requirement in a uniquely numbered section, along with a brief rationale for the requirement, an indication of the source(s) for the requirement, and, if necessary, an explanatory paragraph clarifying the requirement. When a draft pilot requirement is cited as a source, an accompanying reference to a subsection in Appendix B is provided to aid in cross referencing that requirement.

2.4.3 Requirement Format

All requirements listed in chapter 3 are presented in the following format, providing sufficient details on a particular requirement regarding:

A short name including the category the requirement is assigned to	→	REQ{DoW|USR|TEC|DEV}-number: Name of the requirement
The reason why this is a SUDPLAN requirement	→	Rationale
The origin of this particular requirement (which is important for validation)	→	Source
The possibility to add more context to the requirement if necessary	→	Explanation

This format can be summarised as follows:

REQ-{DoW|USR|TEC|DEV}-number: Name of the requirement

Short description of the requirement.

Rationale: The reason for this requirement, if not clear.

Source: Describes where this requirement comes from.

Explanation: Gives a more detailed explanation, for example what is planned within SUDPLAN and what might be out of scope.

2.5. User Categories

Users from the regional and local scale have a key role in the project, ensuring that the final product(s) meet their needs and expectations. End-user involvement is provided by governmental organisations that have already implemented or are in the process of adopting scenario modelling, planning and decision support systems in Sweden, Germany, Austria and the Czech Republic. By involving planners and decision makers in the urban context and environmental experts and system developers at the same time a wide range of requirements can be collected, addressing very different aspects of a powerful scenario management environment.

The primary target users for SUDPLAN products are scientific users and city managers as well as environmental service providers. While scientific users may be able to use such services directly (for instance by using a combination of tools, or by programming scientific analysis software themselves), many decision makers in administration, including decision makers in cities, either lack the computer skills and/or the resources to such independent development. Dealing with a multitude of decision scenarios (which facilitate planning and policy decisions) in the long-term urban planning context is a key challenge for city planners. There is a considerable gap between the services becoming available and the use of such services in the every-day work of urban planning. Even for scientific users, who are capable of handling a multitude of software tools, it is not desirable that they waste precious time on overcoming the barriers between different tools.

To this end the DoW identifies 3 types of users:

- Expert planners (scientific users, e.g. modellers)
- City planners (less scientific users, e.g. city planners, administrators)
- Developers/application providers (supporting the first two groups)

All three groups are important for the applicability of advanced urban planning. The first one – a more scientifically oriented group of users – will develop different alternative decisions either for themselves (in their own daily work) or for less computer-skilled planners in city government. For this group of users, the platform needs to be very powerful and flexible. They may generate customised applications for the second group. The second group is important as they are the ones who support the decision taking in city government. In many cases they may require a more simplified planning model, but some of the users in cities may also fall under the first category of scientific users. Both end user groups may and will be assisted by system developers and application providers where necessary, in particular when it comes to customizing and extending the core SUDPLAN product.

A key step in the specification of user requirements is the definition of the users. On the basis of the preliminary DoW definitions of SUDPLAN users and during the needs assessment where user tasks have been analysed it was possible to develop a sound and generalized definition of primary, secondary and tertiary users in a way which is generic across the application contexts of the four pilots, a prerequisite for the production of a transferable result.

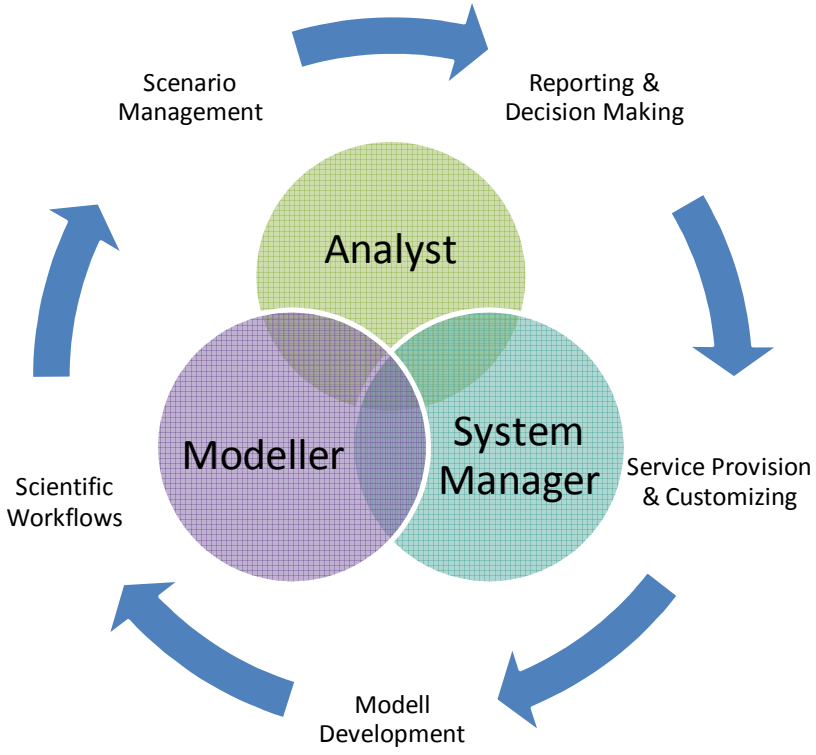

Figure 10: User Categories

SUDPLAN users are described now in three basic categories (Figure 6).

- Analysts are those people who will be using the SUDPLAN applications on a regular basis to carry out analyses in order to arrive at an environmental management decision. In some cases they may be the decision makers, and in other cases they may be supporting the decision makers. This category of user would include expert planners and city planners, as defined in the DoW, and are likely to be primary users (i.e. they will use the SUDPLAN applications directly and regularly).

- Modellers are those people who develop, integrate, and/or configure mathematical models to be used within SUDPLAN applications. While these users might be expert planners as well, this category is reserved for people performing specific model development tasks; if and when they work as planners, they revert to the Analyst category. Modellers may be seen as secondary users in that they will not generally, in this role, use the SUDPLAN application on a regular basis, and might not use it directly at all.

- System Managers are those people who install and maintain SUDPLAN applications and carry out general system administration tasks. This would include the integration of components, such as models, into SUDPLAN applications. While this task might be performed by the same people who developed the models, when they are carrying out the integration into an application they have switched into a role as a System Manager. These users could be considered secondary users. While they will definitely use the SUDPLAN applications directly, it will only be occasionally (in this role).

It is important to note that characterizing SUDPLAN users (pilot users among them) in a generic way simplified the data gathering and generalization process, and facilitated derivation of requirements for a platform that is able to support these users in their various geographic and management contexts. We are convinced that this approach leads to a highly flexible and transferable platform or framework that can be the basis of a vast number of concrete applications implementing concrete use cases (like the pilot applications).

3. Requirements

While the user requirements described here are important, individually they are not necessarily unique. But their integration into a single platform supporting families of environmental decision support systems is. Looking at the entire information processing chain for all involved stakeholders in a holistic way is the essential character of the SUDPLAN Scenario Management System.

3.1. User dependent Overview

In the following we give an overview of the requirements for each user category identified. Obviously, there are a number of requirements common to all user categories identified in chapter 2.4. We therefore present them as common user requirements.

3.1.1 Common User Requirements

Not surprisingly, the common user requirements (i.e. those shared by all three categories of user) include state-of-the-practice attention to usability and user-centred design. After all, SUDPLAN implementations will no doubt be complex, and therefore the user interfaces need to be as easy to use as possible. This is especially critical when it comes to users from specific disciplines interacting with interdisciplinary aspects of the modelled system. To the extent possible, users should not have to educate themselves outside of their disciplines in order to effectively use the system. Table 2 summarizes in more detail the common user requirements.

Category	Requirement	Rationale
Usability	User-centered design	Systematic user-centred design helps ensure that the intended users are successful and improves overall productivity.
	User Errors	Preventing or successfully mitigating user errors is necessary to ensure a productive outcome of the users' use of the system.
	Short-term Memory	Avoiding a reliance on the users' short-term memory significantly increases productivity, reduces error rates, and increases user satisfaction.
	Contextual Help	When users are expected to provide input to an application they may need clarification or explanation of the input that is expected of them.
	Ease of Learning	Users should be able to learn how to use the user interface easily and to readily understand its functionality.
	Memorability	Users should be able to readily remember how to use the user interface.
	Transparency	Users should not need to have technical knowledge outside of their domain.
Profiling	Profiling of the User Interface	User interfaces generally allow configuration by users to suit their needs or preferences. Keeping these configurations in a profile prevents any given user from having to reconfigure the application each time they use it.

	Establishment of User Groups	Some aspects of the user interface configuration may be associated with categories of users rather than individual users.
	Profiling of Automation Tasks	Automatically recurring task configurations should be stored in a profile to allow users to re-establish similar task executions without having to completely re-enter configuration information.
	Profiling of Business Processes	Applications will often require combinations of information and services requested from diverse sources, and these request transactions will need to be configured. Saving of request transaction profiles will help users to streamline their analyses by avoiding extensive reconfiguration.

Table 2: Common User Requirements Summary

3.1.2 Requirements of Analysts

Over and above these common requirements, which apply to all user categories, one particular category of user – analysts – has very specific requirements. One area of significance to analysts is the management of the tremendous amount of information which must be brought to bear in their analyses. Finding, validating, and managing input data, along with appropriate management and display of results are key to this user's function.

Besides this, the nature of the human decision making process, often a 'what if' process, requires that the system be highly interactive, allowing them to manipulate parameters and see corresponding changes in the results as soon as possible thereafter. This necessitates technical approaches such as caching and preloading to facilitate manipulation of large data sets and/or model results.

In addition, analysts need to be able to control the modelling and analysis process itself. This implies the ability to manage the models involved in a simulation scenario, and to have relatively convenient access to models and modelling results regardless of whether the models execute quickly or take a great deal of time to complete. Various techniques (such as asynchronous and pre-calculated model execution) are required to support this flexibility. The ability to save and share model execution scenarios is a natural extension of this.

Finally, and of at least as much importance, is the need to display, report, and publish the results of analyses. Decision-making requires cognitive access to the information that is relevant to the decision. This includes visualization of data to the analyst, as well as reporting of data to other stakeholders and, ultimately, publishing of results to a larger community, possibly to include the general public. Table 3 summarizes in more detail the requirements of analysts.

Category	Requirement	Rationale
Information Management	Information Source Management	An information-intensive application must facilitate the finding, storing, and utilization of information within the application in order to support user success and satisfaction.

	Management of Related Knowledge	Besides actual input data, there may be other information valuable to the analyst, and this information needs to be readily accessible to the users.
	Distributed Information Sources	Applications will often rely on data from multiple external sources.
	Output Data Management	Applications will produce results in a wide variety of forms. These data need to be easily accessible to and manipulated by the analysts.
	Result Processing Management	Given the complexity of applications, output data resulting from primary analytical techniques may need to be post-processed by the user, and system support for these activities is necessary.
	Information Product Management	Information products produced by analysts must be stored and managed in an organized and accessible fashion.
	Coordinate Conversion	Information products produced throughout the platform must be easily convertible to other spatial reference systems.
	Tracing	The system should support the tracing of user and system component interactions.
Interactivity	General Interactivity Requirements	The system shall support analysts by including design features which facilitate manipulation of elements of the modelled system (e.g. parameters, variables, input data).
	Responsiveness	When the analyst has manipulated an input to the modelling system, the system needs to provide an immediate response to this change in situations where that makes sense and is possible. The system must indicate if an immediate response is not possible together with the reason (to “guide” the user to change his manipulation)
	Local Data Copy	Pre-fetching and caching data locally can greatly improve the users’ experience of interactive exploration of the data.
	Differential Data Download	Many data sources contain data that only infrequently change. Fetching of “changes only” in combination with pre-fetching and caching can therefore greatly improve the system responsiveness.
Model Management	Initial and Boundary Conditions	Mathematical models require parameters describing initial and boundary conditions of the model. It is essential that users be assisted where possible in choosing and establishing those conditions.
	Condition Sets	Particular combinations of initial and boundary condition parameters can be stored as a set, and then reused in subsequent model runs.

	Synchronous Model Execution	Models which generally run to completion quickly can be run by users who choose to wait for completion.
	Asynchronous Model Execution	Since some models will take considerable time to complete, users may choose to run these models asynchronously.
	Model Set Execution	Extending the concept of asynchronous model execution, users can run multiple instances of the same model combination with varying sets of parameters, producing a "family" of results.
	Pre-calculated Model Execution	For computationally intensive models limiting the number of times the model has to be executed, and using stored results from previous runs, can help model combinations which use these results to execute in a timely fashion, and can also reduce redundant use of computational resources.
	Model Status	Computationally intensive models can take considerable time to execute, and during their execution analysts will need to be able to check their status.
Scenarios	Establishing Scenarios	Users need to be able to specify the values for parameters within a scenario (including initial and boundary conditions), as well as the particular models to be included for each scenario.
	Scenario Management	As users define scenarios, they will need to be able to manage them.
Visualisation	3D/4D Visualisation	Analysts need to carry out exploratory data analysis on 3- and 4-dimensional data sets, and therefore need visualization support for these data.
	Spatial Visualisation	Environmental data are very often spatial in nature, and therefore require geo-spatial visualization techniques.
	Temporal Visualisation	Environmental phenomena are dynamic in nature, and therefore often require the use of visualization techniques representation variation of one or more variables as a function of time.
	Spatio-temporal Visualisation	More complex environmental data sets vary in both time and space.
	Visualisation of a Model Run Result	Many model runs will generate spatial and/or temporal data which need to be visualized to be interpreted by the analyst.
	Comparison of Model Run Results	Analysis of the results from multiple comparable model runs (such as under different scenarios) requires the ability to simultaneously represent model results visually.

Result Documentation and Annotation	Documentation of a Model Run	The results of each model run needs to be annotated before being stored in order to facilitate search and recovery.
	Documentation of Scenario Set Execution	In addition to storing annotations about individual model runs, analysts will need to annotate scenario sets as well.
Information Products	Creation of Information Products	The value of an analysis can be greatly enhanced by producing information products which are also accessible to other stakeholders. Analysts will require system support to help them generate such information products.
	Report Generation	Basic reports making the results of scenario execution accessible to non-analysts are necessary in order to communicate the results to the other stakeholders.
	Export	In order to support the generation of information products beyond basic reports, the analyst will need to be able to export artefacts (such as model execution results or visualized data) to other formats for use of external tools.
Sharing	Information Sharing	Information regarding an application, including but not limited to input data, should be readily shared between consenting analysts to facilitate collaboration and efficiency.
	Result Sharing	The results of model and scenario set execution can be useful for analysts working on the same or related applications, and should be readily shared along with their documentation annotations.
	Information Product Sharing	Multiple analysts might be producing similar information products to communicate their results. Sharing of these products encourages efficiency and consistency.
	Annotation Sharing	Sharing of annotations among analysts working on the same data sets can increase their efficiency and support additional quality control.
Publishing	Information Publishing	Analysts may wish to make their data and other information available to other web-based services, and therefore need a mechanism for publishing this information to the Internet.
	Web Publishing	Results such as visualizations and information products, may be shared as web content in order to enhance the value added by the analyses.
	Web Publishing Standards	Adherence to standards will increase the availability of information to the wider community.

Table 3: Analyst Requirements Summary

3.1.3 Requirements of Modellers

Modellers have somewhat narrower requirements, focused as they are on the fine-tuning and integration of models into the decision support system framework. Since they are generally somewhat more specialized than the analysts, their needs are also more specific. But because they are involved with the integration of models (not all of which are necessarily within their specialty) they require particular help in the areas of assumption harmonization and calibration/validation of integrated models (Frysinger, 2002). They must also be supported in coping with a range of versions of particular models, and require assistance in distinguishing the nature of their differences. Table 4 summarizes in more detail the requirements of modellers.

Category	Requirement	Rationale
Model Management	Model Integration	Integrating models into an application, possibly with other models, means that the modeller needs to be able to specify the role of the model(s) within the application and to make the necessary connections between the model(s) and other components of the application.
	Model Configuration	Modellers need to be able to configure models by specifying those data which are necessary for the model but which will not be under the control of the analyst.
Model Calibration and Validation	Model Calibration	If an application provides access to sufficient measurement data, it may be desirable to calibrate the model(s) used within the application to those data.
	Model Validation	If an application has access to sufficient measurement data, using these data to validate the model(s) can increase confidence in the results of the model(s) within the context of the application.
	Model Versions	If different versions of a model are available it is necessary for these versions to be managed in such a way that analysts can distinguish their features and employ the correct version for their needs.

Table 4: Modeller Requirements Summary

3.1.4 Requirements of System Managers

Finally, system managers have particular requirements. These include provision for user identification and authorization, and extend to the representation of authorized users to external systems with their own authentication requirements. The system manager may be responsible for integration of data, sensor data, services, and models into a platform configuration supporting the analysts, and will therefore require support for all of these tasks. Table 5 summarizes in more detail the requirements of system managers.

Category	Requirement	Rationale
Platform Management	User Management	In order to manage access to an application the system manager needs to be able to specify users and groups of users to the system.

	Security and Rights Management	System managers need to be able to specify which users are authorized to have what level of access to which parts of the application.
Integration	Data Source Integration	An application may use data from a variety of sources. The system manager needs to be able to integrate these data sources into the application for the system analyst.
	Sensor Service Integration	Applications may use sensor services that are either local to the application or that are distributed and accessible via the web.
	Service Integration	Applications may use other non-modelling services that are either local to the application or that are distributed and accessible via the web.

Table 5: System Manager Requirements Summary

3.2. Full Requirements List

The following sections present the full ensemble of SUDPLAN requirements. The requirements are organized in four sections reflecting the general categories of all SUDPLAN requirements collected:

1. DoW and ICT Requirements
2. User Requirements
3. Technical Requirements
4. Developer Requirements

Each of these sections is further decomposed into layers of subsections intended to provide a logical organization for the requirements, and the requirements themselves each appear in the lowest layer of subsections. They are also tabulated in Appendix A.

These sections are numbered hierarchically, using the prefix of the general category of requirement, followed by section and subsection numbers. Ultimately, this culminates in requirement numbers of the form REQ-ABC-i.j.k where ABC represents the general category's symbol and i.j.k are three integers indicating the requirement's position within the hierarchical organization.

DoW and ICT Requirements

This section contains a list of requirements derived from the DoW and call (SUDPLAN objectives).

REQ-DOW-1: SUDPLAN objectives

These requirements are based on overall project objectives and serve as high level guidance for the development process.

REQ-DOW-1.1: Build an easy-to-use system

SUDPLAN shall provide easy-to-use planning, prediction, decision-support and training tool.

Rationale: The main idea of the SUDPLAN project is to develop an easy-to-use web-based planning, prediction, decision support and training tool, for the use in an urban context, based on a what-if scenario execution environment, which will help to assure population's health, comfort, safety and life quality as well as sustainability of investments in utilities and infrastructures within a changing climate.

Source: DoW 1.1.1 SUDPLAN objectives, Page 12

Scope: SMS Framework

Explanation: This very general requirement refers primarily to the GUI of the SUDPLAN SMS and is decomposed into several more detailed usability related requirements that take also the different types of users into account. See also REQ-DOW-2.10: Offer user-friendly interfaces and REQ-USR-1.1: Usability and the following requirements.

REQ-DOW-1.2: Assess risk for river flooding and inundations

SUDPLAN shall provide the possibility to assess river flooding scenarios.

Rationale: Risk for river flooding and inundations of built-up areas and other developed areas have to be assessed based of future climate scenarios.

Source: DoW 1.1.1 SUDPLAN objectives, Page 12

Explanation: This will be demonstrated in the Czech pilot. Main focus is on soil moisture whereby river discharge is a primary output, along with soil moisture.

REQ-DOW-1.3: Assess maximum rain intensity

SUDPLAN shall provide the possibility to assess maximum rain intensity.

Rationale: Maximum rain intensity to be expected over sealed surfaces is needed to know how water run-off systems must be dimensioned.

Source: DoW 1.1.1 SUDPLAN objectives, Page 12

Explanation: Used in the Pilots Wuppertal (WP6) and Linz (WP7). There must also be the possibility to assess short rainfall events with given probability (e.g. 1 time in 10 years, 1 time in 30 years and so on).

REQ-DOW-1.4: Assess risk from air pollution and extreme temperatures

SUDPLAN shall provide possibility to assess risk from air pollution and extreme temperatures.

Rationale: Spatial distribution of air pollution, risk for extreme events and high ambient temperatures in built-up residential and work areas.

Source: DoW 1.1.1 SUDPLAN objectives, Page 12

Explanation: Used in the Pilots Stockholm (WP5) and Cenia (WP8).

REQ-DOW-1.5: Assess risk from changes in hydrological conditions

SUDPLAN shall provide possibility to assess risk from changes in hydrological conditions with increasing temperature and decreasing precipitation.

Rationale: Hydrological conditions with increasing temperature and decreasing precipitation have major influence on crop yield and my lead in the worst case to farm abandonment due to disadvantageous changes in temperature and soil moisture.

Source: DoW 1.1.1 SUDPLAN objectives, Page 12

Explanation: Used in the Cenia Pilot (WP8).

REQ-DOW-2: Open approach: technical requirements of SISE

These requirements derive from the overall objective for SUDPLAN to contribute to the Single Information Space in Europe (SISE).

REQ-DOW-2.1: Use open standards

The SUDPLAN product shall entirely be based on open standards.

Rationale: The usage of open standards is needed to enable connections to other (existing and future) systems. For example, we need to access already existing city-local data and services which are not based on open standards. This should be done by providing standard based interfaces to this data storages and services.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 16

Explanation: There may be the need to access already existing city-local data and services which are not based on open standards. This should be done by providing standard based interfaces to this data storages and services.

REQ-DOW-2.2: Publish interfaces

SUDPLAN shall define and publish interfaces to access SUDPLAN (in order to access results or to invoke services), which are based on open standards.

Rationale: This will allow other systems to use data and services provided by SUDPLAN.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 16

Explanation: SUDPLASN results shall be accessible through standardized services (e.g. SOS, WMS and WFS). Since input and output data sets for proprietary local models are often specific for the corresponding model, there shall also be the possibility to hide those models behind services providing open standard interfaces (e.g. SOS and SPS).

REQ-DOW-2.3: Use and provide open source

SUDPLAN shall be based on open source products, and will itself be an open source product.

Rationale: Should enable simple extendibility, reuse and make the product available to all cities.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 16

Explanation: SUDPLAN software deliverables (e.g. D3.2.x, D3.3.x, etc.) will also include the source code of the developed components.

REQ-DOW-2.4: Allow discovery of relevant sources

SUDPLAN shall provide applications and tools for the discovery of relevant sources.

Rationale: A decision maker needs to find the relevant facts for his decision.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: User shall have the possibility to easily find relevant sources catalogued within the SMS. Furthermore, a service catalogue should be available for common services and local services that can be used outside of SUDPLAN.

REQ-DOW-2.5: Allow integration of standards-based services

SUDPLAN shall provide applications and tools for the integration and seamless access to data sources residing on a standard based infrastructure (like provided by SANY or ORCHESTRA).

Rationale: There are already a lot of relevant data sources available. It is therefore required to access them in a standardised way.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: Integration of external data sources using known open standard based interfaces (e.g. SOS, WMS, ...) can be done in a simple way. However, it shall be noted, the integration of the data from services with complex data models such as WFS or SOS is known to be tricky. It depends heavily on the quality of meta-information provided by the services. Problems may occur to understand the meaning of the data if an appropriate data description is missing.

REQ-DOW-2.6: Provide tools for the management of scenarios

SUDPLAN shall provide applications and tools for the management of scenarios, without touching the data sources at the provider level. Those applications and tools shall not require the permission to alter the data sources at the provider level.

Rationale: Before coming to a decision different scenarios and there implications have to be compared. SUDPLAN applications rely on external data sources, and need to assure that all information used in defining and running the scenario is stored and available for later reference. However, changing and storing data in third party repositories is often either impossible, or at least discouraged.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: Data and model parameters required in a scenario shall be stored by the SMS and re-used later.

REQ-DOW-2.7: Provide quality controlled repositories

SUDPLAN shall provide applications and tools for the availability of repositories (e.g. databases, caches, inventories) for quality controlled and securely managed scenarios and their results.

Rationale: Decisions based on the SUDPLAN applications may have great impact (e.g. financial impact on city planning). It is therefore important to adequately store all the facts and results leading to the decision, e.g. to allow a-posterior reconstruction of the decision making process and audits. Every piece of data within the internal repositories therefore has to be assessed with descriptions about the origin and processing of these data.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: SUDPLAN is designed to use a lot of external data repositories. These repositories shall be described within SUDPLAN SMS. In order to assure the decision making process can be fully understood and reproduced at a later time (e.g. as a part of an audit), the SMS must assure all data and model parameters are available for later inspection. Please note that since external repositories are not under the complete and exclusive control of SUDPLAN (see requirement REQ-DOW-2.6: Provide tools for the management of scenarios), the availability of the data used for decision making at a later time can not be guaranteed by SUDPLAN. Therefore this requirement applies only to SUDPLAN

internal repositories. Every piece of data within the internal repositories shall be annotated with descriptions about the origin and processing of these data.

REQ-DOW-2.8: Provide a security system

SUDPLAN shall provide applications and tools to implement security and access control as an integral part of the system.

Rationale: Beside the obvious reasons for security this comes also from the need for quality controlled repositories. See also REQ-DOW-2.7: Provide quality controlled repositories.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: The SMS shall provide inherent support for access control. Users have to be authenticated (login) before being able to use the SMS. Their access to the various functionalities of the SMS (e.g. to view and manage scenarios, to run a model, to download a model results, etc.) has to controlled on basis of the role of the user. Other security related topics that may be considered are access control for data and services (repositories), protection against denial of service attacks, protection against data manipulation, protection against unauthorised triggering of the modelling services and protection against theft of confidential data (for instance emission data).

REQ-DOW-2.9: Publish results to the WWW

SUDPLAN shall provide applications and tools to publish results to the public on the World Wide Web.

Rationale: Web publishing is becoming a main information source for large parts of the population.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: SUDPLAN does not intend to implement a full Content Management System functionality, but it should allow the export of results in proper formats to publish them in the WWW to inform the public.

REQ-DOW-2.10: Offer user-friendly interfaces

SUDPLAN shall provide user-friendliness of services and interfaces, in particular ergonomics of the graphical user interface (GUI) and the visualization components.

Rationale: Enable usage by untrained users, not only “SUDPLAN” experts.

Source: DoW 1.1.3 Open Approach: technical requirements of SISE, Page 17

Explanation: See also REQ-USR-1.1: Usability and the following requirements.

REQ-DOW-3: Integrated decision support systems

REQ-DOW-3.1: Provide dynamic composition of work flows

SUDPLAN shall extend the state-of-the-art in the field of environmental decision support systems by offering to users the dynamic composition of scientific work flows.

Rationale: Allow users to define their own workflows as needed.

Source: DoW 1.2.1 Integrated decision support systems, Page 20

Explanation: The SMS shall offer all the information and tools needed for a decision support workflow which can then be used by the System Manager or Modeller to compose arbitrary workflows for Analysts. Analysts need to be able to dynamically configure workflows; there is no requirement from the pilots that they also need to dynamically compose workflows.

REQ-DOW-3.2: Provide highly integrated and interactive 3D / 4D

SUDPLAN shall extend the state-of-the-art in the field of environmental decision support systems by offering to users highly integrated and interactive 3D / 4D.

Rationale: Proper visualization is needed to understand the large data sets, especially if they are georeferenced. The visualization will not only be used by experts for themselves but also to inform other persons.

Source: DoW 1.2.1 Integrated decision support systems, Page 20

Explanation: To understand the implications of a certain value, e.g. a water level, a proper visualization including background data like buildings along a river is needed.

~~REQ-DOW-3.3: Provide automation of model runs, analysis and reporting~~

~~***SUDPLAN shall extend the state-of-the-art in the field of environmental decision support systems by offering automation of model runs, analysis and reporting.***~~

~~Rationale: Simplify the use of modelling, analysis and reporting tools for end users.~~

~~Source: DoW 1.2.1 Integrated decision support systems, Page 20~~

~~Explanation: There is no requirement from the pilots for automation.~~

REQ-DOW-3.4: Provide integration with SOA-based infrastructures

SUDPLAN shall extend the state-of-the-art in the field of environmental decision support systems by offering ubiquitous integration with information sources and services in SOA-based infrastructures.

Rationale: Needed for easy integration of existing and future services.

Source: DoW 1.2.1 Integrated decision support systems, Page 20

Explanation: The SMS shall support the access to standardized OGC service infrastructures (SOS, SPS, WMS, WFS) and data models (O&M).

REQ-DOW-4: Use of models for urban planning

REQ-DOW-4.1: Support city management

SUDPLAN shall offer a powerful tool for assessing environmental factors and their interaction with urban subsystems such as infrastructure, waste water and transport systems, in a climate change perspective to be used for city management.

Rationale: Modelling is used to understand management decisions in a complex system.

Source: DoW 1.2.2 Use of models for urban planning, Page 20

Explanation: SUDPAN shall offer city mangers the integration of sophisticated expert modelling tools and interactive 3D / 4D visualization tools to assess of climate change scenarios.

REQ-DOW-5: Extreme precipitation with potential of causing storm water flooding in urbanized areas

REQ-DOW-5.1: Provide IDF curves

SUDPLAN shall extend the state-of-the-art in the field of extreme precipitation by providing statistical measures (IDF curves) for future intense rainfalls, based on downscaled climate model results.

Rationale: This data is needed to plan efficient strategies to prevent damage caused by future storm water events.

Source: DoW 1.2.2.2 Extreme precipitation..., Page 23

Explanation: Needed in Pilot 7 as input to a local model of the waste water infrastructure. A user interface and corresponding functionality is also needed to extract a short rainfall events with given probability (e.g. 1 time in 10 years, 1 time in 30 years and so on) directly on basis of the IDF curves.

REQ-DOW-5.2: Improved simulation results

SUDPLAN shall extend the state-of-the-art in the field of extreme precipitation by enabling the user to improve the quality of the simulated precipitation results by adding local historical precipitation data.

Rationale: Local historical data can be used to calibrate the results according to the local conditions.

Source: DoW 1.2.2.2 Extreme precipitation..., Page 23

Explanation: The user shall be able to upload own historical precipitation data to improve the results of the predictions.

REQ-DOW-5.3: Identify extreme precipitation events

SUDPLAN shall extend the state-of-the-art in the field of extreme precipitation by identifying future periods – typically 1-2 months – with extreme precipitation events, for which SUDPLAN provides precipitation grids with high temporal (30 min) resolution.

Rationale: This data is needed to plan efficient strategies to prevent damage caused by future accumulations of heavy rain events.

Source: DoW 1.2.2.2 Extreme precipitation..., Page 23

Explanation: Precipitation data of extreme single events with a typical duration of 30 minutes shall be provided with a high temporal resolution (e.g. every 10 seconds).

REQ-DOW-5.4: Provide input for local models

SUDPLAN shall extend the state-of-the-art in the field of extreme precipitation by allowing planners to use such results as input into waste water models, models computing pipe network capacity and storm water flooding.

Rationale: Beside the models with European scope there is a need of local, city-specific models which need the result of the European wide models as input.

Source: DoW 1.2.2.2 Extreme precipitation..., Page 23

Explanation: Used in Pilot 6 and 7

REQ-DOW-5.5: Provide tools to compare scenarios

SUDPLAN shall extend the state-of-the-art in the field of extreme precipitation by allowing planners to use such results as input into waste water models, models computing pipe network capacity and storm water flooding.

Rationale: To get an optimal decision the decision maker needs to compare the results of different scenarios.

Source: DoW 1.2.2.2 Extreme precipitation, Page 23

Explanation: The SMS shall provide the possibility to store, execute and visualise different scenarios and to perform a side by side comparison. It is also necessary to integrate local model components to compare the results of different scenarios.

REQ-DOW-6: Local flood and drought assessment using Pan-European, multi-basin, hydrological models

REQ-DOW-6.1: Simulate directly from SUDPLAN interface

SUDPLAN shall extend the state-of-the-art in the field of flood and draughts by allowing end users to simulate trends and extreme values of river runoff, draughts and ground water levels for whatever city in Europe, directly from the SUDPLAN web interfaces.

Rationale: For a better usability of SUDPLAN there should be no need to run models from outside the SUDPLAN product.

Source: DoW 1.2.2.3 Local flood and drought assessment, Page 27

Explanation: Validated in project version: V2, V3

REQ-DOW-6.2: Provide better downscaling results by using local data

SUDPLAN shall extend the state-of-the-art in the field of flood and draughts by leaving local end users the possibility to improve SUDPLAN model results by adding local precipitation, river runoff and land use data.

Rationale: To get more accurate results some fine grain local data can be used by the downscaling services.

Source: DoW 1.2.2.3 Local flood and drought assessment, Page 27

Explanation: See also REQ-DOW-5.2: Improved simulation results.

REQ-DOW-6.3: Asses future land use scenarios

SUDPLAN shall extend the state-of-the-art in the field of flood and draughts by forming a tool which evaluates how different local land use and urbanization scenarios respond hydrologically to externally driven climate changes.

Rationale: Land use, and to a somewhat lesser extent the urbanisation (e.g. building architecture, requirements on infrastructure, sustainable population density) are very sensitive to climate changes.

Source: DoW 1.2.2.3 Local flood and drought assessment, Page 27

Explanation: To be validated in V2.

REQ-DOW-6.4: Provide future runoff time series

SUDPLAN shall extend the state-of-the-art in the field of flood and draughts by delivering time series output of future river runoff suitable to feed local hydraulic flooding models.

Rationale: To protect existing and plan future infrastructures the risk of flooding has to be assessed.

Source: DoW 1.2.2.3 Local flood and drought assessment, Page 27

Explanation: To be validated in V2.

REQ-DOW-7: Dispersion model systems used to assess air quality in European cities

REQ-DOW-7.1: Provide long term air quality simulation

SUDPLAN shall extend the state-of-the-art in the field of air pollution by delivering long term (10 year) air quality and temperature simulations over the entire Europe, for different climate scenario windows (e.g. 2006-2015, 2026-2035, 2046-2055 etc).

Rationale: Future air quality is needed to map out strategies for future infrastructure and land use.

Source: DoW 1.2.2.4 Dispersion model systems, Page 29

Explanation: Long term air quality simulations enable the end user to identify trends in poor air quality and heat wave incidents.

REQ-DOW-7.2: Assess local influence to air quality

SUDPLAN shall extend the state-of-the-art in the field of air pollution by performing year long downscaling air quality and temperature simulations that allow the assessment of how local sources, activities and land use impact future air quality in particular European cities.

Rationale: This is needed to understand the implications of emission sources like factories or highways.

Source: DoW 1.2.2.4 Dispersion model systems, Page 29

Explanation: Air quality management shall for example be supported by the SMS to assess of the environmental consequences of alternative road transit scenarios.

REQ-DOW-7.3: Connect local emission models

SUDPLAN shall extend the state-of-the-art in the field of air pollution by allowing local emission scenarios and dispersion models to be nested to the downscaled air quality grids, demonstrating the relative importance of local sources within individual industrial, urban and residential environments.

Rationale: This can be used for simpler assessment of different scenarios concerning local emission sources.

Source: DoW 1.2.2.4 Dispersion model systems, Page 29

Explanation: It shall also be possible to use local emission data for the air quality downscaling.

REQ-DOW-7.4: Assess future health risks

SUDPLAN shall extend the state-of-the-art in the field of air pollution by offering the possibility for countries or groups of countries to assess future exposure and health risks caused by air pollutants and high ambient temperature.

Rationale: Air quality has a huge impact on human health, so assessing air quality also means assessing human health risks. For example, a visualization of air quality together with population density will help to support proper decisions

Source: DoW 1.2.2.4 Dispersion model systems, Page 29

Explanation: SUDLAN shall provide data about exposure to air pollutants and high ambient temperature. The risk assessment can then be done by feeding this data into a local human health model.

REQ-DOW-7.5: Assess future fulfilment of air quality standards

SUDPLAN shall extend the state-of-the-art in the field of air pollution by offering the possibility for countries or groups of countries to assess their possibilities to fulfil national air quality standards and environmental objectives, also in a climate change perspective.

Rationale: Assess the implications of decisions met now to the fulfilment of actual air quality standards.

Source: DoW 1.2.2.4 Dispersion model systems, Page 29

Explanation: This would also require a model of future air quality standards.

REQ-DOW-8: Model integration in the daily work environment

REQ-DOW-8.1: Provide models using SOA

SUDPLAN shall contribute to the extension of the state-of-the-art in the area of model integration as models will become available as services in loosely coupled SOAs.

Rationale: The models used within SUDPLAN shall be offered as services

Source: DoW 1.2.3 Model integration in the daily work environment, Page 30

Explanation: It shall be possible to re-use the models used within SUDPLAN in multiple contexts without repeated model development efforts. See also REQ-DOW-2.2: Publish interfaces and REQ-DOW-2.5: Allow integration of standards-based services.

REQ-DOW-8.2: Provide models for the end user

SUDPLAN shall contribute to the extension of the state-of-the-art in the area of model integration as models become more available to administrative end users.

Rationale: Models available as services should be offered to SUDPLAN users.

Source: DoW 1.2.3 Model integration in the daily work environment, Page 30

Explanation: See also REQ-DOW-8.1: Provide models using SOA.

REQ-DOW-8.3: Foster SOA development in the area of model integration

SUDPLAN shall contribute to the extension of the state-of-the-art in the area of model integration as emerging SOA development is fostered.

Rationale: Techniques used for model integration in SUDPLAN shall also be available outside of SUDPLAN.

Source: DoW 1.2.3 Model integration in the daily work environment, Page 30

Explanation: SUDPLAN shall provide open source implementations of OGC SOS and SPS allowing easy integration of models in the SOA world. It shall be possible to integrate local models on the basis of OGC services. The SMS shall provide a GUI for manipulating this kind of model services so that the solution is independent of the actual model. See also REQ-DOW-8.1: Provide models using SOA.

REQ-DOW-8.4: Validate existing standards

SUDPLAN shall contribute to the extension of the state-of-the-art in the area of model integration as existing standards (e.g. OGC Web Processing Service) are tested and validated in terms of their usability.

Rationale: SUDPLAN will collect experiences in using existing SOA standards.

Source: DoW 1.2.3 Model integration in the daily work environment, Page 30

Explanation: Experience with OGC services and resolutions of known shortcomings can be communicated to OGC as “best practice” paper.

REQ-DOW-9: Service-oriented infrastructures for environmental management

REQ-DOW-9.1: Improve existing SOA-based developments

SUDPLAN shall extend the state-of-the-art in the field of service-oriented infrastructures by taking up existing developments, validating and improving them.

Rationale: SUDPLAN will use and where necessary improve existing standards.

Source: DoW 1.2.4 Service-oriented infrastructures for environmental management, Page 31

Explanation: This can probably only be validated through community, e.g. through feedback received on related SUDPLAN publications.

REQ-DOW-9.2: Spread SOA-type service networks

SUDPLAN shall extend the state-of-the-art in the field of service-oriented infrastructures by supporting the spreading of SOA-type service networks.

Rationale: Since SUDPLAN will allow the access to and from SOA based service networks users will have an interest to use SOA networks.

Source: DoW 1.2.4 Service-oriented infrastructures for environmental management, Page 31

Explanation: Common Services delivering downscaling services for all over Europe shall be implementing OGC SOS, SPS and WMS functionality.

REQ-DOW-9.3: Provide new SOA service specifications

SUDPLAN shall extend the state-of-the-art in the field of service-oriented infrastructures by adding to SOAs new types of services (both specifications and implementations).

Rationale: If there are no proper service specifications needed by SUDPLAN will provide new specifications and implementations.

Source: DoW 1.2.4 Service-oriented infrastructures for environmental management, Page 31

Explanation: So far, no need for new service types has been discovered in SUDPLAN.

REQ-DOW-9.4: Provide new SOA modelling services

SUDPLAN shall extend the state-of-the-art in the field of service-oriented infrastructures by complementing SOAs in the field of modelling services.

Rationale: The models used within SUDPLAN will be provided as services

Source: DoW 1.2.4 Service-oriented infrastructures for environmental management, Page 31

Explanation: See REQ-DOW-8.1: Provide models using SOA.

REQ-DOW-10: Visualisation and interaction

REQ-DOW-10.1: Provide 3D/4D visualisation framework

SUDPLAN shall enhance the current state of the art in interactive visualization by a highly interactive, extendable 3D / 4D visualization framework combining geometric, volumetric and information visualization algorithms as well as interaction techniques for analyzing, comparing and presenting of simulated what-if scenarios (in the area of sustainable urban development).

Rationale: A proper visualization is required to understand and compare complex or large data sets. This is needed to understand the implications of different scenarios.

Source: DoW 1.2.5 Visualisation and interaction, Page 36

Explanation: A 3D Map component shall be provided that can be used in various contexts to visualise model results and data in 3D and 4D.

REQ-DOW-10.2: Provide interaction framework

SUDPLAN shall enhance the current state of the art in interactive visualization by an extendable framework regarding visualization as well as interaction metaphors (the system can be adapted to a wide variety of data).

Rationale: The 3D/4D visualization shall also be usable for direct interaction with the SUDPLAN system to allow an intuitive use.

Source: DoW 1.2.5 Visualisation and interaction, Page 36

Explanation: An interaction component shall be provided which provides the suitable interaction methods depending on the chosen data and context.

REQ-DOW-10.3: Provide tools to create customizable presentation material

SUDPLAN shall enhance the current state of the art in interactive visualization by allowing easy customization of the visualization and interaction by the user/planer, which can produce presentations tailored for different recipient groups.

Rationale: This is needed to present facts and document the reasons of decisions outside the interactive SUDPLAN environment.

Source: DoW 1.2.5 Visualisation and interaction, Page 36

Explanation: To highlight certain aspects of the data for user groups not working directly with the system, it shall be possible to export a customized visualisation for use in presentations.

REQ-DOW-10.4: Provide support of different output devices

SUDPLAN shall enhance the current state of the art in interactive visualization by the support of different types of output devices (the system can be adapted to a wide variety of hardware from single-user desktop to immersive multi-user environments).

Rationale: Depending on the systems available to the user proper visualization and interaction techniques have to be used.

Source: DoW 1.2.5 Visualisation and interaction, Page 36

Explanation: A component which automatically adjusts the visualisation and interaction techniques to the available output and interaction devices shall be provided to ensure the best possible presentation of the data.

REQ-USR: User Requirements

The next section will elaborate generic user requirements common to the three types of users identified in Chapter 2, followed by a section devoted to requirements specific to each type.

REQ-USR-1: Common user requirements

These requirements are common to all three categories of SUDPLAN users.

REQ-USR-1.1: Usability

Certain general elements of the user interface design enhance system usability.

REQ-USR-1.1.1: User-centred design

SUDPLAN shall employ user-centred design principles in the design of the user interface. SUDPLAN shall provide user-friendly services and interfaces, graphical user interfaces (GUI), and data visualization components.

Rationale: Systematic user-centred design helps ensure that the intended users are successful and improves overall productivity. Furthermore it enables the use of the SUDPLAN product by untrained users, not only SUDPLAN experts.

Source: LT: Preece et al, 2007; CL/DoW: REQ-DOW-1.1: Build an easy-to-use system, REQ-DOW-2.10: Offer user-friendly interfaces

Explanation: While comprehensive specification of particular usability metrics is inappropriate at this point, the use of an industry standard approach will help substantially to ensure that the SUDPLAN platform itself, and by extension its applications, will have a user interface design (both conceptual and physical) that matches the constraints and expectations of the users. This particularly applies to the conceptual design, which must match the users' mental model of the system in order to avoid errors and unpleasant surprises.

REQ-USR-1.1.2: User errors

SUDPLAN shall employ user interface design features that help prevent users from making errors when possible, allow users to reverse an error if one is made, or minimize the consequences of user errors if neither of these is possible.

Rationale: Preventing or successfully mitigating user errors is necessary to ensure a productive outcome of the users' use of the system.

Source: LT: Preece et al, 2007

Explanation: There are well known methods of user interface design which can significantly reduce damaging consequences of user errors by either preventing the error in the first place, or allowing it to be mitigated if it cannot be avoided. The term *Interaction Design* is generally used to describe this methodology.

REQ-USR-1.1.3: Short-term memory

SUDPLAN shall employ design features which allow the software to carry the burden of remembering information needed from one part of an application by another.

Rationale: Avoiding a reliance on the users' short-term memory significantly increases productivity, reduces error rates, and increases user satisfaction.

Source: LT: Preece et al, 2007

Explanation: Features such as copy/paste and drag and drop are very effective ways to help users by removing the need for them to remember file and path names and other details when attempting to provide information to an application which is already available elsewhere within the application.

REQ-USR-1.1.4: Contextual Help

SUDPLAN shall provide contextual help to users.

Rationale: When users are expected to provide input to an application they may need clarification or explanation of the input that is expected of them.

Source: LT: Preece et al, 2007

Explanation: Highly interactive applications generally provide many opportunities for user input. At any such point the users may not be sure what sort of input is expected, or what the constraints on that input (such as format) might be. Making help available at such points dramatically reduces the occurrence of erroneous input, improves overall effectiveness, and enhances user satisfaction.

REQ-USR-1.1.5: Ease of learning

SUDPLAN shall be easy to understand and to learn.

Rationale: SUDPLAN users should be able to learn how to use the user interface easily and to readily understand its functionality.

Source: PR: ORCHESTRA, 2007; LT: Preece et al, 2007

Explanation: SUDPLAN users will come from varying backgrounds, and some may use SUDPLAN only occasionally, making it essential that the system present a clear, self-explanatory and easy to use interface.

REQ-USR-1.1.6: Memorability

SUDPLAN's user interface shall be easy to remember.

Rationale: SUDPLAN users should be able to readily remember how to use the user interface.

Source: PR: ORCHESTRA, 2007; LT: Preece et al, 2007

Explanation: SUDPLAN users should be able to recall how to perform fundamental tasks even when they use the system only occasionally.

REQ-USR-1.1.7: Transparency

SUDPLAN shall present a transparent user interface.

Rationale: SUDPLAN users should not need to have technical knowledge outside of their domain.

Source: PR: ORCHESTRA, 2007

Explanation: Users should be able to focus on their specialized task without having to gain expertise in other domains. For example, analysts should not have to learn how to configure models, modellers should not have to learn to perform system maintenance tasks, and system managers should not have to learn about the environmental management domain.

~~REQ-USR-1.2: Automation~~

SUDPLAN users will often benefit from the automation of tasks.

~~REQ-USR-1.2.1: Recurring task automation~~

SUDPLAN shall allow automation of recurring tasks wherever possible.

Rationale: In SUDPLAN application analysis and management there will be tasks which must be performed repeatedly. Allowing the users to automate such tasks will greatly enhance ultimate productivity.

Source: ~~CL/DoW: REQ-DOW-3.3: Provide automation of model runs, analysis and reporting, PI: REQ.SCENMGMT.002 (B.2), PI: REQ.SCENMGMT.015 (B.2)~~

Explanation: There is no requirement from the pilots for automation. SUDPLAN model services are so complex and time consuming that the user will invoke them one by one.

~~REQ-USR-1.2.2: Recurring task configuration~~

SUDPLAN shall allow users to configure tasks which are to be executed on a recurring basis.

Rationale: Recurring tasks will generally require configuration of input data, parameters, and other variables.

Source: ~~CL/DoW: REQ-DOW-3.3: Provide automation of model runs, analysis and reporting, PI: REQ.SCENMGMT.002 (B.2), PI: REQ.SCENMGMT.015 (B.2~~)

Explanation: There is no requirement from the pilots for automation. SUDPLAN model services are so complex and time consuming that the user will invoke them one by one.

REQ-USR-1.3: Profiling

Profiles are groups of option or setting values chosen by users to personalize their interaction.

REQ-USR-1.3.1: Profiling of the user interface

SUDPLAN shall support the development and maintenance of user interface profiles for different users.

Rationale: User interfaces generally allow configuration by users to suit their needs or preferences. Keeping these configurations in a profile prevents any given user from having to reconfigure the application each time they use it.

Source: LT: Sundar and Marathe, 2010

Explanation: To maximize productivity and user satisfaction, user interfaces need to allow the user to customize the interface to suit their preferences. This can include features of the graphical user interface (such as display space arrangement) as well as non-graphical features (such as the employment of automated search paths). In both cases the users' experience is substantially improved when their adjustments persist from session to session and they don't have to repeatedly establish their preferences.

REQ-USR-1.3.2: Establishment of user groups

SUDPLAN shall support establishment of user groups with shared profiles.

Rationale: Some aspects of the user interface configuration may be associated with categories of users rather than individual users.

Source: LT: Sundar & Marathe, 2010

Explanation: There are often features of a configurable user interface which may be generalized to categories of users. Allowing users to establish such categories and then define configuration profiles for them can simplify interactions by occasional or intermittent users of the system. For example, while different individuals may perform certain system management tasks, they may all benefit from the same choices of graphical user interface arrangement.

~~REQ-USR-1.3.3: Profiling of automation tasks~~

SUDPLAN shall support the development and maintenance of automation task profiles.

Rationale: Automatically recurring task configurations should be stored in a profile to allow users to re-establish similar task executions without having to completely re-enter configuration information.

Source: PI: REQ.SCENMGMT.002 (B.2)

Explanation: REQ-USR-1.2.1: Recurring task automation became obsolete.

REQ-USR-1.3.4: Profiling of business processes

SUDPLAN shall support profiling of business processes for different users and user groups.

Rationale: SUDPLAN applications will often require combinations of information and services requested from diverse sources, and these request transactions will need to be configured. Saving of request transaction profiles will help users and user groups to streamline their analyses by avoiding extensive reconfiguration.

Source: PI: REQ.TRACE.001 (B.6)

Explanation: When a user requires a combination of information and services they will often have to configure that combination by providing such input as request information and authentication data. Allowing users (and groups of users) to save profiles can significantly simplify repeated requests. This is similar to the "keychain" concept in which users can have user identification and authentication information saved on their computer so that applications can automatically log them into frequently used services.

REQ-USR-2: Specific Requirements of Analysts

These requirements are unique to SUDPLAN analysts, i.e. those people who will directly use SUDPLAN applications to carry out analyses which will support decision making either by themselves or by others.

REQ-USR-2.1: Information management

SUDPLAN applications are information rich in that they depend heavily on extensive and complex input data, and produce output data which must be made accessible to multiple consumers. Therefore, analysts will require support in managing their various and disparate information sources.

REQ-USR-2.1.1: Information source management

SUDPLAN shall allow users to manage their information sources easily.

Rationale: An information-intensive application must facilitate the finding, storing, and utilization of information within the application in order to support user success and satisfaction.

Source: PI: REQ.SCENMGMT.005, REQ.SCENMGMT.006 (B.2)

Explanation: SUDPLAN related information can be of nearly any type. Analysts will need to be able to find and use this information easily in order to successfully employ the SUDPLAN applications to support decision-making. To a large extent the quality of decisions can be related to the quality and completeness of the information behind them. Effective management of information is therefore directly related to the quality of decisions made.

REQ-USR-2.1.2: Management of related knowledge

SUDPLAN shall support users in the management of information related to their activities.

Rationale: Besides actual input data, there may be other information valuable to the analyst, and this information needs to be readily accessible to the users.

Source: PI: REQ.SCENMGMT.005 (B.2)

Explanation: In the analysis and decision making process users will often avail themselves of other information related to the problem at hand. For example, photographic or video data may help to provide a context for their analysis, even if these data are not directly supplied to the tools integrated into a SUDPLAN application. Support for the management, manipulation, and use of such supplemental information will greatly facilitate efficient, high-quality decision-making.

REQ-USR-2.1.3: Distributed information sources

SUDPLAN shall allow users to find and utilize information sources distributed globally via the Internet.

Rationale: SUDPLAN applications will often rely on data from multiple external sources.

Source: CL/DoW: REQ-DOW-2.4: Allow discovery of relevant sources; PI: REQ.SCENMGMT.009 (B.2)

Explanation: One major element of a web-based system is the ability to find and utilize data from other sources using the Internet as the communication vehicle. This significantly enhances the power of the applications because it supports analyses using data not directly under the control of the analyst.

REQ-USR-2.1.4: Output data management

SUDPLAN shall allow users to manage the results of analysis easily.

Rationale: SUDPLAN applications will produce results in a wide variety of forms. These data need to be easily accessible to and manipulated by the analysts.

Source: PI: REQ.SCENMGMT.005 (B.2), REQ.COMMSERV.002 (B.3)

Explanation: Given the wide scope of anticipated SUDPLAN applications, as well as the complexity and variety of analytical results that may be produced, it is essential to support users in the capture and management of these results.

REQ-USR-2.1.5: Result processing management

SUDPLAN shall support processing of the results of users' analyses.

Rationale: Given the complexity of SUDPLAN applications, output data resulting from primary analytical techniques may need to be post-processed by the user, and system support for these activities is necessary.

Source: PI: REQ.SCENMGMT.007, ~~REQ.SCENMGMT.011~~, REQ.SCENMGMT.014 (B.2)

Explanation: The output data from SUDPLAN application models and tools will often require further processing (e.g. statistical analysis). The analysts require support in their efforts to process these data so that the overall analysis is efficient and of a high quality.

REQ-USR-2.1.6: Information product management

SUDPLAN shall support the management of information products.

Rationale: Information products produced by analysts must be stored and managed in an organized and accessible fashion.

Source: SW

Explanation: Information products could include such entities as reports, web pages, videos, and still images. In order to manage these efficiently, SUDPLAN needs to facilitate the process by providing access to the necessary tools supporting storage, searching, and recovery.

REQ-USR-2.1.7: Coordinate conversion

SUDPLAN shall support spatial reference system conversion.

Rationale: Information products produced throughout the platform must be easily convertible to other spatial reference systems.

Source: REQ.SCENMGMT.014

Explanation: The SUDPLAN platform shall provide the necessary functionality (possible through external service) for reference system conversion.
In particular, the SMS should allow loading and showing maps in the coordinate reference system preferred the user.

REQ-USR-2.1.8: Tracing

SUDPLAN shall support tracing of user actions.

Rationale: SUDPLAN shall provide support the tracing of user and system component interactions

Source: REQ.TRACE.001

Explanation: The instructions sent by Scenario Management System to the Common Services shall be stored for later reference to a location controlled by the SMS (tracing of all performed operations) to be able to reconstruct information that was the basis for a decision.

REQ-USR-2.1.9: Input data management and import

SUDPLAN shall allow users to manage the results of analysis easily.

Rationale: Models will need input data in a wide variety of formats. These data need to be easily accessible by the model and to be provided by the analysts.

Source: PI: REQ.SCENMGMT.003, REQ.SCENMGMT.005, REQ.SCENMGMT.006, REQ.SCENMGMT.007

Explanation: It is essential to support the analyst in the upload and management of additional model input data in different formats (XLS, CSV, NetCDF, …), e.g. local time series for the calibration of CS.

REQ-USR-2.2: Interactivity

SUDPLAN applications are intended to be interactive in the sense that the users of the applications can manipulate features and produce a change in the performance and/or functionality of the system.

REQ-USR-2.2.1: General interactivity requirements

The SUDPLAN user interface shall be highly interactive.

Rationale: SUDPLAN needs to support and encourage analysts who want to interact with the system by including design features which facilitate manipulation of elements of the modelled system (e.g. parameters, variables, and input data).

Source: CL/DoW: REQ-DOW-10.2: Provide interaction framework; PI: REQ.SCENMGMT.003 (B.2)

Explanation: The SUDPLAN user interface must provide the means by which users can change conditions, such as data values or the location of geographical objects, through direct manipulation (e.g. using input devices such as a mouse and keyboard).

REQ-USR-2.2.2: Responsiveness

Where feasible, the SUDPLAN user interface shall respond immediately to changes in parameters.

Rationale: When the analyst has manipulated an input to the modelling system, the system needs to provide an immediate response to this change in situations where that makes sense and is possible.

Source: PI: REQ.SCENMGMT.003 (B.2)

Explanation: For some modelling processes, input parameters and variables can have a direct effect on the results of the models. In situations where it is appropriate for a user to expect to be able to change the path of the model immediately, providing this possibility increases the interactivity of the system and encourages the analyst to experiment with alternative scenarios.

REQ-USR-2.2.3: Local data copy

Where feasible, the SUDPLAN system shall pre-fetch and cache data.

Rationale: Pre-fetching and caching data locally (on users' computers or on a fast LAN) can greatly improve the users' experience of interactive exploration of the data.

Source: PI: REQ.SCENMGMT.003 (B.2)

Explanation: "Interesting" data sets are often too large to allow online interactive exploration. However, the system can often predict which data will be required and pre-fetch it in advance. In particular, whenever the user has to schedule the model execution and wait for notification that the results are ready the system will have enough time to pre-fetch the data.

REQ-USR-2.2.4: Differential data download

Where feasible, the SUDPLAN system shall download only the part of the data that actually changed since the last request.

Rationale: Repeated fetching of data over a network is slow and inefficient.

Source: PI: REQ.SCENMGMT.003 (B.2)

Explanation: Many data sources contain data that only infrequently change. For example, an environmental monitoring System typically contains 10-20 years of archived measurements, a relatively modest amount of "live" measurements (e.g. once per hour from each station), and occasional quality assurance related updates for recently archived data (e.g. 1% of the data may change up to 1 week after the observation). Fetching of "changes only" in combination with pre-fetching and caching can therefore greatly improve the system responsiveness.

REQ-USR-2.3: Model management

SUDPLAN analysts will be using and interacting with models, and will therefore need to perform certain management functions associated with those models.

REQ-USR-2.3.1: Initial and boundary conditions

SUDPLAN shall support users in choosing initial and boundary conditions.

Rationale: Mathematical models generally require parameters describing initial and boundary conditions as constraints for internal variables in the model. It is essential that users be permitted, and assisted where possible, in choosing and establishing those conditions.

Source: PI: REQ.SCENMGMT.001, REQ.SCENMGMT.004 (B.2)

Explanation: Users need to be able to choose the necessary parameters for their models. But this choice can often be complicated and require more technical knowledge than a user might have. Therefore, in addition to allowing the user to choose these parameters, when practical SUDPLAN should provide assistance, such as by preventing inappropriate combinations of parameter values.

REQ-USR-2.3.2: Condition sets

SUDPLAN shall support users in storing, managing and re-using sets of conditions.

Rationale: Particular combinations of initial and boundary condition parameters can be stored as a set, and then reused in subsequent model runs.

Source: PI: REQ.SCENMGMT.004 (B.2)

Explanation: Depending on the number and complexity of models involved in an analysis the number of initial and boundary condition parameters can be quite large. Allowing the user to store certain combinations of these will facilitate their re-use in future modelling runs, and will also permit small changes for new runs that are similar to previous ones.

REQ-USR-2.3.3: Synchronous model execution

SUDPLAN shall support end users executing models synchronously.

Rationale: Models which generally run to completion quickly can be run by users who choose to wait for completion.

Source: PI: REQ.SCENMGMT.001 (B.2)

Explanation: The simplest form of model execution applies to models which can run to completion in a short enough time that the user chooses to wait for completion before undertaking any other interactions with the SUDPLAN application.

REQ-USR-2.3.4: Asynchronous model execution

SUDPLAN shall support users executing models asynchronously.

Rationale: Since some models will take considerable time to complete, users may choose to run these models asynchronously.

Source: PI: REQ.SCENMGMT.002 (B.2)

Explanation: This will allow the users to initiate the execution of the model “in the background” so that they can continue to interact with the SUDPLAN application while the model is executing.

~~REQ-USR-2.3.5: Model set execution~~

~~*SUDPLAN shall permit users to instantiate repeated executions of models with a variation of conditions.*~~

~~Rationale: Extending the concept of asynchronous model execution, users can run multiple instances of the same model combination with varying sets of parameters, producing a “family” of results.~~

~~Source: PI: REQ.SCENMGMT.002 (B.2)~~

Explanation: Requirement became obsolete; there are no requirements from the pilots for automation.

REQ-USR-2.3.6: Pre-calculated model execution

SUDPLAN shall support users performing and/or using pre-calculated model executions.

Rationale: For computationally intensive models limiting the number of times the model has to be executed, and using stored results from previous runs, can help model combinations which use these results to execute in a timely fashion, and can also reduce redundant use of computational resources.

Source: LT: Valsala & Maksyutov 2008

Explanation: There are models which take a considerable length of time to run to completion, but whose results may not depend on variations of parameters between scenarios. For example, a complex hydrodynamic model can be executed once for each of its "interesting" parameter sets, with the results stored to be used in subsequent combinations of pollution transport models.

REQ-USR-2.3.7: Model status

SUDPLAN shall allow users to monitor model execution progress and shall notify users of changes in model status.

Rationale: Computationally intensive models can take considerable time to execute, and during their execution analysts will need to be able to check their status and learn if a run has completed, failed, etc.

Source: PI: REQ.COMMSERV.001 (B.3), REQ.NOTIF.001 (B.5)

Explanation: During a model's execution events can occur which will be of interest to the analyst (e.g. completion of the run, failure, need for input). The analyst will also need to be able to check the progress of a model run in order to plan their actions efficiently.

REQ-USR-2.4: Scenarios

SUDPLAN analysts will often choose to analyse a given situation under varying scenarios by using varying parameter values and/or varying choices of models.

REQ-USR-2.4.1: Establishing scenarios

SUDPLAN shall allow users to define scenarios as combinations of models and parameter sets.

Rationale: Users need to be able to specify the values for parameters within a scenario (including initial and boundary conditions), as well as the particular models to be included for each scenario.

Source: PI: REQ.SCENMGMT.003 (B.2)

Explanation: Scenarios represent different modelling conditions for a given problem and are generally intended to support "what if" analyses. Scenarios differ from one another primarily in the values chosen for their parameters (including but not limited to initial and boundary conditions). However, in some cases the choice of model to be used might also be a variable between scenarios.

REQ-USR-2.4.2: Provide tools for the management of scenarios

SUDPLAN shall support the management of user-defined scenarios.

Rationale: As users define scenarios, they will need to be able to manage them.

Source: PI: REQ.SCENMGMT.004 (B.2), CL/DoW: REQ-DOW-2.6: Provide tools for the management of scenarios

Explanation: Before coming to a decision different scenarios and there implications have to be compared Scenario sets can be quite complex, consisting of many parameters (with varying values) and perhaps several models (depending on assumptions underlying the scenarios). Users need to be able to keep track of their scenarios, store information helping them to distinguish them, and find them for future analyses.

REQ-USR-2.5: Visualization

Both measurement and modelling data will be explored by SUDPLAN analysts, who will therefore need a data visualization capability.

REQ-USR-2.5.1: 3D/4D visualization

SUDPLAN shall support the visualization of 3D/4D phenomena.

Rationale: SUDPLAN analysts need to carry out exploratory data analysis on 3- and 4-dimensional data sets (e.g. air quality), and therefore need visualization support for these data.

Source: CL/DoW: REQ-DOW-10.1: Provide 3D/4D visualisation framework, REQ-DOW-3.2: Provide highly integrated and interactive 3D / 4D; PI: REQ.VISUAL.001 (B.4.1)

Explanation: SUDPLAN applications naturally deal with 3-dimensional data (i.e. 3 spatial dimensions or 2 spatial and 1 temporal dimension). In some instances they will deal with 4-dimensional data (3 spatial and 1 temporal). Visualization support for these data sets is an essential element of SUDPLAN.

In particular, the SMS shall offer to possibility to import 3D/4D data from ESRI Shapefiles or from a web service (e.g. WFS) and to visualise the following types of the 3D/4D data:

- 3D building data, whereby buildings should be represented as 2D floor plans with (at least) an accompanying height attribute.
- Road link airquality data, which should be represented as line elements with air quality values as attributes using a predefined colour scale for each pollutant.
- Gridded data (2D and 3D), whereby standard gridded 2D data (e.g. airquality results) should be visualised above a building 3D map.

REQ-USR-2.5.2: Spatial visualization

SUDPLAN shall support visualization based on geo-spatial paradigms.

Rationale: Environmental data are very often spatial in nature, and therefore require geo-spatial visualization techniques.

Source: PI: REQ.VISUAL.001 (B.4.1); PI: REQ.VISUAL.007 (B.4.1)

Explanation: Environmental data sets often include 2-dimensional data, typically in the plane of the Earth, but sometimes involving altitude or depth. In many cases 3-dimensional spatial data sets are involved, requiring the use of “2.5D” or sometimes true 3D displays.

In particular, the users should have the possibility to use their own local maps and their preferred coordinate reference system. Local maps can for example be served by a WMS.

REQ-USR-2.5.3: Temporal visualization

SUDPLAN shall support visualization of time-based phenomena.

Rationale: Environmental phenomena are dynamic in nature, and therefore often require the use of visualization techniques representing the variation of one or more variables as a function of time.

Source: PI: REQ.VISUAL.002 (B.4.1), REQ.VISUAL.003 (B.4.2)

Explanation: Environmental models often deal with the progression of a system with time, and therefore produce data sets which are a function of time. SUDPLAN applications need to be able to represent this temporal component.

REQ-USR-2.5.4: Spatio-temporal visualization

SUDPLAN shall support visualization of phenomena varying in both time and space.

Rationale: More complex environmental data sets vary in both time and space.

Source: PI: REQ.VISUAL.002 (B.4.1), REQ.VISUAL.003 (B.4.2)

Explanation: In general, environmental phenomena vary in both time and space, and therefore visualization schemes which can accommodate both the spatial (in 2 or 3 dimensions) and temporal components will often be necessary.
In particular, it shall be possible to switch between different phenomena (e.g. individual pollutants) and step forward/backward in time.

REQ-USR-2.5.5: Visualization of a model run result

SUDPLAN shall support the visualization of an individual model run.

Rationale: Many SUDPLAN modelling runs will generate spatial and/or temporal data which need to be visualized to be interpreted by the analyst.

Source: PI: REQ.VISUAL.002 (B.4.1)

Explanation: Even a single run of a single model combination can produce rich and complex data which need to be represented visually to be explored by the analyst.
In particular, the SMS should be able visualise coloured 2D grids over grey tone maps whereby the user should be able to edit the individual colour scales for attributes (e.g. pollutants).

REQ-USR-2.5.6: Comparison of model run results

SUDPLAN shall support the visual comparison of multiple model runs.

Rationale: Analysis of the results from multiple comparable model runs (such as under different scenarios) requires the ability to simultaneously represent model results visually.

Source: CL/DoW: REQ-DOW-5.5: Provide tools to compare scenarios; PI: REQ.VISUAL.005 (B.4.2)

Explanation: Very often the results of a modelling scenario are only interesting in comparison to the results from a different one (or from measured conditions). Therefore, it is necessary to be able to visualize the results of multiple model runs for the purposes of comparison by the analyst.
In particular, it should be possible to compare different properties (e.g. pollutants) of a model result and to perform some simple mathematical operations on one or multiple result grids (e.g. difference between two yearly average grids).

REQ-USR-2.5.7: Visualization of model input

SUDPLAN shall support the visualization of model input and configuration data.

Rationale: Many SUDPLAN modelling runs will require spatial and/or temporal data as input which need to be visualized and selected by the analyst.

Source: PI: REQ.VISUAL.008 (B.4.1)

Explanation: Explanation: Visualisation of model input and configuration data may be necessary to gain an overview on the model or to perform a selection of a set of input values, especially if different model versions (or configurations) to choose from exist in the system.

REQ-USR-2.6: Result documentation/annotation

When a model run has been completed SUDPLAN analysts will generally wish to store these results for further consideration. In order to organize, search for, and recover these it will be necessary for analysts to document the nature of such results with user-supplied annotations.

REQ-USR-2.6.1: Documentation of a model run

SUDPLAN shall support the documentation of an individual model run.

Rationale: The results of each model run need to be annotated before being stored in order to facilitate search, recovery, comparison and interpretation.

Source: PI: REQ.SCENMGMT.004, REQ.SCENMGMT.008 (B.2), REQ.SCENMGMT.016

Explanation: When storing the results of a model run, analysts will want to store their notes about that particular run along with the results in order to help them search for and interpret the results in the future.

REQ-USR-2.6.2: Documentation of scenario set execution

SUDPLAN shall support the documentation of a scenario set execution

Rationale: In addition to storing annotations about individual model runs, analysts will need to annotate scenario sets as well.

Source: PI: REQ.SCENMGMT.004, REQ.SCENMGMT.008 (B.2)

Explanation: Scenario sets, consisting of multiple model executions (with varying scenarios) can also be annotated by the analyst so that they can be readily found for later evaluation and analysis.

REQ-USR-2.7: Information products

While result documentation allows an analyst to make notes about results that will be useful to themselves, information products provide a vehicle for them to communicate the results of their analyses to others.

REQ-USR-2.7.1: Creation of information products

SUDPLAN shall support the users' efforts to produce accessible information products from the results of their analyses.

Rationale: The value of an analysis can be greatly enhanced by producing information products which contain or reflect the results but which are also accessible to other stakeholders. Analysts will require system support to help them generate such information products.

Source: CL/DoW: REQ-DOW-10.3: Provide tools to create customizable presentation material; SW

Explanation: Some stakeholders of SUDPLAN applications – including some decision makers – will not be directly using the system but will instead rely on analysts to provide them with the results of their analyses in a form which they can understand. Such information products could include such entities as reports, web pages, videos, and still images. In

order to produce these efficiently, SUDPLAN needs to facilitate the process by providing access to the necessary tools.

REQ-USR-2.7.2: Report generation

SUDPLAN shall support the generation of reports.

Rationale: Basic reports making the results of scenario execution accessible to non-analysts are necessary in order to communicate the results to the other stakeholders of the SUDPLAN application.

Source: CL/DoW: REQ-DOW-10.3: Provide tools to create customizable presentation material; SW

Explanation: Raw results of model or scenario set execution may not be readily interpreted by all stakeholders of a given SUDPLAN application. Therefore, a basic report generation capability is needed to allow the analyst to present results to these stakeholders in a way which is more meaningful to them.

REQ-USR-2.7.3: Export

SUDPLAN shall support the export of its artefacts to external formats.

Rationale: In order to support the generation of information products beyond basic reports, the analyst will need to be able to export artefacts (such as model execution results or visualized data) to other formats so that they can use tools outside of SUDPLAN to develop more information products.

Source: CL/DoW: REQ-DOW-10.4: Provide support of different output devices; PI: REQ.SCENMGMT.008, REQ.SCENMGMT.010, REQ.SCENMGMT.012, REQ.SCENMGMT.014 (B.2)

Explanation: The SUDPLAN application analyst may wish to generate more sophisticated information products than basic reports. For example, they may wish to prepare a slide show, video, or web site to better communicate with the application stakeholders. In order to use tools outside of SUDPLAN to develop such products, they will need to be able to export their artefacts in formats which can be imported by such tools.

REQ-USR-2.8: Sharing

Multiple analysts might be working on the same or related applications and wish to share components of their analyses with one another.

REQ-USR-2.8.1: Information sharing

SUDPLAN shall support the sharing of information among different users.

Rationale: Information regarding a SUDPLAN application, including but not limited to input data, should be readily shared between consenting analysts to facilitate collaboration and efficiency.

Source: SW

Explanation: Multiple analysts working on the same or related applications can benefit from each other's efforts by sharing input data and other information that can support their analyses.

REQ-USR-2.8.2: Result sharing

SUDPLAN shall support the sharing of results among different users.

Rationale: The results of model and scenario set execution can be useful for analysts working on the same or related applications, and should be readily shared along with their documentation annotations.

Source: PI: REQ.SCENMGMT.010 (B.2)

Explanation: Multiple analysts might be able to use the same results, or might need to have access to the same results in order to collaborate on an analysis.

REQ-USR-2.8.3: Information product sharing

SUDPLAN shall support the sharing of information products among different users.

Rationale: Multiple analysts might be producing similar information products to communicate their results. Sharing of these products encourages efficiency and consistency.

Source: SW

Explanation: When an analyst has produced an information product to communicate analytical results to SUDPLAN application stakeholders, the effort that went into the production of that product might benefit another analyst who needs to produce a similar product.

~~REQ-USR-2.8.4: Automation sharing~~

~~***SUDPLAN shall support the sharing of automation tasks among different users.***~~

~~Rationale: The configuration of automation tasks can become complex for some complicated modelling systems. Sharing these configurations for re-use brings increased efficiency and quality control.~~

~~Source: CL/DoW: REQ-DOW-3.3: Provide automation of model runs, analysis and reporting, SW, PI: REQ.SCENMGMT.015 (B.2)~~

~~Explanation: This requirement is obsolete. There is no requirement from the pilots for automation.~~

REQ-USR-2.8.5: Annotation sharing

SUDPLAN shall support the sharing of annotations among users.

Rationale: sharing of annotations among analysts working on the same data sets can increase their efficiency and support additional quality control.

Source: SW

Explanation: The users' annotation of data could contain information that is very valuable for other users, and not available elsewhere (e.g. "this model delivers obviously wrong results for certain combination of parameters", or "the results delivered by model A with this set of parameters closely resemble model B with another set of parameters").

REQ-USR-2.9: Publishing

In order to support broader sharing of environmental services and data which might result from SUDPLAN applications, analysts must be able to publish their artefacts to the Internet.

REQ-USR-2.9.1: Information publishing

SUDPLAN shall support the publishing of its artefacts for use of other services.

Rationale: SUDPLAN analysts may wish to make their data and other information available to other web-based services, and therefore need a mechanism for publishing this information to the Internet.

Source: CL/DoW: REQ-DOW-10.3: Provide tools to create customizable presentation material

Explanation: To be accessible to other web-based services, SUDPLAN application data and other information has to be made available to those services using standard approaches. SUDPLAN needs to facilitate the sharing of information in this way.

REQ-USR-2.9.2: Web publishing

SUDPLAN shall support the publishing of its artefacts as web content.

Rationale: Other SUDPLAN application information, such as visualizations and information products, may also be shared with others as web content in order to enhance the value added by the application analyses.

Source: CL/DoW: REQ-DOW-2.9: Publish results to the WWW

Explanation: Making the results of SUDPLAN application analyses available via the web may in some cases be the most efficient way to communicate with stakeholders, especially when the stakeholders are members of the general public. Facilitating the publishing of results, reports, and/or information products in this way will be very beneficial for this purpose.

REQ-USR-2.9.3: Web publishing standards

SUDPLAN shall use standards for the publishing of information content.

Rationale: Adherence to standards will increase the availability of SUDPLAN application information to the wider community.

Source: CL/DoW: REQ-DOW-2.1: Use open standards

Explanation: Taking advantage of the standardization activities of the recent past (such as OGC WMS, WCS, WFS and SOS) will increase the likelihood that individuals or projects who could benefit from SUDPLAN application information will be successful in accessing this information.

REQ-USR-3: Specific Requirements of Modellers

These requirements are unique to SUDPLAN modellers, i.e. those people who will support SUDPLAN applications by developing and/or configuring the models to be used by SUDPLAN analysts.

REQ-USR-3.1: Model management

Modellers will need to integrate models as well as configure individual models and modelling chains.

REQ-USR-3.1.1: Model integration

SUDPLAN shall support modellers in integrating their models into a SUDPLAN application.

Rationale: Integrating models into a SUDPLAN application, possibly with other models, means that the modeller needs to be able to specify the role of the model(s) within the application and to make the necessary connections between the model(s) and other components of the application.

Source: CL/DoW: REQ-DOW-8.1: Provide models using SOA; LT: Frysinger, 2002

Explanation: Connectivity between models and other components of a SUDPLAN application needs to be accessible by SUDPLAN modellers so that they can incorporate new or enhanced models without undertaking a completely new development of the application.

REQ-USR-3.1.2: Model configuration

SUDPLAN shall support modellers in the configuration of models for analysts.

Rationale: Modellers need to be able to configure models by specifying those data which are necessary for the model but which will not be under the control of the analyst.

Source: CL/DoW: REQ-DOW-5.4: Provide input for local models; LT: Frysinger, 2002

Explanation: Depending on the application context, a given model may need to have certain configuration information adjusted by a modeller familiar with the details of the model. This can include such things as permissible parameter ranges and paths to fixed input data.

REQ-USR-3.1.3: Supplemental model result calculations

SUDPLAN shall support modellers to perform supplemental calculations on models results directly from within the SMS.

Rationale: Modellers need to be able to perform supplemental (simple) calculations on raw models results in order to prepare proper result visualisation and decision support for analysts.

Source: PI: REQ.SCENMGMT.013

Explanation: Depending on the purpose of the model and the usage scenario, supplemented calculations (e.g. compute average values, calculate efficiency rates, etc.) have to be performed on the model results, before it can be used by an analyst to take decisions.

REQ-USR-3.2: Model calibration and validation

Models must be calibrated by adjusting their fixed parameters in order to best fit examples of measurement data. They must also be validated by comparing model results to other examples of measurement data. In some SUDPLAN applications sufficient data may be available to allow this to be accomplished within the application.

REQ-USR-3.2.1: Model calibration

SUDPLAN shall support modellers in calibrating their models within a SUDPLAN application.

Rationale: If a SUDPLAN application provides access to sufficient measurement data, it may be desirable to calibrate the model(s) used within the application to those data.

Source: LT: Frysinger, 2002

Explanation: By calibrating the SUDPLAN application's models to data from that application it may be possible to improve the quality of the model results

REQ-USR-3.2.2: Model validation

SUDPLAN shall support modellers in validating their models within a SUDPLAN application.

Rationale: If a SUDPLAN application has access to sufficient measurement data, using these data to validate the model(s) can increase confidence in the results of the model(s) within the context of the application.

Source: LT: Frysinger, 2002

Explanation: Models validated using data specific to the SUDPLAN application may have more credibility than models validated using data from other contexts, thus improving the overall confidence in the results of the analysis.

REQ-USR-3.2.3: Model versions

SUDPLAN shall support management of different versions of models within a SUDPLAN application.

Rationale: If different versions of a model are available within a SUDPLAN application it is necessary for these versions to be managed in such a way that analysts can distinguish their features and employ the correct version for their needs.

Source: SW; PI: REQ.VISUAL.008 (B.4.1)

Explanation: Modellers might make different versions of a particular model available because of the nature of the model and the potential needs of applications. Analysts will need to be able use the correct version to carry out their analysis. Therefore, SUDPLAN needs to provide support for the maintenance and deployment of multiple versions of a given model.

REQ-USR-4: Specific Requirements of System Managers

These requirements are unique to SUDPLAN system managers, i.e. those people who will support SUDPLAN applications by installing and/or configuring the software to be used by SUDPLAN analysts.

REQ-USR-4.1: Platform management

A key role of SUDPLAN system managers is the control of accessibility to information and tools within the application.

REQ-USR-4.1.1: User management

SUDPLAN shall support system managers in managing users.

Rationale: In order to manage access to a SUDPLAN application the system manager needs to be able to specify users and groups of users to the system.

Source: CL/DoW: REQ-DOW-2.8: Provide a security system; PR: ORCHESTRA 2007; PI: REQ.SEC.001, REQ.SEC.002 (B.1)

Explanation: Application users' access authorization will generally depend on who they are, so it is necessary to allow system managers to identify users of the system.

REQ-USR-4.1.2: Security and rights management

SUDPLAN shall support system managers in managing system security and access rights.

Rationale: System managers need to be able to specify which users are authorized to have what level of access to which parts of the application.

Source: CL/DoW: REQ-DOW-2.8: Provide a security system; PR: ORCHESTRA 2007; PI: REQ.SEC.001, REQ.SEC.002 (B.1)

Explanation: Certain users may have authorization to access or change resources that other users do not. The system manager needs be able to specify these privileges on either a user by user basis or on the basis of user groups.

REQ-USR-4.2: Integration

A SUDPLAN application generally involves the integration of models, data, sensors, and other services. While the integration of models is the domain of SUDPLAN modellers, integration of the others falls to the SUDPLAN system manager.

REQ-USR-4.2.1: Data source integration

SUDPLAN shall support system managers in integrating data sources.

Rationale: A SUDPLAN application may use data from a variety of sources. The system manager needs to be able to integrate these data sources into the application for the system analyst.

Source: CL/DoW: REQ-DOW-2.5: Allow integration of standards-based services

Explanation: Data for a SUDPLAN application could be stored locally, or might be acquired from various web-enabled sources. SUDPLAN application analysts may require the assistance of the system manager in arranging the required connectivity to the data sources.

REQ-USR-4.2.2: Sensor service integration

SUDPLAN shall support system managers in integrating sensor services.

Rationale: SUDPLAN applications may use sensor services that are either local to the application or that are distributed and accessible via the web. Sensor services may provide besides access to measured data (e.g. time series) also event notifications (e.g. overflow events).

Source: CL/DoW: REQ-DOW-2.5: Allow integration of standards-based services; PR: SANY 2009; PI: REQ.NOTIF.002

Explanation: Sensor services used by SUDPLAN applications may need to be integrated into the application and configured by the system manager.

REQ-USR-4.2.3: Service integration

SUDPLAN shall support system managers in integrating arbitrary services.

Rationale: SUDPLAN applications may use other non-modelling services that are either local to the application or that are distributed and accessible via the web.

Source: CL/DoW: REQ-DOW-2.5: Allow integration of standards-based services; PR: ORCHESTRA 2007

Explanation: Services used by SUDPLAN applications may need to be integrated into the application and configured by the system manager.

REQ-TEC: Technical Requirements

This section will elaborate technical requirements that fall upon the software within the SUDPLAN platform.

REQ-TEC-1: General design properties

The general design of SUDPLAN inherits properties from best practices from various sources.

REQ-TEC-1.1: General platform requirements

The SUDPLAN platform is based on an architecture meeting particular standards.

REQ-TEC-1.1.1: Openness

SUDPLAN shall employ an open architecture to the maximum extent practicable. SUDPLAN shall define and publish interfaces to access SUDPLAN (in order to access results or to invoke services), which are based on open standards.

Rationale: This will allow other systems to use data and services provided by SUDPLAN. Openness is necessary to overcome fundamental problems such as integration of data, services and applications.

Source: PR: ORCHESTRA, 2007; CL/DoW: REQ-DOW-2.1: Use open standards, REQ-DOW-2.2: Publish interfaces, REQ-DOW-2.5: Allow integration of standards-based services

Explanation: The SUDPLAN platform should be vendor-neutral, publicly available, and free of charge.

REQ-TEC-1.1.2: Scalability

SUDPLAN shall be scalable.

Rationale: SUDPLAN needs to continue to function well as the size of applications increases.

Source: PR: ORCHESTRA, 2007

Explanation: Successive SUDPLAN applications could grow – for example in the number and size of data sources, the number of collaborating services, and the number of concurrent users. The system needs to be robust under such growth conditions.

REQ-TEC-1.1.3: Accountability

SUDPLAN shall incorporate elements and functions which can account for their characteristics and behaviours.

Rationale: Development and use of correct SUDPLAN applications requires that the elements utilized are correctly understood by all users, and that these elements can account for their behaviours (such as access permission).

Source: PR: ORCHESTRA, 2007; PI: REQ.TRACE.001 (B.6)

Explanation: Data should be accompanied by meta-information, and models should account for their associated conceptual model (especially system definitions and assumptions). When discrete elements (data or functions) are integrated in any fashion, the characteristics of this integration (such as integrative assumptions) should also be self-explanatory. Components should also be able to report on access that was granted in order to ensure that only authorized access was permitted.

REQ-TEC-1.2: Platform design properties

The SUDPLAN platform adheres to relevant standards.

REQ-TEC-1.2.1: Use of standards and concepts

SUDPLAN shall make use of proven concepts and standards. SUDPLAN shall provide applications and tools for the integration and seamless access to data sources residing on a standard based infrastructure (like provided by SANY or ORCHESTRA).

Rationale: This will decrease dependence on vendor-specific solutions, help ensure the openness of the platform and support the evolutionary development process of SUDPLAN. The usage of open standards is needed to enable connections to other (existing and future) systems

Source: PR: ORCHESTRA, 2007; CL/DoW: REQ-DOW-2.1: Use open standards, REQ-DOW-2.5: Allow integration of standards-based services

Explanation: Standards which facilitate interoperability, information sharing, and loose coupling of distributed services have been developing and maturing in recent years, and should be employed where appropriate. There may be the need to access already existing city-local data and services which are not based on open standards. This should be done by providing standard based interfaces to this data storages and services.

REQ-TEC-1.2.2: Evolutionary development

SUDPLAN shall be designed to evolve, i.e. it shall be possible to develop and deploy the system in an evolutionary way.

Rationale: SUDPLAN should be able to cope with changes of user requirements, system requirements, organisational structures, information flows and information types in the source systems.

Source: PR: ORCHESTRA, 2007; SANY, 2009

Explanation: As a platform for future applications, SUDPLAN needs to remain flexible and be capable of evolving to meet the needs of future applications.

REQ-TEC-1.2.3: Generic infrastructure

SUDPLAN shall be independent of the application domain.

Rationale: SUDPLAN should be designed in such a flexible and adaptable way that the platform can be used across different thematic domains and in different organisational contexts, and so that the update of integrated components (e.g. applications, systems, ontologies) does not present unnecessary changes to the users of SUDPLAN.

Source: PR: ORCHESTRA, 2007; SANY, 2009

Explanation: The range of the anticipated application domains is so wide that only independence from it can ensure that SUDPLAN can progressively serve future applications.

REQ-TEC-1.2.4: Clear system structure

SUDPLAN shall use a clear system structure with clear interface definitions.

Rationale: As a platform for future applications, SUDPLAN's structure must be readily understood by developers of those applications.

Source: PR: ORCHESTRA, 2007; SANY, 2009

Explanation: In order for developers to base applications on the SUDPLAN platform efficiently, they must be able to understand the structure of the platform and in particular the interfaces within the platform that allow them to integrate components into the application.

REQ-TEC-2: Platform properties

SUDPLAN has particular properties that will help it to satisfy other requirements.

REQ-TEC-2.1: Web-based platform

The SUDPLAN platform is based on technologies making use of the World Wide Web (e.g. to integrate relevant resources (OGC-Services).

REQ-TEC-2.1.1: Web-based environment

The SUDPLAN platform shall be based on the World Wide Web.

Rationale: SUDPLAN applications are expected to require access to highly distributed data and services, necessitating a web-based approach.

Source: CL/DoW: REQ-DOW-2.9: Publish results to the WWW, REQ-DOW-3.4: Provide integration with SOA-based infrastructures

Explanation: Environmental data and computational services are produced and maintained by a wide variety of organizations and are often made accessible to others through Internet access. SUDPLAN therefore needs to be web-based in order to best take advantage of these data and services. Furthermore, SUDPLAN applications have to be able to expose their results using standardized web service interfaces so that 3rd parties can make use of them.

REQ-TEC-2.1.2: Service web

The SUDPLAN platform shall be able to use information from a loosely coupled web of services.

Rationale: The use of web-based services must be loosely coupled in order to maximize flexibility and minimize interdependence of services.

Source: PR: SANY, 2008; SANY, 2009

Explanation: Web-based services are to a great extent inherently loosely coupled, meaning that the services are independent of each other and their combination can be achieved without requiring internal modification of them. SUDPLAN should maintain this loose coupling in order to maximize flexibility of SUDPLAN applications and eliminate disruption of source services.

REQ-TEC-2.1.3: Use of web technologies

The SUDPLAN platform shall use open web technologies for its implementation.

Rationale: SUDPLAN's openness requirement dictates that open web technologies be employed in its implementation.

Source: PR: ORCHESTRA, 2007

Explanation: The extensive use of proprietary technologies would prevent the development of an open platform and would restrict future SUDPLAN applications.

REQ-TEC-2.2: Use of standards

The use of standards helps SUDPLAN maximize flexibility while fostering interoperability with 3rd party resources that are unknown during the design of the SUDPLAN platform.

REQ-TEC-2.2.1: Use of OGC standards

SUDPLAN shall use OGC standards for spatial elements where applicable.

Rationale: OGC standards facilitate access to and use of spatial data sets widely available via Internet access.

Source: CL/DoW: REQ-DOW-2.1: Use open standards; PR: ORCHESTRA, 2007; SANY, 2008; SANY, 2009

Explanation: Spatial data standards have greatly improved the ability of spatially enabled tools to make use of data generated and maintained by a wide variety of organizations, substantially reducing the cost of applications requiring these data.

REQ-TEC-2.2.2: Use of OASIS standards

SUDPLAN shall use OASIS standards for security and access control where applicable.

Rationale: Use of OASIS security and access control standards (such as specified in the Reference Architecture for Service-oriented Architectures) will help provide necessary controls while maintaining the required SUDPLAN openness.

Source: CL/DoW: REQ-DOW-2.1: Use open standards; PR: SANY, 2008; SANY, 2009

Explanation: OASIS provides standards capable of meeting most of SUDPLAN's security needs, and using these standards will help satisfy other requirements and reduce costs. Moreover OASIS security and access control standards are commonly used in the OGC context.

REQ-TEC-2.2.3: Use of W3C standards

SUDPLAN shall use W3C standards in the absence of OGC and OASIS standards.

Rationale: When OGC and OASIS standards do not apply, W3C standards shall be applied wherever possible.

Source: CL/DoW: REQ-DOW-2.1: Use open standards; PR: SANY, 2009

Explanation: The W3C has established comprehensive standards which facilitate interoperability in general, and the discovery and invocation of service oriented architecture in particular. Adherence to these standards will help SUDPLAN satisfy several of its other requirements, especially those of openness and loose coupling.

REQ-TEC-2.3: Security and access control

SUDPLAN must be able to restrict access to various resources based on the identity and privileges of users. And offer measures to assure a to be defined level of confidentiality.

REQ-TEC-2.3.1: Access Control

SUDPLAN shall provide applications and tools to implement security and access control as an integral part of the system.

Rationale: Some of the data and/or services employed by a SUDPLAN application may need to be protected from modification and/or viewing by unauthorized users. Beside the obvious reasons for security this comes also from the need for quality controlled repositories.

Source: CL/DoW: REQ-DOW-2.8: Provide a security system; PR: SANY, 2008; PI: REQ.SEC.001, REQ.SEC.002 (B.1)

Explanation: Some SUDPLAN applications will require the use of data for which access must be restricted because, for example, they include private information about citizens or the location of highly protected resources. Access to such information must be controlled and limited to authorised users.

REQ-TEC-2.3.2: Service independent security

SUDPLAN shall be able to incorporate mechanisms that ensure confidentiality and integrity independently of the services involved, and in a way which is orthogonal to the thematic context of the application.

Rationale: Loose coupling requires that the security provided by SUDPLAN not intrude on services employed and be independent of SUDPLAN application themes.

Source: PR: ORCHESTRA, 2007

Explanation: Security capabilities implemented within SUDPLAN must not depend on which particular services are used, and must not require changes to those services. Authentication and authorization need not depend on the application.

REQ-TEC-2.3.3: User management, authentication and authorization

SUDPLAN shall provide user management, authentication and authorization facilities.

Rationale: SUDPLAN system managers need to be able to create records for new users of SUDPLAN applications, to establish authentication credentials for them, and to define the resources they are authorized to access.

Source: CL/DoW: REQ-DOW-2.8: Provide a security system; PR: ORCHESTRA, 2007; PI: REQ.SEC.001, REQ.SEC.002 (B.1)

Explanation: Access control depends on the ability of system managers to configure SUDPLAN applications so that they can recognize authorized users and extend authorized capabilities to them, while denying access to unauthorized users.

REQ-DEV: Developer Requirements

SUDPLAN developers are those people who configure and extend the SUDPLAN platform and integrate access to data, models, and other services in such a way that the resulting SUDPLAN application meets the needs of its particular users. This section specifies those requirements that SUDPLAN needs to fulfil in order to appropriately support developers of future SUDPLAN applications.

REQ-DEV-1: Development support

A variety of SUDPLAN characteristics will make development of SUDPLAN applications relatively simple and inexpensive.

REQ-DEV-1.1: Design for cost effectiveness

The design of the SUDPLAN platform can significantly impact the cost effectiveness of SUDPLAN applications.

REQ-DEV-1.1.1: Modularity

SUDPLAN shall be designed in a modular fashion.

Rationale: Modularity reduces the effort required by developers and encourages re-use of SUDPLAN elements.

Source: LT: Buschmann and Henney, 2010

Explanation: Modular software design is widely understood to be necessary for cost effective software development.

REQ-DEV-1.2: Source integration

SUDPLAN applications will use a wide variety of information and service sources, and integration of these sources will be an important task of the SUDPLAN developer.

REQ-DEV-1.2.1: Web map services

SUDPLAN shall support the integration of spatial layers through standardized services.

Rationale: Spatial data will play a crucial role in SUDPLAN applications, and integration of these data using standard tools is essential.

Source: CL/DoW: REQ-DOW-2.1: Use open standards; REQ-DOW-2.5: Allow integration of standards-based services; REQ-DOW-3.4: Provide integration with SOA-based infrastructures; PR: ORCHESTRA, 2007; SANY, 2009

Explanation: Standardized services (such as OGC WMS, WCS and WFS services) will greatly facilitate the integration and incorporation of spatial data within applications.

REQ-DEV-1.2.2: Model service integration

SUDPLAN shall support the integration of models through standardized web services.

Rationale: Integration of distributed models through standardized web services is essential to support the development of SUDPLAN applications.

Source: CL/DoW: REQ-DOW-2.1: Use open standards; REQ-DOW-2.5: Allow integration of standards-based services; REQ-DOW-3.4: Provide integration with SOA-based infrastructures, REQ-DOW-8.1: Provide models using SOA, REQ-DOW-9.4: Provide new SOA modelling services; PR: ORCHESTRA, 2007

Explanation: SUDPLAN applications are intended to make extensive use of distributed models. Therefore support for the integration of these modelling services is necessary to facilitate the development of applications.

REQ-DEV-1.2.3: Sensor service integration

SUDPLAN shall support the integration of sensors through standardized services.

Rationale: Some SUDPLAN applications will integrate data from sensors, and using standardized services will expedite this and further support SUDPLAN's application development.

Source: CL/DoW: REQ-DOW-2.1: Use open standards; REQ-DOW-2.5: Allow integration of standards-based services; REQ-DOW-3.4: Provide integration with SOA-based infrastructures; PR: SANY, 2009

Explanation: Standardized sensor services (such as OGC SWE) will support SUDPLAN's openness and loose coupling, among other requirements.

REQ-DEV-1.2.4: Meta-information

SUDPLAN shall support the integration of meta-information for use by applications.

Rationale: Meta information is a crucial adjunct to information resources discovered and intended to be used in SUDPLAN applications.

Source: PR: ORCHESTRA, 2007

Explanation: Applications will generally need access to meta-information describing the data and other information sources brought into the application.

REQ-DEV-1.2.5: Databases

SUDPLAN shall support the integration of spatial and non-spatial databases.

Rationale: Much useful information will be available to SUDPLAN applications through both spatial and non-spatial (relational) databases.

Source: PI: REQ.SCENMGMT.005 (B.2), REQ.VISUAL.001 (B.4.1)

Explanation: The ability to search and access multiple, possibly distributed databases within SUDPLAN applications will greatly facilitate successful analyses and improved decision making. Since data regarding a particular entity is often distributed across multiple databases, the ability to virtually integrate these databases will allow analysts to conduct relevant searches without necessarily knowing which databases contain the information sought.

REQ-DEV-1.3: Information modelling

A structured approach to organization of SUDPLAN information entities is key to application integration. Therefore, the use of formalized information modelling techniques is necessary to allow precise specification of information structure.

REQ-DEV-1.3.1: Information modelling support

SUDPLAN shall support the development and utilization of information models.

Rationale: Information models provide important structure to the various attributes of information, and therefore require support both for the use of such models and the development of them by application developers.

Source: PR: ORCHESTRA, 2007

Explanation: Application developers will often need to access the models that carry the structure of the application's information and in some cases may need to develop or extend these models.

REQ-DEV-1.3.2: Information product modelling support

SUDPLAN shall support information product modelling.

Rationale: Elements of SUDPLAN application information products can also be structured using information modelling methods.

Source: SW

Explanation: Models of SUDPLAN application information products can facilitate automation of the generation of these products, and the development of new information products using previous products as templates. Using information modelling techniques, information products can be described in such a way that designers of new information products can discover and interpret existing information products which might serve as a starting point for the new one to be developed.

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Appendix A. Platform Requirements

This appendix provides a listing of each SUDPLAN platform requirement within the structure of the requirements taxonomy.

DoW and ICT Requirements

- REQ-DOW-1: SUDPLAN objectives
  - REQ-DOW-1.1: Build an easy-to-use system
  - REQ-DOW-1.2: Assess risk for river flooding and inundations
  - REQ-DOW-1.3: Assess maximum rain intensity
  - REQ-DOW-1.4: Assess risk from air pollution and extreme temperatures
  - REQ-DOW-1.5: Assess risk from changes in hydrological conditions
- REQ-DOW-2: Open approach: technical requirements of SISE
  - REQ-DOW-2.1: Use open standards
  - REQ-DOW-2.2: Publish interfaces
  - REQ-DOW-2.3: Use and provide open source
  - REQ-DOW-2.4: Allow discovery of relevant sources
  - REQ-DOW-2.5: Allow integration of standards-based services
  - REQ-DOW-2.6: Provide tools for the management of scenarios
  - REQ-DOW-2.7: Provide quality controlled repositories
  - REQ-DOW-2.8: Provide a security system
  - REQ-DOW-2.9: Publish results to the WWW
  - REQ-DOW-2.10: Offer user-friendly interfaces
- REQ-DOW-3: Integrated decision support systems
  - REQ-DOW-3.1: Provide dynamic composition of work flows
  - REQ-DOW-3.2: Provide highly integrated and interactive 3D / 4D
  - ~~REQ-DOW-3.3: Provide automation of model runs, analysis and reporting~~
  - REQ-DOW-3.4: Provide integration with SOA-based infrastructures
- REQ-DOW-4: Use of models for urban planning
  - REQ-DOW-4.1: Support city management
- REQ-DOW-5: Extreme precipitation with potential of causing storm water flooding in urbanized areas
  - REQ-DOW-5.1: Provide IDF curves
  - REQ-DOW-5.2: Improved simulation results
  - REQ-DOW-5.3: Identify extreme precipitation events
  - REQ-DOW-5.4: Provide input for local models
  - REQ-DOW-5.5: Provide tools to compare scenarios
- REQ-DOW-6: Local flood and drought assessment using Pan-European, multi-basin, hydrological models
  - REQ-DOW-6.1: Simulate directly from SUDPLAN interface
  - REQ-DOW-6.2: Provide better downscaling results by using local data
  - REQ-DOW-6.3: Asses future land use scenarios
  - REQ-DOW-6.4: Provide future runoff time series
- REQ-DOW-7: Dispersion model systems used to assess air quality in European cities

- REQ-DOW-7.1: Provide long term air quality simulation
- REQ-DOW-7.2: Assess local influence to air quality
- REQ-DOW-7.3: Connect local emission models
- REQ-DOW-7.4: Assess future health risks
- REQ-DOW-7.5: Assess future fulfilment of air quality standards

- REQ-DOW-8: Model integration in the daily work environment
  - REQ-DOW-8.1: Provide models using SOA
  - REQ-DOW-8.2: Provide models for the end user
  - REQ-DOW-8.3: Foster SOA development in the area of model integration
  - REQ-DOW-8.4: Validate existing standards
- REQ-DOW-9: Service-oriented infrastructures for environmental management
  - REQ-DOW-9.1: Improve existing SOA-based developments
  - REQ-DOW-9.2: Spread SOA-type service networks
  - REQ-DOW-9.3: Provide new SOA service specifications
  - REQ-DOW-9.4: Provide new SOA modelling services
- REQ-DOW-10: Visualisation and interaction
  - REQ-DOW-10.1: Provide 3D/4D visualisation framework
  - REQ-DOW-10.2: Provide interaction framework
  - REQ-DOW-10.3: Provide tools to create customizable presentation material
  - REQ-DOW-10.4: Provide support of different output devices

REQ-USR: User Requirements

- REQ-USR-1: Common user requirements
  - REQ-USR-1.1: Usability
    - REQ-USR-1.1.1: User-centred design
    - REQ-USR-1.1.2: User errors
    - REQ-USR-1.1.3: Short-term memory
    - REQ-USR-1.1.4: Contextual Help
    - REQ-USR-1.1.5: Ease of learning
    - REQ-USR-1.1.6: Memorability
    - REQ-USR-1.1.7: Transparency
  - ~~REQ-USR-1.2: Automation~~
    - ~~REQ-USR-1.2.1: Recurring task automation~~
    - ~~REQ-USR-1.2.2: Recurring task configuration~~
  - REQ-USR-1.3: Profiling
    - REQ-USR-1.3.1: Profiling of the user interface
    - REQ-USR-1.3.2: Establishment of user groups
    - ~~REQ-USR-1.3.3: Profiling of automation tasks~~
    - REQ-USR-1.3.4: Profiling of business processes
- REQ-USR-2: Specific Requirements of Analysts
  - REQ-USR-2.1: Information management
    - REQ-USR-2.1.1: Information source management
    - REQ-USR-2.1.2: Management of related knowledge
    - REQ-USR-2.1.3: Distributed information sources

- REQ-USR-2.1.4: Output data management
- REQ-USR-2.1.5: Result processing management
- REQ-USR-2.1.6: Information product management
- REQ-USR-2.1.7: Coordinate conversion
- REQ-USR-2.1.8: Tracing
- REQ-USR-2.1.9: Input data management and import

REQ-USR-2.2: Interactivity
- REQ-USR-2.2.1: General interactivity requirements
- REQ-USR-2.2.2: Responsiveness
- REQ-USR-2.2.3: Local data copy
- REQ-USR-2.2.4: Differential data download

REQ-USR-2.3: Model management
- REQ-USR-2.3.1: Initial and boundary conditions
- REQ-USR-2.3.2: Condition sets
- REQ-USR-2.3.3: Synchronous model execution
- REQ-USR-2.3.4: Asynchronous model execution
- ~~REQ-USR-2.3.5: Model set execution~~
- REQ-USR-2.3.6: Pre-calculated model execution
- REQ-USR-2.3.7: Model status

REQ-USR-2.4: Scenarios
- REQ-USR-2.4.1: Establishing scenarios
- REQ-USR-2.4.2: Provide tools for the management of scenarios

REQ-USR-2.5: Visualization
- REQ-USR-2.5.1: 3D/4D visualization
- REQ-USR-2.5.2: Spatial visualization
- REQ-USR-2.5.3: Temporal visualization
- REQ-USR-2.5.4: Spatio-temporal visualization
- REQ-USR-2.5.5: Visualization of a model run result
- REQ-USR-2.5.6: Comparison of model run results
- REQ-USR-2.5.7: Visualization of model input

REQ-USR-2.6: Result documentation/annotation
- REQ-USR-2.6.1: Documentation of a model run
- REQ-USR-2.6.2: Documentation of scenario set execution

REQ-USR-2.7: Information products
- REQ-USR-2.7.1: Creation of information products
- REQ-USR-2.7.2: Report generation
- REQ-USR-2.7.3: Export

REQ-USR-2.8: Sharing
- REQ-USR-2.8.1: Information sharing
- REQ-USR-2.8.2: Result sharing
- REQ-USR-2.8.3: Information product sharing
- ~~REQ-USR-2.8.4: Automation sharing~~
- REQ-USR-2.8.5: Annotation sharing

- REQ-USR-2.9: Publishing
  - REQ-USR-2.9.1: Information publishing
  - REQ-USR-2.9.2: Web publishing
  - REQ-USR-2.9.3: Web publishing standards
- REQ-USR-3: Specific Requirements of Modellers
  - REQ-USR-3.1: Model management
    - REQ-USR-3.1.1: Model integration
    - REQ-USR-3.1.2: Model configuration
    - REQ-USR-3.1.3: Supplemental model result calculations
  - REQ-USR-3.2: Model calibration and validation
    - REQ-USR-3.2.1: Model calibration
    - REQ-USR-3.2.2: Model validation
    - REQ-USR-3.2.3: Model versions
- REQ-USR-4: Specific Requirements of System Managers
  - REQ-USR-4.1: Platform management
    - REQ-USR-4.1.1: User management
    - REQ-USR-4.1.2: Security and rights management
  - REQ-USR-4.2: Integration
    - REQ-USR-4.2.1: Data source integration
    - REQ-USR-4.2.2: Sensor service integration
    - REQ-USR-4.2.3: Service integration

REQ-TEC: Technical Requirements

- REQ-TEC-1: General design properties
  - REQ-TEC-1.1: General platform requirements
    - REQ-TEC-1.1.1: Openness
    - REQ-TEC-1.1.2: Scalability
    - REQ-TEC-1.1.3: Accountability
  - REQ-TEC-1.2: Platform design properties
    - REQ-TEC-1.2.1: Use of standards and concepts
    - REQ-TEC-1.2.2: Evolutionary development
    - REQ-TEC-1.2.3: Generic infrastructure
    - REQ-TEC-1.2.4: Clear system structure
- REQ-TEC-2: Platform properties
  - REQ-TEC-2.1: Web-based platform
    - REQ-TEC-2.1.1: Web-based environment
    - REQ-TEC-2.1.2: Service web
    - REQ-TEC-2.1.3: Use of web technologies
  - REQ-TEC-2.2: Use of standards
    - REQ-TEC-2.2.1: Use of OGC standards
    - REQ-TEC-2.2.2: Use of OASIS standards
    - REQ-TEC-2.2.3: Use of W3C standards
  - REQ-TEC-2.3: Security and access control
    - REQ-TEC-2.3.1: Access Control

REQ-TEC-2.3.2: Service independent security
REQ-TEC-2.3.3: User management, authentication and authorization

REQ-DEV: Developer Requirements

REQ-DEV-1: Development support
REQ-DEV-1.1: Design for cost effectiveness
REQ-DEV-1.1.1: Modularity
REQ-DEV-1.2: Source integration
REQ-DEV-1.2.1: Web map services
REQ-DEV-1.2.2: Model service integration
REQ-DEV-1.2.3: Sensor service integration
REQ-DEV-1.2.4: Meta-information
REQ-DEV-1.2.5: Databases
REQ-DEV-1.3: Information modelling
REQ-DEV-1.3.1: Information modelling support
REQ-DEV-1.3.2: Information product modelling support

Appendix B. Pilot Requirements

This appendix contains draft requirements distilled from the four SUDPLAN pilot applications, a process which is described in section 2.2.3 of this document.

While not all of these requirements generalize into SUDPLAN platform requirements, some of them inform platform requirements documented in Chapter 3 and are referred to in the *Source* section therein.

B.1. Security and Access Control (SEC)

This section contains the requirements concerning the means to control who is provided with access to which resources. Requirements on the level of access control are gathered here. User Management, Authentication and Authorisation are architectural building blocks necessary to control access to data and services as appropriate for a given application.

ID	REQ.SEC.001
Name	Scenario Management System user authentication
Description	The Scenario Management System shall provide support for user authentication upon login.
Additional Info	The authentication shall support multiple methods (User name/Password, Public Private Key, etc.)
Open Issues	
Trace	UC-711 “Upload pilot specific data”
Priority	High
Phase	V1

ID	REQ.SEC.002
Name	Scenario Management System user authorization
Description	The Scenario Management System shall provide support for user authorization.
Additional Info	The authorisation shall provide support for user rights management.
Open Issues	
Trace	UC-711 “Upload pilot specific data”
Priority	High
Phase	V1

B.2. Scenario Management (SCNMGMT)

The requirements in this section concern the Scenario Management part of the SMS, execution of scenarios and analyses.

ID	REQ.SCENMGMT.001
Name	Model orchestration
Description	The Scenario Management System shall be able to interact with and run the necessary models. These are the Common Services (e.g. downscaling) and local pilot specific models.
Additional Info	CS urban downscaling results will be used as boundary conditions for the local models.
Open Issues	
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-6111 “Show Simulated Precipitation”, UC-6112 “Generate Rain Fall Pattern”, UC-6114 “Model Surface Run-Off”, UC-712 “Start Downscaling”, UC-714 “run local model”, UC-821 “Execute air quality downscaling”, UC-832 “Autocalibration of the CS hydrological model”
Priority	Medium
Phase	V1, V2

ID	~~REQ.SCENMGMT.002~~
Name	Common Services Model batch execution
Description	The Scenario Management System shall support batch execution of “Common Services” models.
Additional Info	
Open Issues	Batch Execution (automation) is not described in the respective use cases nor requested by the pilots.
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-6111 “Show Simulated Precipitation”, UC-821 “Execute air quality downscaling”
Priority	Medium
Phase	V1, V2

ID	REQ.SCENMGMT.003
Name	Interactive model parameterization
Description	The Scenario Management System shall provide support for the interactive parameterization of the models (e.g. common services or local models).

Additional Info	Includes the support for the selection of desired model, phenomenon, existing model results (e.g. list of European scale model result files), AOI (area of interest), POI (point of interest), time period and already existing datasets needed as input for the models (e.g. selection of a specific emission database covering the downscaling area), model version, Q-station for calibration, switch to run model in calibration mode, etc. Includes also advanced and visual manipulation of model input data, e.g. alteration of 2D & 3D models (Digital Surface Model).
Open Issues	For the selection of the model and phenomenon it has to be decided on the selection order in that the two are dependent of each other.
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-6111 “Show Simulated Precipitation”, UC-6114 “Model Surface Run-Off”, 5.15 "UC-621 Modify Digital Surface Model", UC-714 “run local model”, UC-821 “Execute air quality downscaling”, UC-832 “Autocalibration of the CS hydrological model”
Priority	High
Phase	V1, V2

ID	REQ.SCENMGMT.004
Name	Scenario management simulation settings
Description	The Scenario Management System shall be able to define and save / load model run settings (set of parameters).
Additional Info	The user shall be able to store and access a description of the simulation.
Open Issues	
Trace	UC-6114 “Model Surface Run-Off”
Priority	Medium
Phase	V1

ID	REQ.SCENMGMT.005
Name	Scenario Management System data repository
Description	The Scenario Management System shall provide a data repository and the necessary management functionality for pilot and common services specific data.
Additional Info	
Open Issues	

Trace	UC-611 “Show Basin Information”, UC-612 “Show Catchment Information”, UC-614 “Assess Basin Risk Level”, UC-617 “Trace Prioritisation Changes”, UC-6111 “Show Simulated Precipitation”, UC-6112 “Generate Rain Fall Pattern”, UC-61114 “Model Surface Run-Off”, UC-711 “Upload pilot specific data”, UC-713 “Download downscaling results”, UC-832 “Autocalibration of the CS hydrological model”
Priority	Medium
Phase	V2

ID	REQ.SCENMGMT.006
Name	Pilot specific data selection and upload
Description	The Scenario Management System shall support the upload of pilot specific data to the repository (input for models). This includes for example • measurement data (e.g. in XLS, CSV, NetCDF format) to be used for upload to CS or for validation or for calibration • other data e.g. gridded emission data • 2D/3D map data (e.g. digital elevation models)
Additional Info	File transfer component. The SMS will most probably reside at location A, SMS client at location B and model at location C. The model needs fast access to the input data and result storage. Best topology would be to have the repository at the same site as the model.
Open Issues	
Trace	UC-61114 “Model Surface Run-Off”, UC-711 “Upload pilot specific data”, UC-832 “Autocalibration of the CS hydrological model”
Priority	Medium
Phase	V1, V2

ID	REQ.SCENMGMT.007
Name	Pilot specific data conversion and upload to the Common Services

Description	The Scenario Management System shall provide support for conversion of pilot specific data and its transfer to the CS database. This includes for example • measurement data (e.g. in XLS, CSV, NetCDF format) to be used for upload to CS or for validation or for calibration • other data e.g. gridded emission data • 2D/3D map data (e.g. digital elevation models) • local model results
Additional Info	For the auto calibration of models (Common Services) with historical data it is necessary to upload those data to the common services.
Open Issues	
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-6111 “Show Simulated Precipitation”, UC-6112 “Generate Rain Fall Pattern”, UC-61114 UC-821 “Execute air quality downscaling”, UC-832 “Autocalibration of the CS hydrological model”
Priority	Medium
Phase	V1, V2

ID	REQ.SCENMGMT.008
Name	Model run result selection
Description	The Scenario Management System shall support the browsing (listing) and selection of model results for the purpose of visualization, download, export, upload.
Additional Info	The SMS shall allow for filtering of model results based on its properties and time span.
Open Issues	
Trace	UC-511 ”Visualise air quality model results“, UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-717 “Standard Visualisations”, UC- UC-6113 “Compare Precipitation Data”, 61114 “Model Surface Run-Off”, UC-811 ”Visualise air quality model results“ UC-821 “Execute air quality downscaling”, UC-831 “Visualise hydrological information on the panEuropean scale”
Priority	Medium
Phase	V1, V2

ID	REQ.SCENMGMT.009
Name	Selection of observation data
Description	The Scenario Management System shall be able to interact with observation databases (e.g. data from monitoring stations) and support the listing and selection of observation data for a specified time period (e.g. for visualization or upload to models).
Additional Info	
Open Issues	
Trace	UC-513 “Add monitor data to compare with model results”, UC-6110 “Show Historic Precipitation”, UC-6113 “Compare Precipitation Data”, UC-813 “Add monitor data to compare with model results”
Priority	Medium
Phase	V1

ID	REQ.SCENMGMT.010
Name	Data export
Description	The Scenario Management System shall be able to export computed time series, time-series data by the sensor network or data from external sources of gridded or simple (non-gridded) data for a specific AOI. (e.g. in order to enable comparison with monitored / measured time series).
Additional Info	Export might be done by the SMS or by an external component controlled by the SMS. Export format selection shall be possible (CSV, netCDF, Excel, etc.). Selection of the coordinate reference system for exported data shall be possible.
Open Issues	
Trace	UC-511 ”Visualise air quality model results”, UC-513 “Add monitor data to compare with model results”, UC-716 “export data”, UC-722 “Export Measurement data”, UC-811 ”Visualise air quality model results”, UC-813 “Add monitor data to compare with model results”
Priority	Medium
Phase	V1

ID	~~REQ.SCENMGMT.011~~
Name	Result post processing

Description	The Scenario Management System shall be able to process selected simulation grid and store it as a new result (e.g. (normally averaging hourly data to daily, monthly or annual averages).
Additional Info	This pilot requirement became invalid in V2 since the pilot use cases UC-512 and 812 “post-process model results” have been eliminated, as all downscaled air quality results will be automatically post-processed as part of model execution
Open Issues	Done probably indirectly by instructing an external service.
Trace	~~UC-512 “Post-process model results”, UC-812 “Post-process model results”~~
Priority	Medium
Phase	V1

ID	REQ.SCENMGMT.012
Name	Simulation result access
Description	The Scenario Management System shall provide the necessary functionality for downloading the model results (common services or local model results).
Additional Info	Pilot use cases UC-512 and 812 “post-process model results” have been eliminated, as all downscaled air quality results will be automatically post-processed as part of model execution.
Open Issues	
Trace	~~UC-512 “Post-process model results”~~, UC-6111 “Show Simulated Precipitation”, UC-6112 “Generate Rain Fall Pattern”, ~~UC-812 “Post-process model results”~~
Priority	Medium
Phase	V1

ID	REQ.SCENMGMT.013
Name	CSO efficiency rate processing
Description	The Scenario Management System shall provide the necessary functionality for interacting with CSO efficiency rate processing service.
Additional Info	Necessary for computing and displaying the CSO efficiency rates.
Open Issues	
Trace	UC-715 “calculate efficiency rates”
Priority	Medium

Phase	V3

ID	REQ.SCENMGMT.014
Name	Reference system conversion
Description	The Scenario Management System shall provide the necessary functionality (possible through external service) for reference system conversion.
Additional Info	Necessary for exporting data.
Open Issues	
Trace	UC-716 “export data”
Priority	Medium
Phase	V1

ID	REQ.SCENMGMT.015
Name	Automatic model parameterization
Description	The Scenario Management System shall provide support for the automated parameterization of the model runs (e.g. common services or local models).
Additional Info	In particular it shall be possible to save and load model execution configurations, and to perform an auto calibration of models.
Open Issues	
Trace	UC-832 “Auto calibration of CS hydrological mode”, UC-833 “Execute CS hydrological model”
Priority	Medium
Phase	V2

ID	REQ.SCENMGMT.016
Name	Model Result Annotation
Description	The Scenario Management System shall provide support for the annotation of the model results (e.g. local model results) to assess the effectiveness and efficiency of the annotated model result in comparison to other results of the same model.
Additional Info	In particular the user will shall be able to annotate local model results with his findings to keep hold of them.
Open Issues	

Trace	UC-622 “Annotate Local Model Results”
Priority	Medium
Phase	V3

B.3. Common Services (COMMSERV)

ID	REQ.COMMSERV.001
Name	Common Services Model status
Description	The Scenario Management System shall provide information on the execution status of “Common Services” models.
Additional Info	
Open Issues	
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-6111 “Show Simulated Precipitation”, UC-821 “Execute air quality downscaling”, UC-832 “Autocalibration of the CS hydrological model”
Priority	Medium
Phase	V1, V2

ID	REQ.COMMSERV.002
Name	Common Services Model results storage
Description	The Scenario Management System shall support the management of Common Services Model result storage.
Additional Info	This might be accomplished through a Common Services repository that stores the model input and output data sets.
Open Issues	
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-712 “Start Downscaling”, UC-821 “Execute air quality downscaling”, UC-832 “Autocalibration of the CS hydrological model”
Priority	Medium
Phase	V1, V2

B.4. Visualisation and Interaction (VISUAL)

One of the most important ways of transporting information to the end user as well as decision makers is visualisation of data. This may be manifold often tailored to the user needs or a

specific user profile. In many cases the most appropriate and intuitive way is to use maps, tables and diagrams.

B.4.1. Maps

ID	REQ.VISUAL.001
Name	Selection of the area of interest
Description	The Scenario Management System shall support the display of maps and interactive selection (including zooming) of the area of interest for model runs.
Additional Info	This might be partially accomplished by usage of a WMS.
Open Issues	
Trace	UC-511 ”Visualise air quality model results”, UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-613 “Visualise Objects in Map”, UC-619 “Browse 3D Map”, UC-712 “Start Downscaling”, UC-713 “Download downscaling results”, UC-717 “Standard visualisations”, UC-811 ”Visualise air quality model results”, UC-821 “Execute air quality downscaling”
Priority	Medium
Phase	V1, V2

ID	REQ.VISUAL.007
Name	Visualization of model and processing results
Description	The Scenario Management System shall support the display of model and processing results blended on the map and definition of the color scale (e.g. function of pollution concentration)
Additional Info	Required range adjustability of the Y axis. This might be partially accomplished by the usage of WMS and WCS. Time series and coverages (gridded data) shall be supported.
Open Issues	
Trace	UC-511 ”Visualise air quality model results”, UC-6113 “Compare Precipitation Data”, UC-717 “Standard visualisations”, UC-811 ”Visualise air quality model results”, UC-831 “Visualise hydrological information on the panEuropean scale”
Priority	Medium
Phase	V1, V2

ID	REQ.VISUAL.008
Name	Visualization of model input

Description	The Scenario Management System shall support the display of model input (e.g. as features) and show relevant parameters of the features on the map. The SMS shall support a geospatial selection (e.g. Bounding Box)of features that will be used as input for a for model run.
Additional Info	
Open Issues	
Trace	UC-721 “Visualize geographical features of the SWMM Model”
Priority	Medium
Phase	V2, V3

B.4.2. Display elements

ID	REQ.VISUAL.003
Name	Time series display
Description	The Scenario Management System shall support the display of computed and measured time series or time series from a sensor network or external sources. (e.g. measured data originates from the databases storing data collected by environment monitoring stations like SULFV air quality monitoring).
Additional Info	
Open Issues	
Trace	UC-513 “Add monitor data to compare with model results”, UC-6113 “Compare Precipitation Data”, UC-717 “Standard visualisations”, UC-723 “Visualize Measurement data”, UC-813 “Add monitor data to compare with model results”, UC-831 “Visualise hydrological information on the panEuropean scale”
Priority	Medium
Phase	V1, V2

ID	REQ.VISUAL.004
Name	Gridded data display
Description	The Scenario Management System shall support the display of gridded time series data.
Additional Info	
Open Issues	

Trace	UC-511 ”Visualise air quality model results”, UC-717 “Standard visualisations”, UC-811 ”Visualise air quality model results”, UC-831 “Visualise hydrological information on the panEuropean scale”
Priority	Medium
Phase	V1, V2

ID	REQ.VISUAL.005
Name	Visual comparison
Description	The Scenario Management System shall support the visual comparison of time series (both gridded and simple). (e.g. simulated with measured time series)
Additional Info	Scrolling of the time series on the time axis shall be supported. Scrolling shall result in a synchronized display of time series. For each polygon and for each statistical variable a comparison should be possible for: • Each climate scenario • Mean value over all scenarios • Standard deviation over all scenarios • Max and min values
Open Issues	
Trace	UC-513 “Add monitor data to compare with model results”, UC-6113 “Compare Precipitation Data”, UC-813 “Add monitor data to compare with model results”, UC-831 “Visualise hydrological information on the panEuropean scale”
Priority	Medium
Phase	V1, V2

ID	REQ.VISUAL.006
Name	Monitoring station display
Description	The Scenario Management System shall support the display of the monitoring locations on the map.
Additional Info	
Open Issues	
Trace	UC-513 “Add monitor data to compare with model results”, UC-813 “Add monitor data to compare with model results”
Priority	Medium

Phase	V1

B.5. Events and Notification (NOTIF)

The technical requirements in this section address the general demand for event notification systems. Those systems are required to ensure timely delivery of messages concerning events. Publish/Subscribe mechanisms allow the fine-grained definition of interests and publication options.

ID	REQ.NOTIF.001
Name	Common Services Model notification
Description	The Scenario Management System shall provide support for the notification of the user on important model execution state changes.
Additional Info	This might be accomplished using standardized interfaces and languages to define conditions and notification strategies, manage notification targets. Supported user notification mechanisms might encompass email, SMS messages. For inter-service notification the WS-Notification is a possible approach.
Open Issues	
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”, UC-6111 “Show Simulated Precipitation”, UC-724 “Event detection”, UC-821 “Execute air quality downscaling”
Priority	Medium
Phase	V1, V2

ID	REQ.NOTIF.002
Name	Sensor Network event notification and visualisation
Description	The Scenario Management System shall provide support for the notification of events in the data delivered by a sensor network (e.g. detection of overflow events).
Additional Info	This might be accomplished using standardized interfaces and languages to define conditions and notification strategies, manage notification targets. Supported user notification mechanisms might encompass email, SMS messages. For inter-service notification the WS-Notification is a possible approach.
Open Issues	
Trace	UC-724 “Event detection”, UC-725 “Visualize Event detection data”
Priority	Medium
Phase	V2, V3

B.6. Tracing (TRACE)

The technical requirements in this section are addressing the context that a privileged user wants to be able to check the actions performed by the other users, in order to backtrack the decisions made using the system.

ID	REQ.TRACE.001
Name	Common Services instruction tracing
Description	The instructions sent by Scenario Management System to the Common Services shall be stored for later reference to a location controlled by the SMS (tracing of all performed operations).
Additional Info	
Open Issues	
Trace	UC-521 “Execute air quality downscaling”, UC-531 “Local 3D model execution”
Priority	Medium
Phase	V1, V2

Appendix C. Pilot Use-Cases Trace Matrix

This appendix contains the pilot requirement to pilot use-cases requirement trace matrix. This matrix maps pilot requirements to the use-cases from which they were extracted. The requirements are listed in Appendix B while the use-cases are contained within their respective "Pilot Definition Plan" deliverable documents D[5-8].1.2.

	SEC		SCENMGMT																COMM SERV		VISUAL							NOTIF		TRACE
	01	02	01	~~02~~	03	04	05	06	07	08	09	10	~~11~~	12	13	14	15	16	01	02	01	02	03	04	05	06	07	01	02	01
UC-511										x		x								x	x		x							
~~UC-512~~*														x																
UC-513											x	x										x		x	x					
UC-521			x		x				x	x							x		x	x							x		x	
UC-531			x		x				x	x							x		x	x							x		x	
UC-611							x																							
UC-612							x																							
UC-613																				x										
UC-614							x																							
UC-615																														
UC-616																														
UC-617							x																							
UC-618																														
UC-619																				x										
UC-6110											x																			
UC-6111			x		x		x		x					x			x										x			
UC-6112			x				x		x					x																
UC-6113							x			x	x										x	x		x						
UC-6114			x		x	x		x	x	x																				

* This use-case has been eliminated in V2, as all downscaled air quality results will be automatically post-processed as part of model execution.

	SEC		SCENMGMT																COMM SERV		VISUAL							NOTIF		TRACE
	01	02	01	~~02~~	03	04	05	06	07	08	09	10	~~11~~	12	13	14	15	16	01	02	01	02	03	04	05	06	07	01	02	01
UC-622																		x												
UC-711	x	x					x	x																						x
UC-712			x																x	x										
UC-713							x													x										
UC-714			x		x																									
UC-715															x															
UC-716												x				x														
UC-717										x	x									x	x	x	x							
UC-721												x														x				
UC-722																														
UC-723																						x								
UC-724																											x			
UC-725																												x		
UC-811										x		x								x	x		x							
~~UC-812~~*														x																
UC-813											x	x										x		x	x					
UC-821			x		x				x	x							x		x	x							x		x	
UC-831																					x	x	x	x						
UC-832					x		x	x	x	x							x		x											

* This use-case has been eliminated in V2, as all downscaled air quality results will be automatically post-processed as part of model execution.

Appendix D. Pilot Requirements Trace Matrix

This appendix contains the platform requirements to pilot requirements trace matrix. This matrix maps generalised SUDPLAN platform requirements to the respective pilot requirements, which are listed in Appendix B of this document and referenced in the *Source* section of the related platform requirement.

	SEC		SCENMGMT																COMM SERV		VISUAL							NOTIF		TRACE
	01	02	01	~~02~~	03	04	05	06	07	08	09	10	~~11~~	12	13	14	15	16	01	02	01	02	03	04	05	06	07	01	02	01
~~REQ-USR-1.2.1~~				x																										
~~REQ-USR-1.2.2~~				x																										
~~REQ-USR-1.3.3~~				x																										
REQ-USR-1.3.4																														x
REQ-USR-2.1.1							x	x																						
REQ-USR-2.1.2							x																							
REQ-USR-2.1.3											x																			
REQ-USR-2.1.4							x													x										
REQ-USR-2.1.5									x				x			x														
REQ-USR-2.1.7																x														
REQ-USR-2.1.8																														x
REQ-USR-2.2.1					x																									
REQ-USR-2.2.2					x																									
REQ-USR-2.2.3					x																									
REQ-USR-2.2.4					x																									
REQ-USR-2.3.1			x			x																								
REQ-USR-2.3.2						x																								
REQ-USR-2.3.3			x																											
REQ-USR-2.3.4				x																										
~~REQ-USR-2.3.5~~				x																										
REQ-USR-2.3.7																			x									x		
REQ-USR-2.4.1					x																									

	SEC		SCENMGMT																COMM SERV		VISUAL							NOTIF		TRACE
	01	02	01	~~02~~	03	04	05	06	07	08	09	10	~~11~~	12	13	14	15	16	01	02	01	02	03	04	05	06	07	01	02	01
REQ-USR-2.4.2						x																								
REQ-USR-4.2.2																													x	
REQ-USR-2.5.1																						x								
REQ-USR-2.5.2																						x								
REQ-USR-2.5.3																							x	x						
REQ-USR-2.5.4																							x	x						
REQ-USR-2.5.5																							x							
REQ-USR-2.5.6																										x				
REQ-USR-2.5.7																											x			
REQ-USR-2.6.1						x				x								x												
REQ-USR-2.6.2						x				x																				
REQ-USR-2.7.3										x		x		x		x														
REQ-USR-2.8.2												x																		
REQ-USR-2.8.4																	x													
REQ-USR-3.1.3					x																									
REQ-USR-4.1.1	x	x																												
REQ-USR-4.1.2	x	x																												
REQ-TEC-1.1.3																														x
REQ-TEC-2.3.1	x	x																												
REQ-TEC-2.3.3	x	x																												
REQ-DEV-1.2.5							x														x									

Appendix E. DoW Requirements Trace Matrix

This appendix contains the trace matrix that maps User Requirements (REQ-USR), Technical Requirements (REQ-TEC) and Developer Requirements (REQ-DEV) to DoW and ICT Requirements (REQ-DoW). DoW and ICT Requirements (CL/DoW) are also referenced in the *Source* section of the respective REQ-USR, REQ-TEC and REQ-DEV requirement. This matrix is especially useful for the validation of the high-level project objectives.

REQ-DoW-	1.				2.										3.				4.	5.					6.				7.					8.				9.				10.			
	1	2	3	4	1	2	3	4	5	6	7	8	9	10	1	2	~~3~~	4	1	1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
REQ-USR-1.1.1	x													x																															
REQ-USR-1.2.1																	x																													
~~REQ-USR-1.2.2~~																	x																													
REQ-USR-2.1.3								x																																					
REQ-USR-2.2.1																																										x			
REQ-USR-2.4.2										x																																			
REQ-USR-2.5.1																x																											x			
REQ-USR-2.5.6																								x																					
REQ-USR-2.7.1																																												x		
REQ-USR-2.7.2																																											x		
REQ-USR-2.7.3																																													x	
REQ-USR-2.8.4																	x																													
REQ-USR-2.9.1																																											x		
REQ-USR-2.9.2													x																																
REQ-USR-2.9.3			x																																										
REQ-USR-3.3.1																																		x											
REQ-USR-3.1.2																							x																						
REQ-USR-4.1.1												x																																	
REQ-USR-4.1.2												x																																	
REQ-USR-4.2.1									x																																				
REQ-USR-4.2.2									x																																				
REQ-USR-4.2.3									x																																				
REQ-TEC-1.1.1					x	x			x																																				

REQ-DoW-	1.				2.										3.				4.	5.					6.				7.					8.				9.				10.			
	1	2	3	4	1	2	3	4	5	6	7	8	9	10	1	2	~~3~~	4	1	1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
REQ-TEC-1.2.1					x				x									x																											
REQ-TEC-2.1.1													x						x																											
REQ-TEC-2.2.1					x																																							
REQ-TEC-2.2.2					x																																							
REQ-TEC-2.2.3					x																																							
REQ-TEC-2.3.2												x																																
REQ-TEC-2.3.3												x																																
REQ-DEV-1.2.1					x				x									x																											
REQ-DEV-1.2.2					x				x									x																x							x				
REQ-DEV-1.2.3					x				x									x																											

Appendix F. Requirements Updates

This appendix provides an overview on the updates compared to the initial requirements specified in the previous version of this document.

Requirement	Updates in V2
REQ-DOW-1.1: Build an easy-to-use system	Explanation updated and reference to usability requirements
REQ-DOW-1.2: Assess risk for river flooding and inundations	Explanation updated
REQ-DOW-1.3: Assess maximum rain intensity	Requirement defined more precisely
REQ-DOW-1.5: REQ-DOW-1.5: Assess risk from changes in hydrological conditions	New requirements for WP8
REQ-DOW-2.1: Use open standards	Rationale updated
REQ-DOW-2.2: Publish interfaces	Requirement defined more precisely
REQ-DOW-2.3: Use and provide open source	Explanation added
REQ-DOW-2.4: Allow discovery of relevant sources	Explanation added
REQ-DOW-2.5: Allow integration of standards-based services	Explanation added
REQ-DOW-2.6: Provide tools for the management of scenarios	Requirement extended
REQ-DOW-2.7: Provide quality controlled repositories	Scope of requirement clarified
REQ-DOW-2.8: Provide a security system	Requirement defined more precisely
REQ-DOW-2.9: Publish results to the WWW	Requirement defined more precisely
REQ-DOW-2.10: Offer user-friendly interfaces	Explanation added
REQ-DOW-3.1: Provide dynamic composition of work flows	Explanation added
~~REQ-DOW-3.3: Provide automation of model runs, analysis and reporting~~	Requirement removed; there is no requirement from the pilots for automation.
REQ-DOW-3.4: Provide integration with SOA-based infrastructures	Explanation added
REQ-DOW-4.1: Support city management	Explanation added
REQ-DOW-5.1: Provide IDF curves	Explanation added
REQ-DOW-5.2: Improved simulation results	Explanation added

REQ-DOW-5.3: Identify extreme precipitation events	Explanation added
REQ-DOW-5.5: Provide tools to compare scenarios	Explanation added
REQ-DOW-6.3: Asses future land use scenarios	Rationale added
REQ-DOW-7.2: Assess local influence to air quality	Explanation added
REQ-DOW-7.1: Provide long term air quality simulation	Explanation added
REQ-DOW-7.3: Connect local emission models	Explanation added
REQ-DOW-7.4: Assess future health risks	Rationale and Explanation updated
REQ-DOW-8.1: Provide models using SOA	Explanation added
REQ-DOW-8.3: Foster SOA development in the area of model integration	Explanation updated
REQ-DOW-8.4: Validate existing standards	Explanation added
REQ-DOW-9.2: Spread SOA-type service networks	Explanation updated
REQ-DOW-10.1: Provide 3D/4D visualisation framework	Explanation added
REQ-USR-1.1.1: User-centred design	Source updated
~~REQ-USR-1.2.1: Recurring task automation~~	Requirement removed. There is no requirement from the pilots for automation. SUDPLAN model services are so complex and time consuming that the user will invoke them one by one.
~~REQ-USR-1.2.2: Recurring task configuration~~	Requirement removed. There is no requirement from the pilots for automation. SUDPLAN model services are so complex and time consuming that the user will invoke them one by one.
~~REQ-USR-1.3.3: Profiling of automation tasks~~	Requirement removed. Recurring task automation became obsolete
REQ-USR-2.1.3: Distributed information sources	Source updated
REQ-USR-2.1.7: Coordinate conversion	Explanation updated
REQ-USR-2.1.9: Input data management and import	New Requirement
REQ-USR-2.2.1: General interactivity requirements	Source updated
REQ-USR-2.4.2: Provide tools for the management of scenarios	Source updated

REQ-USR-2.5.1: 3D/4D visualization	Source updated, Explanation updated and more concrete 3D visualisation requirements added.
REQ-USR-2.5.2: Spatial visualization	Explanation updated and more concrete 2D visualisation requirements added.
REQ-USR-2.5.4: Spatio-temporal visualization	Explanation updated and more concrete 2D visualisation requirements added.
REQ-USR-2.5.5: Visualization of a model run result	Explanation updated and more concrete visualisation requirements added.
REQ-USR-2.5.6: Comparison of model run results	Source updated, Explanation updated and more concrete visualisation requirements added.
REQ-USR-2.5.7: Visualization of model input	New User Requirement
REQ-USR-2.6.1: Documentation of a model run	Trace and description updated
REQ-USR-2.7.1: Creation of information products	Source updated
REQ-USR-2.7.2: Report generation	Source updated
REQ-USR-2.7.3: Export	Source updated
REQ-USR-2.8.4: Automation sharing	Source updated
REQ-USR-2.9.1: Information publishing	Source updated
REQ-USR-2.9.2: Web publishing	Source updated
REQ-USR-2.9.3: Web publishing standards	Source updated
REQ-USR-3.1.1: Model integration	Source updated
REQ-USR-3.1.2: Model configuration	Source updated
REQ-USR-3.1.3: Model result post processing	New User Requirement
REQ-USR-3.2.3: Model versions	Source updated
~~REQ-USR-2.3.5: Model set execution~~	Requirement became obsolete; there are no requirements from the pilots for automation.
REQ-USR-4.1.1: User management	Source updated
REQ-USR-4.1.2: Security and rights management	Source updated
REQ-USR-4.2.1: Data source integration	Source updated
REQ-USR-4.2.2: Sensor service integration	Source and description

REQ-USR-4.2.3: Service integration	Source updated
REQ-TEC-1.1.1: Openness	Source updated
REQ-TEC-1.2.1: Use of standards and concepts	Source updated
REQ-TEC-2.1.1: Web-based environment	Source updated
REQ-TEC-2.2.1: Use of OGC standards	Source updated
REQ-TEC-2.2.2: Use of OASIS standards	Source updated
REQ-TEC-2.2.3: Use of W3C standards	Source updated
REQ-TEC-2.3.1: Access Control	Source updated
REQ-TEC-2.3.3: User management, authentication and authorization	Source updated
REQ-DEV-1.2.1: Web map services	Source updated
REQ-DEV-1.2.2: Model service integration	Source updated
REQ-DEV-1.2.3: Sensor service integration	Source updated
REQ.SCENMGMT.001	Trace updated
~~REQ.SCENMGMT.002~~	Common Services Model batch execution Batch Execution (automation) is not described in the respective use cases nor requested by the pilots.
REQ.SCENMGMT.003	Trace, description and additional info updated
REQ.SCENMGMT.005	Trace updated
REQ.SCENMGMT.006	Trace and description updated
REQ.SCENMGMT.007	Trace and description updated
REQ.SCENMGMT.008	Trace updated
REQ.SCENMGMT.010	Trace and description updated
~~REQ.SCENMGMT.011~~	Requirement deleted as originating pilot use cases have been deleted
REQ.SCENMGMT.012	Trace updated
REQ.SCENMGMT.015	New pilot requirement
REQ.SCENMGMT.016	New pilot requirement

REQ.COMMSERV.001	Trace updated
REQ.COMMSERV.002	Trace updated
REQ.VISUAL.003	Description and Trace updated
REQ.VISUAL.005	Description updated
REQ.VISUAL.007	New pilot requirement
REQ.NOTIF.001	Trace updated
REQ.NOTIF.002	New Pilot Requirement