SEVENTH FRAMEWORK PROGRAME

Specific Targeted Research Project

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D2.2 Reference and Validation Scenarios for IoT Virtualization

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TABLE OF CONTENTS

LIST OF TABLES

TERMS AND ACRONYMS

BPM	Business Process Management
CEP	Complex Event Processing
CTU	Camden Town Council
DoW	Description of Work
FCAPS	Fault, Configuration, Accounting, Performance, Security
GSN	Global Sensor Networks
ICO	Internet-Connected Objects
IMM	Istanbul Metropolitan Municipality
IoT	Internet-of-Things
SSN	Semantic Sensor Networks
VUAIs	Virtualized Unified Access Interfaces
WSN	Wireless Sensor Networks
W3C	World Wide Web Consortium
X-GSN	eXtended Global Sensor Networks

1 INTRODUCTION

1.1 Scope

The main objective of the VITAL project is to introduce and validate a new integrating approach to the development of IoT-based applications in smart cities, which emphasizes the integration of information and processes that are supported by heterogeneous IoT platforms and applications. To this end, VITAL is designing a platform that supports the virtualization of existing (silo) IoT platforms and applications. This platform will be validated against a range of specific use cases for smart cities, including integrated scenarios that will be designed and implemented within the two cities of the consortium (Camden/ London and Istanbul).

The purpose of the present deliverable is to describe these validating scenarios, each one comprising several use cases. The scenarios should be appropriate in order to validate the main functionalities of the VITAL platform, as well as its non-functional features and capabilities. In addition to a description of the validation scenarios, the deliverable illustrates the IoT platforms that will be used in the scope of validation as silo platforms. To this end, it lists the candidate platforms and selects the platforms to be exploited on the basis of a number of selection criteria.

The deliverable builds on the list of stakeholder's requirements specified as part of the earlier WP2 deliverable D2.1 [VITAL-Req-13]. In particular, these requirements are used in order to identify the functional and non-functional characteristics of VITAL, which should be validated in the scope of the VITAL scenarios. At the same time, the present deliverable will serve as valuable input towards producing the VITAL architecture as part of deliverable D2.3.

1.2 Audience

The deliverable is primarily targeted towards the VITAL consortium, notably to researchers, integrators and developers of the VITAL architecture and platform. These consortium members will need to understand and use the various validation use cases as part of their efforts to design, implement, test and validate the VITAL platform. However, the deliverable is also of interest to IoT and smart cities researchers and developers outside the consortium, notably to developers that need to understand and/or implement smart city use cases and scenarios that integrate information and processes from existing silo platforms and applications.

1.3 Summary

The present deliverable presents a wide range of use cases, which will be taken into account at various phases of the VITAL workplan towards the design, development, deployment, validation, evaluation and demonstration of the VITAL platform and the applications that will be developed for the two cities of the consortium. The presented use cases cover several functionalities of the VITAL platform, notably the functionalities that have been identified and elaborated as part of the earlier deliverable of WP2, deliverable D2.1. The use cases include two integrated scenarios, which are specified as the integrated use cases that will be implemented in Istanbul and the Camden borough of London. At the same time, the deliverable includes smaller scale atomic fine-grained use cases, which will be used as a basis for validating individual functionalities of the VITAL platform. The latter use cases can also serve as mini demonstrations of the VITAL capabilities, which could be used later to stimulate the interest of stakeholders (including the open source community), as well as to support the project's dissemination strategy.

Note that most of the above mentioned scenarios and use cases assume access and processing of data from multiple underlying IoT platforms and applications. To this end, this deliverable also analyzes and selects the IoT platforms to be used in order to demonstrate/validate the VITAL silo integration and virtualization concept. The selected platforms include background platforms of the partners, as well as third party platforms. Furthermore, they include platforms that feature heterogeneity in terms of their architecture and functionality, thereby being ideal for showcasing VITAL's ability to bridge this heterogeneity.

Finally, the deliverable includes a presentation of the main legal issues that should be considered in the process of developing smart city applications in the VITAL urban environments. Relevant legal requirements should be considered for incorporation in the smart city governance use cases. The legal considerations of the deliverable include an analysis of applicable data protection laws in UK and Turkey, where VITAL applications will be deployed in realistic pilot environments.

1.4 Structure

The deliverable is structured as follows. Section 2 (following the introductory section), reviews the VITAL virtualization paradigm in terms of actors and stakeholders, main technological building blocks, as well as the main functional and non-functional requirements to be validated through the various scenarios. Section 3 identifies the background IoT platforms that will be integrated as silo platforms within VITAL in order to validate and showcase the project's virtualization paradigm. Section 4 reports on the reference validation use cases to be used in the validation and evaluation phases of the project. Each use case is focused on dedicated aspects, work packages and features of the platform. All functional requirements are addressed. Some requirements are addressed by more than one use case. Sections 5 and 6 present integrated smart city scenarios for each reference city (Istanbul and Camden respectively). These scenarios are somewhat larger in scope and present an integration format that is broken down in a number of use cases. Note that the presented scenarios include features to be developed and deployed in the two smart cities of the consortium, as well as other stand-alone validating scenarios (and use cases) targeting the validation of specific functionalities of the VITAL platform. In that sense the validation becomes twofold i.e. per functionality and per application. Section 7 discusses some legal requirements, based on rules and regulations in effect across various countries. These could be taken into account in the scope of governance use cases. Finally, Section 8 concludes the deliverable with a short summary.

2 REVIEW OF THE VITAL VIRTUALIZATION PARADIGM

The specification of reference scenarios is motivated by the need to validate, showcase and evaluate the VITAL virtualization paradigm, which foresees integrated development of IoT-based smart city applications. In this chapter we first introduce the main elements of this paradigm, including the main functionalities of the VITAL platform (based on functional requirements derived in deliverable D2.1 [VITAL-Req-13]), so as to drive the specification of aptitude and relevant scenarios.

2.1 Main Actors, Users and Stakeholders

In the scope of deliverable D2.1, we have identified the main stakeholders of the VITAL platform, which include: (A) City Authorities, (B) Citizens and Businesses in the city, (C) Developers, solution providers and integrators of VITAL solutions, (D) Services providers based on the VITAL platform, (D) Research, students and engineers focusing on novel IoT application for smart cities. These stakeholder groups define also the main actors of the VITAL validation scenarios and use cases. Indeed, the VITAL platform will:

- Be a vehicle to develop, deploy and operate integrated applications that will be used by city authorities, citizens and businesses.
- Provide a number of tools and techniques for solution providers, solution developers and integrators, with a view to ease the implementation of integrated (cross-silo) applications.
- Implement and provide a set of monitoring and governnance utilities facilitating service providers in the management and operation of smart city applications based on the VITAL model.

As a result, the functionalities to be provided by the VITAL platform will be offering benefits to all the actors outlined above.

2.2 Main Building Blocks

Based on the VITAL DoW and the analysis of stakeholder requirements, the following (high-level) building blocks of the VITAL platform can be already identified:

- **VITAL ontology**: The VITAL ontology will provide the basis for cross-silo platform agnostic modeling of IoT data and metadata. This ontology is designed and developed in the scope of WP3 and will comprise both IoT and smart city concepts.
- **Platform adapters**: A number of middleware adapters will be implemented in order to map and adapt existing IoT platforms and applications to the VITAL platform. The mapping should address several aspects, including data structures,

filtering mechanisms, CEP mechanisms and security mechanisms. Note that we plan to implement the mapping of IoT platforms to VITAL in WP3, while it is also discussed in later paragraphs.

- **VUAIs (Virtualized Universal Access Interfaces) middleware**: VITAL will implement a number of virtualized interfaces for accessing the IoT Services of the VITAL ontologies (Data, Data Streams, Event Streams, Applications,…) and the cross-platform capabilities of the platform. These interfaces will be supported by appropriate middleware libraries. They will include interfaces for executing common requests/queries in smart city applications, along with management interfaces for accessing the low-level management and configuration capabilities of the VITAL platform.
- **Internet Connected Object (ICO) Discovery Module:** Smart city applications complying with the VITAL paradigm are expected to provide the means for selecting sensors, ICOs, data streams, IoT services and applications within the urban environment. To this end, a discovery module is designed as part of WP4.
- **Process composition and orchestration tools:** VITAL is expected to provide the means for composing IoT services in smart city processes and applications. We are planning to implement a web-based workflow management infrastructure to support such process composition.
- **Integrated Development tools:** A set of tools for developing applications over the VITAL ontology and according to the VITAL development paradigm will be provided.
- **Management and governance tools**: The project intends to provide a number of management and governance tools, enabling the configuration of the VITAL infrastructure (including the underlying IoT platforms and applications). The governance tools will also put emphasis on the configuration of smart city scenarios across different urban environments and based on city-specific parameters (such as the city demographics and city regulations).

The VITAL validation scenario should enable the validation of all the above building blocks, as a prerequisite for validating the VITAL platform and paradigm as a whole. Note that the specific validation use cases that are outlined in this deliverable will drive the detailed technical specifications of these building blocks, but also their structuring/integration on the basis of a coherent technical architecture. This architecture will be documented in deliverable D2.3.

2.3 Functionalities to be Validated

2.3.1 Overview

As part of D2.1, VITAL has specified key functionalities of its platform. These functionalities provide a basis for defining several of the validation use cases listed in this document, given that the purpose of these validation use cases is to validate the key functionalities of the VITAL platform. Nevertheless, in addition to functionalities listed in D2.1, we herewith list additional functionalities that should be included in the validation, based on the DoW of the project, as well as on additional requirements identified by the technical partners of the project.

2.3.2 Functional Requirements

The scenarios and use cases should enable the validation of all the functional requirements of the project, as outlined in Table 1. Note that these requirements are in general high-level and each one can be associated with multiple validating use cases.

Code	Label	Description/Remarks
VITAL-FR-1	Low-level filtering of sensor streams	Ability to reduce the amount of information that is transferred from low-level sensing layers to higher-level application layers
VITAL-FR-2	Semantic level filtering of application events	Selection of events at the application layer of the IoT system based on the (high-level) semantics of the sensors (sensor data and sensor metadata)
VITAL-FR-3	Information/ Data Fusion (Multi-Source)	Combination of sensor data feeds from multiple-source; Emphasis on fusion of feeds that stem from different platforms
VITAL-FR-4	Complex Event Processing	Extraction of events that adhere to specific user-defined rules; Emphasis on Complex Events that signify several contextual dimensions (who, where, what, when, how and why); Emphasis on the correlation of diverse data streams towards generating non-obvious events
VITAL-FR-5	Management of Sensor (Meta)data	Management of information contained in the VITAL data models (ontologies)
VITAL-FR-6	Discovery of Sensors and ICOs	Dynamic discovery of sensor data and metadata in smart city contexts; Emphasis on discovery of sensors and sensor data based on a variety of parameters including sensor type, sensor location, timing constraints, etc.
VITAL-FR-7	Visual development of smart city apps	Ability to develop applications using a GUI (based on minimal programming effort)

VITAL-FR-8	Management Functionalities	Monitoring, logging and configuration of smart city sensors, platforms and applications
VITAL-FR-9	Management of Smart City Workflows	Specification and enactment of workflows of IoT services for smart cities applications
VITAL-FR-10	Sensor Data access	Ability to access data/information stemming from any of the IoT platforms that will be integrated through the VITAL platform
VITAL-FR-11	Data Analysis	Ability to run data analytics queries over the data based on dimension such as sensor type and time window/frame, but also based on standard statistical processing functionalities (e.g., sum, average, standard deviation).

Table 1: VITAL Functional Requirements to be Validated

2.3.3 Non-Functional Requirements

In addition to the functional requirements outlined above, the validation and evaluation scenarios should be appropriate for showcasing and assessing a set of non-functional requirements. These are illustrated in Table 2.

Code	Label	Description/Remarks
VITAL-NFR-1	Performance and Scalability	Ability to handle thousands of data streams (per city) with decent performance – Scalability in terms of number and types of data streams
VITAL-NFR-2	Development and Deployment Flexibility	Ability to develop smart city applications with minimal effort (e.g., in terms of time and developers' resources)
VITAL-NFR-3	Management and Configurtion	Ability to manage (e.g., monitor, configure) the elements that comprise a VITAL system
VITAL-NFR-4	Extensibility and Expandability	Ability to expand the system on the basis of new platforms, services and data streams
VITAL-NFR-5	Compliance with standards	Support for standards (notably W3C SSN and OGC)
VITAL-NFR-6	Authentication and Authorization	Users' authentication and authorization against specific sensors or services
VITAL-NFR-7	Single Sign On	Access to VITAL sensor data (from multiple platforms) using a single set of credentials

Table 2: Non-functional Requirements to be Validated

3 IOT PLATFORM INTEGRATION IN VITAL

3.1 Background IoT platforms

In the scope of deliverable D2.1, we have analyzed a large number of IoT platforms that could be integrated into the VITAL platform. These IoT platforms included platforms developed by the project partners (e.g., Hi REPLY, INRIA's FIT), commercial cloud based platforms (e.g., xyvily.com), as well as open source platforms (e.g., GSN). The purpose of this section is not to describe these platforms again (we refer interested readers to D2.1), but rather to outline their characteristics that prioritize them for integration with the VITAL platform. These characteristics match the selection criteria set for choosing the platforms, which are discussed in the following paragraphs.

3.2 Selection Criteria

VITAL has promised to demonstrate its silo integration paradigm through the practical interconnection of four distinct (silo) platforms with the VITAL platform. A critical milestone for the project (as also listed in the DoW) is therefore the selection of the four platforms that will be integrated, which should signify that the integration process can start in parallel with the specification of the VITAL architecture. The selection of specific platforms to be integrated should allow the demonstration and validation of the functionalities of the VITAL platform in terms of its ability to integrate diverse silos. Therefore it is specifically valuable for the consortium to pick platforms with different characteristics. Nevertheless, the selection is also constrained by other factors, such as the availability of the appropriate access/IPR rights over the platform, as well as considerations of reuse and value-for-money aspects. Overall the selection of the platforms to be integrated is based on the following criteria:

- **C1 – Heterogeneity:** The platforms to be integrated should be diverse and heterogeneous in terms of the data models (and/or standards) that they support, the functionalities that they provide, as well as their provider/owner. As already outlined, heterogeneity is a key towards validating the wide applicability of the VITAL paradigm. Based on this criterion, the platforms to be selected should include: (A) Research platforms (such as FIT and GSN), (B) Enterprise Platforms (such as the on-line IoT/cloud platforms xively (https://xively.com) and Thingsworx (www.thingworx.com), but also Hi Reply platform), (C) Platforms that partly support standards (e.g., Hi Reply), (D) Platforms that are based on proprietary data access methods and formats (such as GSN), (E) Platforms that support low-level IoT functionalities i.e. data access and filtering (such as FIT).
- **C2 – Maturity:** The platforms to be integrated should be mature in terms of their functionalities and operation i.e. they should feature a high Technology Readiness Level (TRL) based on their proven deployment and validation in actual IoT (or smart city) applications. Maturity is a key to ensuring that VITAL researchers will be able to focus on the validation of the project's virtualization layer, without any need to deal with issues/problems of the low-level platforms. At the same time, it is a prerequisite in order to ensure their deployment in practical

SC applications. Note that this criterion is not a very strict constraint in terms of the platforms presented in D2.1, since the majority of them feature acceptable maturity. In most cases these platforms have been used to support real-life deployments as is the case with some of the enterprise platforms outlined above.

- **C3 – Minimal Effort:** The integration of the platforms should be performed with minimum possible effort, in order to allow optimal use of the VITAL resources and maximization of the overall value for money. To this end, work of the partners as part of their background projects shall be exploited as much as possible. This criterion brings platforms such as Hi Reply, GSN and FIT in the foreground of the selection process, while it makes also possible the selection of platforms developed in the scope of partners' projects such as OpenIoT and iCore.

3.3 Platforms selected for integration with VITAL

Based on the above-mentioned selection considerations, the consortium has opted for the selection of the following platforms that will be integrated and federated as part of the VITAL virtualization paradigm:

- **The Hi Reply platform**, which covers the full stack of IoT functionalities (from data acquisition to filtering, eventing and application-oriented data processing). The IPR of the platform is owned by REPLY, which can make it available for integration in the scope of the project's platform. Partner REPLY has a deep know-how on the technical characteristics and functionalities of the platform, which renders it a good option according to criterion C3 above. Also, this platform scores well in terms of criterion C2, since it has been deployed in practical enterprise contexts.
- **The GSN platform**, which is a proven widely deployed open source sensor middleware platform. GSN focuses on sensor middleware and uses simple formats for sensor data and metadata, which ease the configuration and deployment of sensors. In this respect it is different from Reply's Hi platform, thereby contributing to the goals of criterion C1. At the same time, the platform has several deployments in sensor applications thereby fulfilling the requirements set in criterion C2. Finally, several VITAL partners (notably NUIG and AIT) have experience with integrating this platform, as required by criterion C3. Note that the partners will have the option of using the enhanced version of GSN, named *extended GSN* (X-GSN), which has been developed and integrated in the scope of OpenIoT project with the participation of NUIG and AIT. X-GSN has the ability to semantically annotate the data that it produces, thereby facilitating integration of ontologies. This feature can be handy for the VITAL integration tasks. X-GSN (and GSN) are available as open source software modules under appropriate licensing schemes that permit their reuse and integration in the scope of VITAL.
- **The FIT platform** (http://fit-equipex.fr/), which is a sensor platform emphasizing on low-level tasks. In terms of criterion C1, FIT will provide a basis for experimenting with the virtualization and integration of low-level IoT functionalities such as sensor data access and filtering. FIT is contributed to the project by

partner INRIA. It is already used for supporting a large scale experimental testbed for sensors. Hence, it fulfills the requirements outlined by criteria C2 and C3.

- **The Thingsworx enterprise IoT/cloud**. Integration with this platform will aim at demonstrating VITAL's ability to federate, consolidate and use data streams from third-party platforms that provide appropriate data access APIs. This is in-line with the selection objectives outlined as part of criterion C1. Note that the same objective could be accomplished on the basis of the integration of the xively platform. Hence, the partners reserve the right to change the target enterprise platform, especially since the forerunner of this platform (i.e. COSM.COM) has been a supporter of the VITAL proposal. Based on an initial analysis of the two platforms (xively, thingsworxx) the integration effort is more or less similar. Hence, the final selection is likely to depend on the market momentum of the two platforms, as VITAL will attempt to prioritize support for the platform that could maximize the project's wider impact.

4 VALIDATION USE CASES

4.1 Overview and Purpose

In this chapter we outline an initial set of use cases that will be used for validating the VITAL platform. These use cases will also drive other design and implementation tasks of the project. For example they will be taken into account towards the specification of the VITAL architecture, which shall be in principle able to address all the use cases outlined above. As illustrated in the following paragraph, in terms of the presentation of the various use cases we distinguish between: (A) Integrated scenarios (typically comprising multiple use cases), which will be tested and piloted in the cities of the consortium and (B) Fine-grained use cases addressing specific functionalities of the VITAL platform, which will be used to test and validate individual/atomic functional requirements of the VITAL platform. The fine-grained use cases that address atomic VITAL functionalities are also characterized as basic. Basic use cases will be used to test specific modules of the VITAL platform, as a prerequisite step for the development and validation of the integrated scenarios and use cases, which will comprise multiple functionalities. We expect the modularity of the VITAL architecture to facilitate the development of integrated scenarios based on the (re)use and integration of the individual functionalities addressed by the basis use cases. In the sequel, we illustrate the classification of the VITAL use cases in the above two categories, along with its implications in the structuring and subsequent implementation of the use cases.

4.2 Classification of VITAL Use Cases

In presenting and validating the VITAL platform' aptitude to address a multitude of diverse cases, the following division has been adopted:

- **Integrated Scenarios** for the two (2) pilot cities to showcase the general ability and potential of the platform for integration within a real smart-city environment. This constitutes a more business-centric approach.
- **Validation Use cases** and Scenarios, which drill down into the specifics of the components of the VITAL platform. Such validation use cases are more targeted towards showcasing functionality per project workpackage or alternatively per function and per partner expertise. This constitutes a more functional-centric approach.

In the former case (integrated scenarios for cities) all participants co-operate under the leadership and scenario unification of the relevant city authority. In the latter case (validation use cases per function) all participants co-operate under the leadership and scenario unification of the VITAL partner with the relevant expertise, e.g. a workpackage leader.

The taxonomy of the building blocks as presented in Section 2.2 as well as a draft segmentation approach towards the project's architecture that will be finalized at a later stage, should serve as a guide to identify functionalities and features within the workpackages. These should be the guide for the validation use cases to address properly each segment at least once per use case. This is a general guide rather than a strict reference for the validation use case break-down.

4.3 Basic Validation Use Cases

4.3.1 Use cases for Platform Agnostic Data Acquisition, Querying and Integrated Data View (leader NUIG)

4.3.1.1 Developer Reflection Interface Use Case

Use case Id:	**UC01**
Use case Short Title:	Developer Reflection Interface

What WP or VITAL Functionality does the Use case address:
WP3, specifically the VITAL Ontology and the dynamic platform-agnostic querying for metadata
Why is this use case needed to validate the VITAL platform?
It allows to inspect all aspects of the VITAL (meta)data ontology and provides a basic tool for further experiments (by helping developers to plan ahead).
What would the Added Value of such a use case be to the end-user?
Developers can inspect the data and functionality that they will be able to use in a given area, gaining a better understanding of their possibilities. Developers can also get a better understanding of the available metadata in the VITAL ecosystem before actually developing an application, reducing development risks. Furthermore the use case will be usable as the basis for more sophisticated monitoring tools (developed in WP3, too) and as a demo to showcase VITAL to external partners.
Who is the intended end-user for the use case?
System and application developers
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
VITAL Ontology (NUIG) and VUAI(s) for metadata querying (NUIG, AIT)
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VITAL discovery, data management servers hosting the metadata description of all IoT systems in a requested area as well as the involved IoT systems.

b. Trigger (What event or time value or other factor would trigger the use case):
A developer initiating an introspection request to a specific area.
c. Preconditions (What pre-requisites does the use case have):
IoT systems must be available and registered in VITAL, users must have access rights for metadata.
d. Normal Flow (What usually happens during the use case):
A user selects a target area using a PC tool. The tool initiates a VITAL discovery of all IoT systems that are relevant for the target area, retrieves metadata from them and renders it (possibly textual) for the user.
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
Event-driven
h. Notes and Issues (if any):
This use case does not involve retrieving actual sensor data from an IoT system or initiating activities in it. The use case focuses on the metadata descriptions and thus is expected to have a low update frequency. Thus, the use case does not focus on scalability or low overhead of the involved data query interfaces.

Table 3: Developer Reflection Interface Use case UC01

4.3.1.2 Mobile Density Map Use Case

Use case Id:	UC02
Use case Short Title:	Mobile Density Map

What WP or VITAL Functionality does the Use case address:
WP3, specifically VUAIs
Why is this use case needed to validate the VITAL platform?
The use case showcases the platform-agnostic access to data and services of multiple deployed IoT systems in a specific spatial area, independent of a specific application scenario.
What would the Added Value of such a use case be to the end-user?
The end user can use the provided functionality to learn about how to access actual data and services of IoT systems. He/she can extend the use case for his/her own actual application. The user can further test that actual data is retrieved before

deploying their application to end users.
Who is the intended end-user for the use case?
Application developers
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
VUAIs (AIT, NUIG), VITAL Ontology (NUIG), Android development, graphical data presentation
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VITAL discovery, VITAL added value services, deployed IoT systems
b. Trigger (What event or time value or other factor would trigger the use case):
The use case is triggered by the user starting an app.
c. Preconditions (What pre-requisites does the use case have):
Deployed and registered IoT systems, access rights for data and services.
d. Normal Flow (What usually happens during the use case):
The user starts an app and selects a target spatial area. The app contacts the VITAL discovery and identifies the IoT systems registered for this area. The app then continuously requests and renders current sensor data and available services.
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
Once triggered, the use case runs continuously until the user explicitly stops it.
h. Notes and Issues (if any):
Note that the graphical representation quality is intended for prototypical usage and will not be sufficient for actual products. This is not the focus of VITAL.

Table 4: Mobile Density Map Use case UC02

4.3.1.3 Explanation

As part of WP3 it will be of particular importance to showcase and validate VITAL's platform-agnostic data acquisition and querying and the integrated data view, i.e. the ability of the VITAL ontology to describe all associated IoT systems and their components (i.e. meta-data). The following use cases are envisaged:

4.3.1.4 Developer Reflection Interface

To ease development we will provide a tool for standard PCs/Laptops that will allow developers to retrieve a description of all IoT systems and their abilities in a specified geographical area. The tool will allow to list and inspect all available subsystems and their descriptions/parameters. As an example, a developer can see (live) that in Camden there are currently 7 IoT systems deployed. He/she can get a detailed description of each system including basic platform, available sensors and data items, security levels, etc. Basically this allows a developer to get a better understanding of what will be possible to do in a specific area and will ease development of applications both internally in the project as well as by external partners. This tool shows the integrated data view with all details of the Ontology and the platform agnostic querying for meta-data. The tool may also allow to inspect real data but this is optional and not in the focus. Note that this developer reflection interface tool, could be also a foundation for implementing and validating several of the management and monitoring functionalities of the project (to be developed in WP3).

4.3.1.5 Mobile Density Map

In contrast to showing the metadata, this use case concentrates on retrieving actual data. A mobile app will be developed that shows the amount of users and traffic in a specific geographical area. To do so we will overlay different colors on top of a map interface, depending on the number of people/cars in a segment of a road, a building or a walkway. The resulting map can be used e.g. by people to see where there is a lot of traffic but also to identify ‘hot’ areas to go to at a weekend evening. The data will be taken from all available IoT Systems, possibly including participatory sensing platforms like GAMBAS and our Cisco system. This is a nice app but also a building block for further, more complex scenarios in the integrated city scenarios. As such it should be developed as an Android activity that can be reused by other mobile apps. We will also make sure to develop the activity in a way such that it can be easily extended and adapted to visualize other sensor data. Note that the focus is not on visualization quality but instead on showcasing how to retrieve dynamic data from multiple IoT systems. Please also note that this use case might require basic discovery and filtering capabilities. However, it does not provide a complex interface to access all aspects of discovery and filtering since they are the focus of other use cases.

4.3.2 Use cases for Intelligent Sensor/ICO Discovery (leader INRIA)

4.3.2.1 Reprogrammable Sensor Discovery Use Case

Use case Id:	UC03
Use case Short Title:	Reprogrammable Sensor Discovery

What WP or VITAL Functionality does the Use case address:
VITAL Ontology, Discovery Module
Why is this use case needed to validate the VITAL platform?
In this use case we exploit the ICO discovery of the VITAL platform.
What would the Added Value of such a use case be to the end-user?
A most effective usage of the sensors already available.
Who is the intended end-user for the use case?
Public Administration, sensors owners
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
The semantic annotation of the sensors that has been already effectively realized using background platforms of the partners (i.e. OpenIoT open source platform).
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VUAIs, VITAL Applications
b. Trigger (What event or time value or other factor would trigger the use case):
The necessity to have specific functionalities on the sensors.
c. Preconditions (What pre-requisites does the use case have):
Reprogrammability of the sensors
d. Normal Flow (What usually happens during the use case):
When a new functionality appears, the VITAL discovery process will dynamically find it, either in terms of kind of values, localisation, application, etc. Such dynamics can occur through the use of re-programmable sensors that can be required to send new data (such as temperature) at different rates or through node mobility or through addition of new sensors. The services and objects to be proposed by the discovery services will be dynamically and automatically adapted.
e. Alternative Flows (If any):
N/A

f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
Event-driven
h. Notes and Issues (if any):
N/A

Table 5: Reprogrammable Sensor Discovery Use case UC03

4.3.2.2 Explanation

The VITAL platform is exploited to allow the dynamic discovering of sensors that can be either mobile or re-purposed (if re-programming is permitted). A reprogrammable sensor can be "enriched", with a different functionality by updating its firmware instead of deploying a new sensor. In the scope of WP4, VITAL will showcase platform-agnostic discovery of sensors, ICOs and data streams. A number of relevant validation cases can be:

- Discovery of mobile sensors around end-user's location.
- Discovery of sensors by type and area. Please note that the type of a sensor may change over time if the sensor is reprogrammable.
- Discovery of sensors by application, platform or project involved.

To show these discovery cases, a small application will be provided that allows a user to select the sensors that he/she would like to get information about, e.g. based on the use case for the Developer Reflection Interface (see Section 4.3.1.1).

4.3.3 Use cases for Data Access and Filtering (leader INRIA)

4.3.3.1 Smart Lighting Use Case

Use case Id:	UC04
Use case Short Title:	Smart Lighting

What WP or VITAL Functionality does the Use case address (see conceptual figure):
VITAL Ontology, Discovery Module, Data Access, Filtering
Why is this use case needed to validate the VITAL platform?
In this use case we exploit the ICO discovery and filtering and we will test their effectiveness.

What would the Added Value of such a use case be to the end-user?
A better management of the energy consumption
Who is the intended end-user for the use case?
Public Administration
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
The semantic annotation of the sensors that has been already effectively realized with OpenIoT.
If the use case were to be fully deployed, what would be its details when running
i. Actors (which parties are involved when the use case is running):
VUAIs, CEP, VITAL Applications
j. Trigger (What event or time value or other factor would trigger the use case):
Weather, Lighting Measurements, Pedestrian Detection
k. Preconditions (What pre-requisites does the use case have):
Equipped lamp-posts
l. Normal Flow (What usually happens during the use case):
The trigger activates a kind of “request“, that is managed from the VITAL platform and the system reacts by sending a command message (i.e. switch on the light, etc.)
m. Alternative Flows (If any):
N/A
n. Exceptions to the Normal Flow (If any):
N/A
o. Frequency of the Use case (temporal, event-driven or other):
Event-driven

Table 6: Smart Lighting Use case UC04

4.3.3.2 Explanation

Lampposts are equipped with different sensors that can monitor light and movement. They are powered trough solar cells that provide power during the day thanks to the sun and during the night thanks to the lamps. They allow accurate street lighting based on the natural luminosity and street activity. When the sunlight is sufficient, lampposts are off. When it is not, the intensity of the light will adjust with the traffic and movement detection. If there is no vehicle and no pedestrian in the street, there is no use to light it. This will allow energy saving and decrease the light pollution.

4.3.4 Use cases for Security (leader REPLY)

4.3.4.1 Security policy Use Case

Use case Id:	UC05
Use case Short Title:	Security policy

What WP or VITAL Functionality does the Use case address:
Mainly WP3 but in addition it is transversal to many features.
Why is this use case needed to validate the VITAL platform?
Because it can demonstrate the effectiveness of the developed security model, which is a key requirement of the project.
What would the Added Value of such a use case be to the end-user?
It ensures that user data are not compromised or shared with malicious entities, their storage is safe, and all of the data and high-level features offered by the system can be trusted.
Who is the intended end-user for the use case?
This is related to all of the end-users of the system, i.e. service providers, solution providers, city authorities, citizen and businesses in the city.
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Security protocols, standards and architectures. Experience in validating security solutions in mission critical or commercial deployments is fundamental as well. Reply and Atos, being system integrators, seems to be the best fit. Knowledge of the integrated platforms involved in demonstrating this use case is needed as well.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
End users, integrated IoT platforms, VITAL middleware.
b. Trigger (What event or time value or other factor would trigger the use case):
An actor opens a communication channel with another one and sends or requires data.
c. Preconditions (What pre-requisites does the use case have):
• The system has been deployed. • Identities and certificates are well configured for all of the entities.
d. ***Normal Flow (What usually happens during the use case)***:
• A party starts a communication with another one (i.e.: a platform forwards its

sensed data to VITAL) • The two entities verify their identities and secure the channel • Data is encrypted (and eventually signed) and sent • Data is received, decrypted and elaborated
e. ***Alternative Flows (If any)***:
• A party starts a communication with another one • The two entities verify their identities and secure the channel • A man-in-the-middle attacker intercepts the flow • The attacker tries to decode the data and fails • The attacker injects some data, although he doesn't know the encryption key • Data is received, decrypted and it's found to be corrupted • Data is discarded
f. ***Exceptions to the Normal Flow (If any)***:
The communication link gets broken, data gets intercepted, dropped, or altered
g. ***Frequency of the Use case (temporal, event-driven or other)***:
• Every time there is a data exchange • Every time data is stored in the system
h. Notes and Issues (if any):
The end-to-end guarantees that VITAL will be able to provide across the integrated platforms heavily depend on how these were structured and developed. Interoperability aspects need to be considered.

Table 7: Security Policy Use case UC05

4.3.4.2 Explanation

The VITAL platform will adopt a security policy aimed at ensuring the security of data exchanged between all of the actors of the system, be it end users, the VITAL middleware, integrated platforms or devices. The goal is to provide data integrity and confidentiality, preventing man-in-the-middle or other kind of attacks. If a malicious user or attacker tries to intercept a communication on one of the existing channels, for example a wireless one, the data will be useless to him because it will be encrypted. If the attacker simply alters that data, the system is able to detect it and discard the corrupted data.

Since the information collected by VITAL comes from multiple sources, it can contain user related data. If an attacker gains access to the data repository or to a communication channel, he will not be able to associate data to a physical person or entity, since this will be anonymized and protected as stated by laws, regulations, and common sense rules that will be adopted in the development of the system.

This use case will extend one of the user cases that access data, e.g. use case UC4 (see Section 4.3.3) or use case UC3 (see Section 4.3.1.2), with security support. This also allows to compare use cases with and without security and to evaluate the performance and overhead.

4.3.5 Use cases for Authorization / Authentication (leader REPLY)

4.3.5.1 Authentication and Authorization Use Case

Use case Id:	UC06
Use case Short Title:	Authentication and Authorization

What WP or VITAL Functionality does the Use case address (see conceptual figure):
Addresses the WP3 but in addition is transversal to many features.
Why is this use case needed to validate the VITAL platform?
Because it can demonstrate the security model, which is a key requirement of the project. VITAL will be dealing with a multitude of systems and data streams, with different requirements in terms of security and access rights. For this reason, showing off this capability is a key objective of the project.
What would the Added Value of such a use case be to the end-user?
The end-user can trust the system and be confident that data inserted into it will be treated in the safest possible way. Also, the user can have a custom set of features associated to his identity.
Who is the intended end-user for the use case?
End-users, citizens, city authorities, solution providers, physical devices constituting the network, existing platforms to be integrated.
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Security protocols, standards and architectures. Experience in validating security solutions in mission critical or commercial deployments is fundamental as well. Knowledge of the integrated platforms involved in demonstrating this use case is needed as well.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
End-users, VITAL middleware, integrated IoT platforms
b. Trigger (What event or time value or other factor would trigger the use case):
A user or system requires access to VITAL

c. *Preconditions (What pre-requisites does the use case have):*
• Accounts, certificates or other authentication means have been already configured in VITAL and the peripheral systems. • The parties are able to communicate.
d. *Normal Flow (What usually happens during the use case):*
• A user/platform requires access to the system. • The system requires credentials. • The user/platform sends its credentials. • The systems checks for the correct access level to grant and sends the response. • The user/platform is now authenticated and has a list of authorizations.
e. *Alternative Flows (If any):*
• The system detects wrong credentials and denies access to the user/platform.
f. *Exceptions to the Normal Flow (If any):*
The communication link gets interrupted, the whole procedure is stopped
g. *Frequency of the Use case (temporal, event-driven or other):*
Event-driven, every time a user or system requires access to VITAL
h. *Notes and Issues (if any):*
N/A

Table 8: Authentication and Authorization Use case UC06

4.3.5.2 Explanation

Every actor of the system must be authenticated against the VITAL security modules. This is especially true for human end-users who access the features of the system through web or mobile applications, but it also applies to end systems to be integrated into VITAL. When a user requires access to VITAL, he has to insert his credentials, which can be in form of username and password pair or certificates or any other means. Then, VITAL compares them with the credentials repository and grants a certain level of access, or denies it. Every user/system can have different privileges, expressed in terms of access to specific features or data. Every exchange of information must be accompanied with authorization information. Developing such an authentication-authorization scheme implies developing a SSO (Single Sign-On) system between VITAL and all of the peripheral systems involved. This strategy will help to prevent malicious users to inject fake services or data into the system, or to extract unauthorized data from it. Moreover, it is the means to manage different access levels to users, applications, system administrators, etc.

In this use case we will develop an example application that allows the user to sign in to the VITAL system in order to access data. The application will provide a user interface to do so and will integrate a data access part to showcase authenticated data access.

4.3.6 Use cases for Complex Event Processing (leader ATOS)

4.3.6.1 Smart Meeting and Mobility Use Case

Use case Id:	UC07
Use case Short Title:	Smart Meeting and Mobility

What WP or VITAL Functionality does the Use case address (see conceptual figure):
Complex Event Processing
Why is this use case needed to validate the VITAL platform?
This use case aims to demonstrate processing of events (including CEP) through the combination of data from multiple information sources including information sources stemming from multiple IoT platforms.
What would the Added Value of such a use case be to the end-user?
The use case will be centered round collection and processing of information regarding the activities of several users that are expected participants in a meeting. Correlation of different events associated with the participant's context will take place relating to occupancy, proximity for all participants to the meeting, traffic conditions at selected day/time. Based on the correlation (CEP processing) of this information, the VITAL (sub)system will provide them with information for optimally reaching the meeting facilities base on real time traffic and/or public transport information.
Who is the intended end-user for the use case?
End users, citizens, city authorities, third party companies sharing/renting their facilities for meetings.
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
CEP, Business process modeling, ICOs discovering, Security, Semantic annotation of ICOs
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VUAIs, CEP, Security, Business processes, IoT Service Orchestration.
b. Trigger (What event or time value or other factor would trigger the use case):
User requests, geographical position, network connection establishment, time lines.
c. Preconditions (What pre-requisites does the use case have):
N/A
d. Normal Flow (What usually happens during the use case):
This use case will be implemented and validated in a lab environment. It will rely on

the intial provision of static information about meeting location(s) and participants context. Once an user has started to set a new meeting and fill up the list of participants and attendance mode (in person, remote) and their common location, the application will localize the best facility for the meeting based on the locations and traffic conditions at the selected day/time, to let all in-person attendants reach the meeting facility with the most effective time-cost. A predefined time before the meeting, the application will keep track the geographical position of in-person attendants to suggest the best way to reach the meeting facility, which will be updated on the fly based on changes of the traffic and attendant position changes. If any in-person attendant is not able to reach the meeting facility, will be offered with alternative means to join the meeting remotely.
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
N/A
h. Notes and Issues (if any):
N/A

Table 9: Smart Meeting and Mobility Use case UC07

4.3.6.2 Explanation

This use case aims at showcasing the CEP functionalities of VITAL in terms of correlating and combining information from multiple platforms. Roaming users provide a good option for such a showcase, since they can provide their constantly changing context through various IoT platforms and/or applications in the urban environment.

4.3.7 Use case for cross platform business process orchestration (leader SILO)

4.3.7.1 Smart Cities BPM Use Case

Use case Id:	UC8
Use case Short Title:	Smart Cities BPM

What WP or VITAL Functionality does the Use case address:
WP 4 – Management and Orchestration of IoT-driven Business Processes
Why is this use case needed to validate the VITAL platform?
It demonstrates the operation of the BPM / Orchestration services of the VITAL

platform. The specific use case will present the ability of VITAL to provide parameterized workflows that combine and orchestrate services from multiple connected systems.
What would the Added Value of such a use case be to the end-user?
This is one of the basic goals of the VITAL platform, i.e. to allow orchestration of heterogeneous services and implement dynamic workflows.
Who is the intended end-user for the use case?
Solution providers and city authorities
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Experience in BPM and orchestration of RESTful services.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VUAIs
b. Trigger (What event or time value or other factor would trigger the use case):
N/A
c. Preconditions (What pre-requisites does the use case have):
N/A
d. Normal Flow (What usually happens during the use case):
N/A
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
N/A
h. Notes and Issues (if any):
N/A

Table 10: Smart Cities BPM Use case UC8

4.3.7.2 Explanation

This use case demonstrates the orchestration & workflow management services of the VITAL platform. The goal is to be able to combine data feeds emanating from heterogeneous sensor networks / connected systems, which the VITAL platform homogenizes structurally and semantically, into parameterized workflows. As an example, we can use the BPM/orchestration services to implement the smart lighting use case (see Section 4.3.3.1) or an extended version of the smart meeting use case (see Section 4.3.6.1) in which the system offers a user alternative ways to participate in a meeting in case he/she cannot reach the meeting in time.

4.3.8 Use cases for System Monitoring and Management (leader SILO)

4.3.8.1 VITAL Health Map Use Case

Use case Id:	UC9
Use case Short Title:	VITAL health map

What WP or VITAL Functionality does the Use case address:
WP 5 – Cross-Architecture Management Platform
Why is this use case needed to validate the VITAL platform?
It demonstrates the operation of the management services of the VITAL platform. The specific use case is related to Configuration and Performance management of the FCAPS model.
What would the Added Value of such a use case be to the end-user?
The management layer enables the efficient monitoring and management of the VITAL platform. This is required for supporting uninterrupted and efficient operation of the services and applications built on top of VITAL. The health map provides a tool for getting insight on the overall operational status of the specific VITAL platform instance with more detailed (drill-down) information on the status of specific components/services as well as utilization / throughput information on components and services (internal and connected systems) that offer such information to the platform.
Who is the intended end-user for the use case?
Mostly VITAL Platform Administrators, as well as solution providers and city authorities.
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Experience in network, system and application management, knowledge of the VITAL Platform Architecture and related management instrumentation (services) of the VITAL components.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VUAIs and all VITAL components via management/monitoring hooks.
b. Trigger (What event or time value or other factor would trigger the use case):

A user with monitoring permission enters the health management map view
c. Preconditions (What pre-requisites does the use case have):
The VITAL management platform is operational.
d. Normal Flow (What usually happens during the use case):
The user is presented with an overall health map of the VITAL platform. A visual high level representation of the platform is presented with colour coding that denotes operation status. This is a conceptual topology diagram of the architecture including internal high level components and connected systems. The user may drill down in each component and view more detailed health status information of individual sub-components. As an example, if the user drills down in a specific adapter, the visual representation will provide a view of the operational status of individual functional areas of all supported services, etc. The health map shows the operational status of VITAL components and services and tries to also provide an indication of utilization or throughput for components that this information is available.
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
N/A
h. Notes and Issues (if any):
N/A

Table 11: VITAL health map Use case UC9

4.3.8.2 Explanation

This is a use case that demonstrates in a dashboard-like user interface a group of VITAL management and monitoring services. The specific functionality provides an overview of the health and operational status of the VITAL platform instance. It also demonstrates more detailed views with drill-down analysis and historical data for specific components, services and connected systems.

4.3.9 Use cases for System Monitoring and Management (leader SILO)

4.3.9.1 Platform Accounting Service Use Case

Use case Id:	UC10
Use case Short Title:	Platform accounting service

What WP or VITAL Functionality does the Use case address:
WP 5 – Cross-Architecture Management Platform
Why is this use case needed to validate the VITAL platform?
It demonstrates the operation of the management services of the VITAL platform. The specific use case is related to Accounting of the FCAPS model.
What would the Added Value of such a use case be to the end-user?
The accounting functionality enables detailed monitoring of the usage of the platform by the various solution providers on top of VITAL. It will ensure fairness between hosted applications/solutions and provide a mechanism for safeguarding the quality of service delivered to the end-user. Note that accounting is a pre-requisite for supporting usage-based charging models that would allow a wider range of high quality connected data streams that may follow such models.
Who is the intended end-user for the use case?
VITAL Platform Administrators. Reports generated will be targeted to solution providers and city authorities.
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Experience in network, system and application management, knowledge of the VITAL Platform Architecture and related management instrumentation (services) of the VITAL components.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
VUAIs and all VITAL components via management/monitoring hooks.
b. Trigger (What event or time value or other factor would trigger the use case):
A user with monitoring permission enters the accounting view
c. Preconditions (What pre-requisites does the use case have):
The Vital management platform is operational.
d. Normal Flow (What usually happens during the use case):
The user can view aggregated accounting information on the usage of the VITAL platform for specific date ranges and for specific solution providers. Drill down is supported for viewing information on specific components / services / subsystems.
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A

g. Frequency of the Use case (temporal, event-driven or other):
N/A
h. Notes and Issues (if any):
N/A

Table 12: Platform accounting service Use case UC10

4.3.9.2 Explanation

This is a use case that demonstrates the VITAL accounting model and services offered by the platform. Although the domain model and interaction logic is similar to the “health map” use case, this use case focuses on the recording and analysis of usage data and accounting reporting by the users of the platform. This is an important aspect of the management services since it enables QoS management and usage fairness.

4.3.10 Use cases for Governance Toolkit (leader SILO)

4.3.10.1 City Incident Reporting Use Case

Use case Id:	UC11
Use case Short Title:	City incident reporting

What WP or VITAL Functionality does the Use case address:
WP 5 – IoT Applications Smart Governance Toolkit
Why is this use case needed to validate the VITAL platform?
It demonstrates the usage of the Smart Governance Toolkit for implementing a city wide incident reporting and management application.
What would the Added Value of such a use case be to the end-user?
Leveraged city management efficiency and faster incidents response by the city authorities.
Who is the intended end-user for the use case?
City Authorities, Citizens
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Experience in network, system and application management, experience in rich user interfaces with geographical information.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):

VUAIs
b. Trigger (What event or time value or other factor would trigger the use case):
N/A
c. Preconditions (What pre-requisites does the use case have):
N/A
d. Normal Flow (What usually happens during the use case):
The user can view a geographical view of the city with annotations on incidents with colour coding / icons and drill-down capabilities for viewing detailed information. Data are derived by feeds from typical city wide sensors, social media analysis or direct citizen participation (mobile application for reporting incidents via text, photo and geo-location data).
e. Alternative Flows (If any):
N/A
f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
N/A
h. Notes and Issues (if any):
N/A

Table 13: City incident reporting Use case UC11

4.3.10.2 Explanation

This is a use case for demonstrating the VITAL smart governance toolkit. It is built around a geographic dashboard that provides a layered overview of high level events with drill-down views and linked actions and reports. It is also interesting to demonstrate near real-time mash-ups of citizen feedback.

4.3.11 Use case for Development Environment and Toolkit (leader AIT)

4.3.11.1 Smart Cities Applications Development Use Case

Use case Id:	UC12
Use case Short Title:	Smart Cities Applications Development

What WP or VITAL Functionality does the Use case address:
WP5, with emphasis on application development environments and tools
Why is this use case needed to validate the VITAL platform?
Among the main objectives of VITAL is to ease the development of semantically interoperable applications in smart cities. To this end, a relevant development tool (and an associated development environment) will be developed, showcased and used.
What would the Added Value of such a use case be to the end-user?
Faster accelerated development of smart cities applications at a lower effort and cost
Who is the intended end-user for the use case?
Developers and Integrators of smart cities solutions with strong interest in developing integrated applications in smart cities (i.e. applications spanning multiple IoT platform and silo applications).
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
The OpenIoT project provides a tool for the visual development of IoT solutions at large, which could serve as a basis for a similar tool customized to the needs of smart cities solutions.
If the use case were to be fully deployed, what would be its details when running
a. Actors (which parties are involved when the use case is running):
Solutions developers and integrators, sensors / data streams registered and available within the VITAL repositories (ontologies)
b. Trigger (What event or time value or other factor would trigger the use case):
No specific trigger, the use case is triggered by the developers wishing to develop integrated smart city applications.
c. Preconditions (What pre-requisites does the use case have):
Sensors and ICO's deployment in the city; IoT platforms and applications deployed in the city; Availability of data streams in the VITAL ontology and information repositories.
d. Normal Flow (What usually happens during the use case):
A developer drags-drops sensors/ICOs on a canvas and can visually defining filtering and processing functionalities over the data of these sensors/ICOs. The developer can access tools for producing smart cities information and indicators. The tool generates automatically code that is deployed over the VITAL infrastructure.
e. Alternative Flows (If any):
Integrators can use the visual tools to bootstrap the application development process. Accordingly they can add code to achieve enhanced and/or more customized behaviour.

f. Exceptions to the Normal Flow (If any):
N/A
g. Frequency of the Use case (temporal, event-driven or other):
N/A
h. Notes and Issues (if any):
N/A

Table 14: Smart Cities Applications Development UC12

4.3.11.2 Explanation

In addition to supporting integrated development of IoT applications for smart cities, notably applications leveraging data streams from multiple heterogeneous IoT platforms and applications, VITAL will also work towards facilitating the development of such integrated applications and use cases. To this end, it will provide a set of integrated visual tools, which will support developers and integrators of smart city solutions in the design and implementation of VITAL-based applications. The use case specified above aims at showcasing that VITAL developers will be able to use a visual tool in order to access and process the outputs of VITAL sensors and data streams regardless of their source IoT platform. The tools will primarily facilitate the definition of sensor-based queries, notably queries leveraging information from multiple information sources and data streams. This will be empowered by the VITAL virtualization paradigm, which will render access to multiple distributed virtual sensor as easy as querying a distributed database.

5 INTEGRATED SCENARIOS IN CAMDEN CITY

5.1 Overview and Purpose

Following the presentation of the basic use cases outlined above, this chapter focused on the presentation of an integrated scenario, which will drive the deployment and demonstration of the VITAL platform at the Camden borough of London. The integrated scenario will be taking advantage of several of the functionalities of the VITAL platform, including the functionalities reflected in the basis use cases.

Note that the specification of the integrated scenario has been also driven the requirements and needs of the cities, as the latter have been reflected and documented in the requirements engineering process of the second workpackage of VITAL. Furthermore, in order to ensure the feasibility of the integrated scenario (i.e. in terms of its actual implementation and deployment), the available data sources/ data feeds in the city have been taken into account in order to define the scenario. Note that in principle it is possible to simulate data feeds as part of a validation scenario or use case. However, reliance of real-life data feeds provides a sound basis for the more realistic implementation and with a higher potential for exploitation and sustainability. Therefore, VITAL has opted to strongly consider existing sensors, data feeds and applications available at Camden.

Prior to introducing the integrated scenario and use cases, we briefly review the application areas and needs identified as most important for the Camden borough by the relevant parties. At the same time, we also review the available data feeds, which have been taken into account towards defining the scenario.

5.2 Application areas identified by stakeholders

Based on the input that the project stakeholders have provided in the relevant questionnaires (see [VITAL-req-13]), the preferred sectors of application in a validation scenario for Camden were:

- From the viewpoint of city officials security and disaster prevention scenarios have been prioritized as most important, while traffic and transport management was selected as the second priority.
- From the viewpoint of the citizens living or working in the Camden borough, security and disaster prevention was again deemed as top priority, while the provision of assistive applications for citizens was identified as second top option.

The identification of the above-listed applications areas has guided the definition of the integrated scenarios for Camden which are illustrated below.

5.3 Available Data Sources

In terms of live feeds the available data sources for Camden include:

- **Cameras (Security)**: CTU has access to the data produced by the CCTV application, not the physical sensors (cameras).
- **Footfall counters**: Head count as in pedestrian cases.
- **London TFL (Transport For London)**: Open Data set provided by TFL.
- **Weather Condition Sensors**.

These can be enriched on the basis of the following static datasets:

- **Camden Council Data (demographics and statistical)**.
- **Business Directory (used to calculate financial contributions of business members)**.
- **Waste Management Information**.

In addition to the above-listed available data sets there are other types of physical sensors that could be added to local sites with special relevance to a scenario. For example, internet-linked low-cost sensors, co-funded by Google (owners of the sensor company NEST) could be used for real-time risk-monitoring as part of security and disaster prevention. Such sensors can provide live data on noxious gases, temperature, moisture, water level, unauthorized access and ingress by vermin (e.g., rats biting through wires). The use of these additional sensors can serve as a basis for enhancing the validation scenario presented in the sequel.

Overall, the aim of the proposed validation scenario is to combine as many of the above as possible based on meaningful metadata and queries, which address the needs of the end-users (including both authorities and citizens).

5.4 What is the need, the problem to be solved and the added value

The project is to create a Camden Town-specific data hub relevant to Internet of Things and Smart Cities, which can be used to demonstrate ways for smart cities to deploy their data sources to meet both routine information needs (e.g., hourly monitoring of dangerous oxides of nitrogen at street level) and short-term/emergent needs (e.g., early spotting and subsequent tracking of a significant event affecting safety and/or travel).

In studying different modes of deploying/analyzing data, we shall add value by taking a lifecycle approach that can be emulated in other smart cities, for example:

- **Initiation**. Developing and evaluating processes to accommodate new data sources (e.g., new types of sensor, as above) and new queries, and to enhance the analytics accordingly.
- **Maintenance and Archiving**. Updating historic data, to take account of new editions of metadata and new versions of associated archiving processes.

The Camden Town character of the data hub is determined / reinforced by availability, selection and creation of available data sources within the Camden area.

We intend to use the VITAL platform (and prototypes leading up to) to make the hub available specifically to smart city app developers in Camden Town (The Collective and local creative businesses) (encouraging local development), so developing a hub of smart city developers.

The outcome will be previously non-existent and non-imagined smart city applications focused on:

- **Critical Infrastructure and Related Challenges** (branding: Camden Town as Safe City) and/or on
- **Liveability and Funkiness** (branding: Camden Town as the creative business hub of London).

Moreover, we aim to encourage Camden smart city developers and key stakeholders such as insurance companies to undertake joint projects with their counterparts in Istanbul.

5.5 Concepts and Functionalities

The development of the integrated scenario is based on the integration of the following concepts and functionalities, which include a blend of application functionalities associated with activity monitoring and visualization for security and transport management purposes.

5.5.1 Camden «HeatMap» Concept and Functionalities

By combining specific ideas presented by stake holders in the “free text” input boxes of the questionnaires, concepts used in other reference smart cities and the available data feeds, we deduce that a first step towards combining all the above into a meaningful validation scenario is creating a color coded live “heatmap” of pedestrians and vehicles by collecting fine-grained data on a given geographical area. This heatmap should be the basis of historic and moment-by-moment comparisons (essential to spot the characteristic signatures of possible emerging problems in policy-relevant domains like security, safety, transport, logistics and other needs of citizens and local businesses. All validation scenarios and multiple layered filters to be applied should have the heatmap as a starting point of live data.

5.5.2 Layered Filtering & Application Queries Concept and Functionalities

Monitoring traffic (pedestrian and vehicles), public transport, safe shopping, a Business Improvement District (multiple stakeholders), Monitoring as per disaster plans and relevant simulations as well as Balancing loads on public and private transport are all possible applications that were proposed by stakeholders in the relevant questionnaires. Taking this further, an initial idea is to create the following possible queries:

- **Traffic and Activity at Camden**: Camden is well known for its markets (a major tourist attraction at weekends), but also for its night-time economy. Camden Town has a large cluster of land uses and licensed premises including restaurants, cafes and takeaways, pubs and bars, music and other entertainment venues. These have variations in traffic at different intervals during the day (morning for market, evening for cafes, night for clubs etc.) and also weekdays vs weekends and other temporal divisions. Filtering time stamped data on the live traffic heat-map and trying to find correlations with particular venues is a possible first step. Patterns of activity, average time spent per venue etc. are also quite interesting.
- **Patterns of Activities and Impacts**: Spatial and temporal patterns of activities and impacts (street cleanliness, crime, anti-social behaviour and street noise, street drinkers and drug dealers) could be the next obvious queries that should be correlated with the live traffic heatmap.
- **Pedestrian Flows and Business Data**: Pedestrian flows and headcount/footfall (per day, hour, street, etc.) could be used to calculate entrances and exits to/from shops, restaurants and other venues as depicted on a map. By combining with the available “Business Directory” data, and even sales data (if venue owners wish to share these in the future), traffic and sales projections per venue could be derived, broken down per hour of the day, per time window (weekday, month etc.), according to weather conditions, according to specific incidents or major events, per street, per city sector etc. Moreover traffic is a good starting point to estimate adjusted rental rates for venues. The matters of privacy concerning cameras and footfall have been raised by project stakeholders and special care should be taken.
- **Waste Management Monitoring**: Based on the “traffic heatmap” a correlation with garbage / waste gathered per point and per day can be derived using the available waste management information and optimization scenarios could be drawn. We expect street cleanliness to coincide broadly with pedestrian flows.
- **Transport Information (smart transport)**: TFL OpenData is available for our purposes and we strongly believe that it should be used. Camden is surrounded by Regent’sPark, Fitzrovia, Somers Town, Kings Cross, Islington, Holloway, Kentish Town and Belsize Park whose travel data is available. Kentish Town Rail Station, St Pancras and Euston stations are nearby. Tube, buses, night buses and even taxis and licensed mini-cabs could be accounted for. Combining transport data (example arrivals), balancing loads on public and private transport and extracting how travel patterns vary per time-stamp is the first step. Comparing with the color-coded heatmap of pedestrian flows could be the second step. As an extension, demand for night buses, busiest times and the busiest routes, identification of taxi touts, unlicensed minicabs are possible queries for the heatmap. How all the above vary according to weather is another issue to look for.
- **Citizen security Information (smart security)**: Citizen security is of utmost importance, and a live heatmap of relevant data such as traffic (pedestrians and vehicles) would be extremely useful for disaster prevention and evacuation plans for cases such as the Camden fire (February 2008) or other extreme cases (riots, terrorism, violent weather phenomena etc.).

5.5.3 Stop food waste concept

The scenario assumes that local supermarkets and restaurants are running a self-policed scheme to donate currently-discarded food in a safe way, which helps to stop food waste and is focused on needy local people and groups. Such a scheme could have its own code of conduct and processes. It would need participation of key stakeholders in the BID (e.g., police, Camden health and safety, citizens' groups).

Technically, the concept is to establish a map showing the location of each registered participant in the scheme. This could be turned into a heat map by adding live data to show details of the food donation, and how much of their donation still remains. The live data can come from scanning a food-waste bar code developed by CTU.

To prevent criminality (e.g., re-packaging donations with new dates) and other abuse (e.g., the first-comer takes all the food), the scheme would need some way to fairly allocate donations to local people (e.g., a registration scheme and/or a smart card).

This concept could be integrated with a disaster scenario (limited food stocks have to be allocated fairly and efficiently

5.5.4 Recycling concept

This in an advance on the UK's FreeCycle scheme: (online advertising of goods that are "free to collectors"). The Camden heatmap shows the real-time location of donated objects and also the location of volunteers who can demonstrate how to use the object and/or who can help to repair or modify donations that have a fault.

This concept could be integrated with a disaster scenario (manufactured objects may be hard to replace, so need to be kept in use for as long as possible).

5.6 Integrated Scenario Presentation - Full Use Case Description

A full use case presentation follows with full description of attributes in tabular form in Table 15.

Scenario Id:	SC01
Scenario Short Title:	Safe and Livable
City:	Camden

1. What WP or VITAL Functionality does the Scenario address (see conceptual figure):
VITAL Ontology, Discovery Module, Data Access, Filtering
2. Why is this scenario needed to validate the VITAL platform?
Combines known fixed sensors and crowd-sourced sensors 'there at the time'
3. What would the Added Value of such a scenario be to the end-user?
Provides resilient local real-time data, including data from within any local crowds

(which could be at or near the source of the security/safety issue)
4. Who is the intended end-user for the scenario?
Local citizens (residents); visitors (tourists and shoppers); people trying to find a safe place; people passing through as fast as they can; local businesses, police and care services, public administrations; sensor owners who could be directed to go to a particular location to provide data
5. What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
Semantic annotation of data from any known fixed sensors.
6. Which datafeeds present in the city will be used in this use case
Traffic, emergency services
7. Are there any metrics or KPIs that will assist in evaluating whether the use case was successful or not ?
Performance in civil defence trials, compared to previous trials
8. Are there any legal, privacy or security issues to consider for the use case?
Must follow 'need to know' and 'managed disclosure' protocols for disclosing the plans, emergency processes, systems, sensors, communication channels, and contingency procedures of public agencies and major locations e.g., Civil defence, police, fire, ambulance, shopping mall safety teams.
9. If the scenario were to be fully deployed in the future, what would be its details when running
a. Actors (which parties are involved when the scenario is running):
Live data (heat maps) available routinely to security camera operators and other authorised people across the district
b. Trigger (What event or time value or other factor would trigger the scenario):
Event-driven: civil defence practice or actual happenings, including serious accidents, fires, explosions, floods, riots and disasters
c. Preconditions (What pre-requisites does the scenario have):
Affects sensors in more than one street; spreads faster than the response time of emergency services (like ambulances)
d. Normal Flow (What usually happens during the scenario):
The problem comes under control; fall in % of serious reports from sensors
e. Alternative Flows (If any):
Some sensors must have a secondary data channel to avoid common mode failures
f. Exceptions to the Normal Flow (If any):
Becomes out of control, new types of sensor are needed (e.g., to monitor fumes),

local sensors are re-programmed to provide needed functionality
g. Frequency of the Scenario (temporal, event-driven or other):
Event-driven, also periodically-checked
h. Notes and Issues (if any):
N/A

Table 15: Camden Integrated Scenario SC01

6 INTEGRATED SCENARIOS IN ISTANBUL

6.1 Overview and Purpose

Similar to the case of Camden, an integrated scenario is proposed for development and validation in the city of Istanbul, as a means of showcasing and validating the VITAL platform functionalities in real-life urban environments. This integrated scenario is also driven by end-users' requirements and needs identified and expressed in the scope of the requirements engineering process of the project. As in the Camden case, end-users include citizens and the city authorities. Furthermore, the specification of the integrated scenario at Istanbul takes into account the available data sources (including live feeds) in the city, in order to be as feasible and exploitable as possible. Following paragraphs illustrate the above-mentioned needs and data sources, which are among the main drivers of the scenario.

6.2 Application areas identified by stakeholders

Based on the input that the Istanbul project members and stakeholders have provided in the relevant questionnaires, the preferred sectors of application in a validation scenario for Istanbul are slightly different compared to Camden:

- From the viewpoint of city authorities, traffic and transport management applications are the top priority, while smart security is a second priority.
- The citizens' viewpoint is exactly the same, yet smart security was ranked somewhat higher.

The above need is fully in-line with the original intentions of the IMM and ITU partners, when joining the VITAL project, given that Istanbul faces the challenges of severe traffic, which have adverse implications in the transportation services and the commuting of the citizens. Naturally, the integrated scenario is focused on employing available data-feeds and technologies, towards a validation scenario that addresses traffic and transport solutions, which are a priority as part of smart city implementations.

6.3 Available data sources

According to numerous inputs received through "ibb.gov.tr" officials, engineers, transportation planners etc. the datafeeds available for usage in our case, are as follows:

A) Basic Live Datafeeds

- 500+ traffic cameras (PTZ and 360 rotation capability, on 20m poles);
- 500+ road sensors;
- 250 Bluetooth sensors;
- 35 weather sensors.

Initially, demo data will be provided for the purposes of the project. At a later stage, real data can be released. A request for this data has already been made to the local authorities.

B) Traffic-related Systems available at Istanbul:

In addition, a number of traffic-related systems are available as shown in Table 16. Note that the numbers listed in the table are subject to change, due to new installations, but also due to failures/problems with existing deployments.

System	Number
Variable message boards on Istanbul's highways.	40+ (likely to become 70 during the course of the project
Remote Traffic Microwave Sensor (RTMS)	400+
Bluetooth Sensor	250
TERRA	18
TERRA Tunnel	145
Smart Sensor	11
Wireless Magnetic Sensors	50
Loop Detectors	1229
Traffic Cameras	564
Electronic Violation Detection System (EVDS)	338
Variable Message Signs (VMS)	20
Lane Control System (LCS)	22
Online Signalized Intersections	1993
Weather Observation Sensors	35

Table 16: Type and Number of Traffic-related Systems available at Istanbul

C) Services Present:

- tkm.ibb.gov.tr (Official Web Site).
- Traffic Density Map (50,000 visitors per day).
- IMM Mobile Traffic (1.5 million iPhone users .& 750K Android users)
- its.ibb.gov.tr (failure reporting and tracking)
- tkmcocuk.ibb.gov.tr (TCC Children awareness Web Site).
- EDS (Traffic Enforcement System).

- Travel Time Estimation Services (TCC apps).
- Location/speed data of mobile applications' users and fleet management systems. These applications keep privacy rights of the users.

6.4 Subset of Data Sources (feeds) that can be used for validation

IMM Traffic Department has various data sources for collecting live traffic information and for publishing it to the general public. Since IMM allocates a considerable amount of its budget to maintaining different data source systems, all the collected data that is published on Traffic Department's web site, on mobile phone traffic apps, on TV channels, on smart TV apps is proprietary data of IMM.

For the validation and demonstration of VITAL project, IMM can provide live or historic data to feed into the VITAL platform and may use the VITAL platform to easily carry out its current software development and management tasks if the consortium agrees. Without prior written permission of IMM, the provided data cannot be used in any applications by any parties.

Below are some of the data sources that IMM can provide and that could be used for creating use cases:

- **Announcements Data**: Type of announcement (road work, accident, local event, news, etc.), GPS location (if any), title, description, expiration date, effect to traffic (i.e. high, low, etc) info are provided as announcements data.
- **Traffic Measurement Sensor Data** (Physical Sensors' Data):
    - Metadata: Sensor Type: Radar-based sensor, image processing sensor, GPS location of sensor, # of directions which sensor feed data, etc
    - Data: average speed measured, average occupancy measured, traffic volume counted, etc.
- **Mobile App Sensor Data**: Those are traffic measurement data collected from mobile application users of IMM's traffic app. They are collected separately from iPhone and Android users of the app. We get GPS location, traffic speed from those mobile app users.
- **Fleet Management Sensor Data**: Those are traffic measurement data collected from fleet management system of IMM and its subsidiary companies. Currently, four different fleet management system data is collected. We get GPS location, traffic speed from those fleet management data..
- **Traffic Camera Screenshots**: Screenshots obtained from IMM's traffic cameras could be fed to VITAL platform to show current traffic status.
    - Metadata: Camera GPS locations, direction info
    - Data: Camera screenshot
- **Weather Data**: Weather temperature/Felt temperature/asphalt temperature, wind speed, surface status (raining, snowing, etc), humidity, etc are collected by IMM

- Metadata: Weather station GPS locations
- Data: temperature, humidity, etc.

- **Bluetooth Sensor Data:** Those sensors are used for calculating travel time between source and destination points in Istanbul.
  - o Metadata: Sensor GPS locations.
  - o Data: Travel time between predefined links.

6.5 What is the need, the problem to be solved and the added value

The above leads us to three conclusions:

A) Istanbul, being the third-largest city in the world by population “within city limits” (14mil), has a very intense traffic problem (one of the worst traffic congestion indices globally with 57% according to TomTom's analysis – Nov 2013). Indicative data has been presented in deliverable D2.1.

B) A very large effort and investment has been made by local authorities and as far as information and prediction are concerned, the progress of systems available is admirable.

C) Yet, the traffic problem persists and the datasets available, approach the definition of “Big Data” with all the inherent difficulties that this poses in managing and handling.

We divide the expected output of the systems at hand in the following categories:

- **Information**: Information is useful but only tells what is happening now without providing much of a solution.
- **Prediction**: Based on algorithms and simulations, travel time data, traffic estimation data and re-routing can be accomplished.
- **Action**: What can really be done with all this data.

Istanbul Authorities have devoted significant effort and resources in the first two categories and are already offering high quality solutions with millions of users. Yet, the challenge that VITAL should meet, is to proceed in proposing solutions instead of mere ascertainment and verification of the problem based on the datafeeds. Given the availability of the above data, the challenge is to process them in a way that can lead to meaningful conclusion and knowledge. This is essentially a «BigData» problem given that the dispersed data is extremely difficult to handle and real-time calculations are very intensive.

Estimated travel time for long trips and for dense traffic situations has not been fully accomplished yet (according to stakeholder input in questionnaires). For this purpose, the usage of Bluetooth sensors has recently been introduced in Istanbul, yet this also increases complexity and in stakeholder’s words “spreading its usage, gaining the know-how and adapting this system to current ITS applications in Istanbul require some time”. Traffic information on interior arterials (FCD-Floating Car Data) can only be gathered via vehicle tracking systems. This brings another problem: collecting the distributed data. Different authorities in Istanbul have different rights to access different types of fleet management system data, hence IMM has to develop its own solutions to collect this distributed data and to integrate it into its current systems.

6.6 Concepts and Functionalities of the Integrated Scenario

6.6.1 Layered Filtering – Transport Management Queries

In the questionnaire respondents words: “TCC endeavors to deploy solutions which not only fuse heterogeneous data to provide real-time traffic data but also to archive data properly to be utilized as historic data for traffic prediction applications.”

We hence propose the development of a Data Mining toolset that will implement a subset of the following processing functions:

- Data Fusion Algorithms.
- Sensor Fusion Algorithms.
- A/B Testing and other data reduction technologies.
- Data Mining, and Analysis of Massive Distributed Data Sets.
- Decision Fusion of Separate Data-mining Subsystems on Multiple Data Sources.
- Assigning importance weights (live adjustment).
- Other advanced Statistics and Recursion Algorithms
- Caching, Archiving etc.

Based on the above-listed processing, a data processing/reduction toolset could be implemented, which should be the basis towards a “reduced dataset of live datafeeds” and which in turn will be the input for all IoT-enabled traffic management services to be designed. At a later stage (as a pilot) these services can be implemented, deployed, and evaluated. Initially they can be used towards planning, monitoring, controlling and even influencing traffic on top of the VITAL virtualization layer for Istanbul but can also be the basis for similar applications in other interested cities. A “reduced meta-data set” including the same condensed information allows for the following easier queries and processes:

- Fused and condensed meta-data do not necessarily include raw data which are “Sensitive” in terms of privacy for disclosure to third parties who have commercial or other concerns.
- General Urban Planning Queries (Ex. Where should the next Metro Station or Public Parking space be built, which traffic light adjustments or one-way street re-designs are optimal, which spots would be best for possible toll stations as in the center of London example etc.).

- Easier spatio-temporal filters (just as in the Camden case). Regions, dynamic lines (roads in our case), geographical tiles and polygons, correctly filtered temporally (per time windows or time series) can all be implemented. The same query set with Camden can be adopted with minor modifications.
- Sensor Network Re-design (i.e. which cameras, feeds and sensors are used mostly in the fusion process, and which less employed ones can be re-located to more appropriate positions).
- How is traffic in the City varying (spatio-temporally) according to weather conditions (usage of existing weather sensors). What infrastructure actions (ex. Rain water drainage systems) can be proposed in which positions. How the average travel time (currently 49 mins according to authorities input) is varying with weather changes etc.
- Which regions (geo-tiles) seem to present the largest bursts of traffic per time-window (ex. During the last X months or during massive events or even darwing comparisons before/after a large venue such as a shopping mall was introduced). Moreover, how registered vehicles vary per geo-tile and what is their most common destination geo-tile.

6.6.2 Layered Filtering of Announcement Data

Filtering for different criteria could be performed on announcements data. Moreover, locations where a high number of accidents occur could be extracted and visualized by VITAL tools.

6.6.3 Fusion of Fleet Management Sensor Data

Currently, IMM has its own software to fuse data coming from above-mentioned data sources and publishes it with its apps. The VITAL platform can fuse data coming from these data sources and can do complex event processing or spatial analysis such as identifying the mostly congested regions during peak hours. Congestion distribution of different locations of Istanbul could be extracted by VITAL tools based on different time intervals.

6.6.4 Making the traffic more fluid

Based on data coming from traffic camera, traffic measurement sensor data, VITAL will add intelligence to the highways through the production and display of warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams. Whether an accident occurs on the highway, the immediate and opportunistic reaction with warning messages will allow the correct management of the traffic by avoiding side-effects like crowding, etc. This could also be coupled with pollution and weather sensors and adapt the speed limitations to the pollution level.

6.6.5 Weather and traffic data correlation

Weather data, traffic data and Bluetooth sensor data can be analysed together to observe how traffic is affected by weather conditions, which routes become congested; correlations could be extracted (variation according to weather conditions).

6.6.6 Other concepts

Traffic estimation & re-routing could be made using VITAL platform. Urban-planning queries such as where should the metro station or public parking area be built, where traffic light adjustments are needed, where one-way street re-designs are optimal etc.

6.7 Integrated Scenario Presentation - Full Use Case Description

A full use case presentation follows with full description of attributes in tabular form.

Scenario Id:	SC02
Scenario Short Title:	Integrated VITAL Validation Scenario in Istanbul
City:	Istanbul

What WP or VITAL Functionality does the Scenario address:
It addresses functionalities to be developed in WP3, WP4, WP5 and WP6 and the reference Architecture concept. For the validation of WP3's functionality, VUAIs could be developed for generating interfaces to be utilized by IMM authorities and VITAL partners to visualize analysis results. For the validation of WP4's functionality, CEP, Data Access & Filtering and Discovery Module could be performed within the context of the scenario. For the validation of WP5's functionality, IMM may use VITAL Development Environment and Tools to carry out its current tasks easily or develop custom applications on top of VITAL platform. For the validation of WP6's functionality, a mobile application could be developed to be used by citizens, which is a common way of dissemination of services provided by IMM.
Why is this scenario needed to validate the VITAL platform?
It is needed because it will enable to demonstrate the functionalities provided by the VITAL platform in a pilot area, the city of Istanbul, which is one of the most congested cities in the world. Further, it will allow developers of the VITAL platform to observe the efficiency of the overall system in a real environment and see whether non-functional requirements of VITAL are satisfied. Local authorities of IMM will be willing to share as much of their data as possible for VITAL's validation activities.

What would the Added Value of such a scenario be to the end-user?
It may provide analysis and prediction results to end-users which could be used for scientific research. Citizens of Istanbul may plan their travels based on predictions/suggestions of VITAL platform and also can have an idea about traffic status for a future date. Considering sensor network-redesign suggestions of VITAL may enable users of the system to obtain traffic data from a wider range. Provision of real-time travel times on road segments in a mobile app will be quite interesting and helpful for drivers. Based on the statistics obtained some conclusions can be reached and congestion reducing precautions can be taken.
Who is the intended end-user for the scenario?
The intended end-users of the scenario is both citizens in Istanbul and the IMM traffic department
What specific know-how from which VITAL partner is needed? (previous projects, expertise field etc.)
The scenario will make use of the VITAL platform and there involves all partners that will contribute to its development and deployment at the cities.
Which datafeeds present in the city will be used in this use case?
Traffic data obtained from radar/image processing sensors, fleet management systems will be used. Travel time data obtained from bluetooth sensors, weather data obtained from weather observation sensors and announcements data will also be used.
Are there any metrics or KPIs that will assist in evaluating whether the use case was successful or not ?
For traffic prediction, it could be compared with real traffic data and prediction accuracy could be measured.
Are there any legal, privacy or security issues to consider for the use case?
All data provided by IMM should be kept securely within the VITAL platform and shouldn't be shared with third-parties except the developers of the platform.
If the scenario were to be fully deployed in the future, what would be its details when running
a. Actors (which parties are involved when the scenario is running):
- Citizens of Istanbul who are using the developed mobile app - IMM traffic department personnel who are running the internal queries and doing analysis.
b. Trigger (What event or time value or other factor would trigger the scenario):
Whenever the mobile app starts, it will trigger the real-time scenario; not based on a

specific time. When IMM authorities run the queries or do analyses, scenario will execute; not based on a specific time.
c. Preconditions (What pre-requisites does the scenario have):
IMM provides real-time data all the time without service outage.
d. Normal Flow (What usually happens during the scenario):
- A mobile app user gets real-time traffic info, gets traffic prediction info, route suggestions for arriving at his/her destination or suggestions when to start his/her travel. - IMM personnel using VITAL platform will be able to run queries or do visual analyses easily using VITAL tools without having to resort to any other platform. For example, below queries will be easily run by any IMM personnel without having to know relations between data sources: • How is the traffic in the City varying (spatio-temporally) according to weather conditions. • How the average travel time is varying with weather changes etc. • Which regions (geo-tiles) seem to present the largest bursts of traffic per time-window. • Locations where the number of accidents are high. • Congestion distribution of different locations of Istanbul. Furthermore, a set of strategic level (planning level) queries will be implemented in order to extract data that will provide insights for the redesign of the sensor network, as well as for urban planning.
e. Alternative Flows (If any):
There is no alternative flow.
f. Exceptions to the Normal Flow (If any):
When real-time data couldn't be fed into the system, mobile app will not be able to present it.
g. Frequency of the Scenario (temporal, event-driven or other):
It will be used whenever citizens run the mobile app. Since there is a widespread use of IMM's traffic apps, it has the potential of being widely used by public.
h. Notes and Issues (if any):
A wide range of different functionalities are listed in the use case above. These will be subject to access to the datasets (i.e. depending on the availability of the technical means/interfaces for accessing the datasets through the VITAL platform). Therefore the integrated scenario is likely to be further refined in the light of upcoming developments of the project, such as the definition/specification of technical interfaces.

Table 17: Integrated VITAL Validation Scenario in Istanbul SC02

7 LEGAL CONSIDERATIONS

7.1 Overview and Purpose

Smart city deployments should always consider the ever important privacy and data protection aspects, as well as other legal considerations which are essential for any practical deployment of IoT or multi-sensor application in a city. In the scope of the project, four specific aspects are specially taken into consideration when analyzing legal considerations for the VITAL platform:

- Data protection - with special attention to personal data,
- Data retention and reuse,
- Responsibility in data processing and data Ownership,
- Privacy by design.

Following paragraphs elaborate on these aspects, which will be taken into account in the VITAL platform and applications implementation in the following ways:

- The VITAL applications should comply with relevant rules and regulations associated with data protection, data processing and data ownership. Applicable laws, rules and regulations include both EU and national laws (i.e. laws and directives applicable in UK and Turkey where the VITAL applications will be deployed).
- The VITAL platform should provide facilities for customizing VITAL applications to different operational environments where different legal considerations are in-effect. The VITAL governance tool is the natural place where such facilities/utilities could be implemented.

VITAL commits to take into account the considerations analyzed below, in order to ensure that its developments are ethical, privacy-friendly and in-line with rules and regulations at both national and EU levels.

7.2 On Data Protection

European Directives together with national legislation on data protection from Member States rule in this case. Special protection is addressed to ***personal data***, that is, “any information relating to an identified or identifiable natural person”. Data are considered “personal data” “when someone is able to link the information to a person, even if the person holding the data cannot make this link”[1].

The ***Data Protection Directive*** (***Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free***

[1] *Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free movement of such data*,

http://ec.europa.eu/justice/dataprotection/document/review2012/com_2012_11_en.pdf

movement of such data) regulates the processing of personal data regardless of whether such processing is automated or not, within the European Union.

The directive intends processing as "any operation or set of operations which is performed upon personal data (collection, recording, organization, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, blocking, erasure or destruction)".

The Directive states that personal data should not be processed at all, except when certain conditions are met. These conditions fall into three categories: transparency, legitimate purpose and proportionality[2].

It also states that the data subject has the rights:

- to access all data processed about him
- to demand the rectification, deletion or blocking of data that is incomplete, inaccurate or isn't being processed in compliance with the data protection rules.
- to object at any time to the processing of personal data for the purpose of direct marketing

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[2] *1. **Transparency**: The data subject has the right to be informed when his personal data is being processed. The controller must provide his name and address, the purpose of processing, the recipients of the data and all other information required to ensure the processing is fair. Data may be processed only under the following circumstances:*

- *when the data subject has given his consent*
- *when the processing is necessary for the performance of or the entering into a contract*
- *when processing is necessary for compliance with a legal obligation*
- *when processing is necessary in order to protect the vital interests of the data subject*
- *processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller or in a third party to whom the data are disclosed*
- *processing is necessary for the purposes of the legitimate interests pursued by the controller or by the third party or parties to whom the data are disclosed, except where such interests are overridden by the interests for fundamental rights and freedoms of the data subject. The data subject has the right to access all data processed about him. The data subject even has the right to demand the rectification, deletion or blocking of data that is incomplete, inaccurate or isn't being processed in compliance with the data protection rules.*

2. ***legitimate purpose:*** *Personal data can only be processed for specified explicit and legitimate purposes and may not be processed further in a way incompatible with those purposes.*

3. ***Proportionality****: Personal data may be processed only insofar as it is adequate, relevant and not excessive in relation to the purposes for which they are collected and/or further processed. The data must be accurate and, where necessary, kept up to date; every reasonable step must be taken to ensure that data which are inaccurate or incomplete, having regard to the purposes for which they were collected or for which they are further processed, are erased or rectified; The data shouldn't be kept in a form which permits identification of data subjects for longer than is necessary for the purposes for which the data were collected or for which they are further processed. Member States shall lay down appropriate safeguards for personal data stored for longer periods for historical, statistical or scientific use.*

The Directive also regulates - through Article 8 - specific restrictions that apply for data processing on sensitive personal data related to religious beliefs, political opinions, health, sexual orientation, race, membership of parties and organizations.

Regarding automatic processing of data, the Directive states that a decision which produces legal effects or significantly affects the data subject may not be based solely on automated processing of data, and a form of appeal should be provided when automatic decision making processes are used (Article 14).

7.3 On Data Retention and Reuse

Directive 2006/24/EC of the European Parliament and of the Council of 15 March 2006 on the retention of data generated or processed in connection with the provision of publicly available electronic communications services or of public communications networks and amending Directive 2002/58/EC sets the rules for data retention in the European Union, together with national legislation.

According to this Directive, Member States shall ensure that communications providers retain, for a period of between 6 months and 2 years, the data needed:

- to trace and identify the source of a communication;
- to trace and identify the destination of a communication;
- to identify the date, time and duration of a communication;
- to identify the type of communication;
- to identify the communication device;
- to identify the location of mobile communication equipment.

The data is required to be available to "competent" national authorities in specific cases, "for the purpose of the investigation, detection and prosecution of serious crime, as defined by each Member State in its national law"[3]. This directive sets the rules for fixed telephony, mobile telephony, Internet access, Internet email and Internet telephony. A report evaluating the Directive was published by the European Commission in April 2011[4].

Intellectual and industrial property rights of the specific country where VITAL platform is used, including that referred to the data collected by sensors, should also be considered when addressing data reuse. In case of public open data, the Directive on the re-use of public sector information (Directive 2003/98/EC) rules.

[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006L0024:en:NOT

[4] *A report evaluating the Directive was published by the European Commission in April 2011.* http://ec.europa.eu/commission_20102014/malmstrom/pdf/archives_2011/com2011_225_data_retention_evaluation_en.pdf

7.4 On Responsibility in data processing and data Ownership

The ***Directive on Data Protection*** (Directive 95/46/EC) and the proposal to reform the data protection opened in 2012 with the Proposal - known as the General Data Protection Regulation- will rule - together with national legislations and Service Level Agreements – SLAs- among the parties- regarding both responsibility and ownership.

Responsibility on the data flowing through or generated by an IoT platform relies on the platform´s owner.

““The responsibility for compliance rest on the controller, meaning the natural or artificial person, public authority, agency or any other body which alone or jointly with others determines the purposes and means of the processing of personal data” [5]

The ***proposed new European Union Data Protection Regulation*** (a draft for which was unveiled in January 2012) extends the scope of the EU data protection law to all foreign companies processing data of European Union residents.

Responsibility could be shared through specific SLAs with the sensor owners providing the data or, in the case of VITAL, with the platforms feeding data to VITAL.

Regarding ownership, the 2012 reform proposal on a *data user-centric approach* is similar to some approaches given to data ownership within the Internet of Things, where this is still an open issue. Actor´s like Pachube/Cosm promoted and shared in the Open Internet of Things Assembly held in London, 2012, “The Internet Bill of Rights”[6]

1. People own the data they (or their "things") create
2. People own the data someone else creates about them
3. People have the right to access data gathered from public space
4. People have the right to access their data in full resolution in real-time
5. People have the right to access their data in a standard format
6. .People have the right to delete or backup their data
7. People have the right to use and share their data however they want
8. People have the right to keep their data private

At the same time, the “user-centric” tendency in the IoT ecosystem, is deriving towards putting more emphasis on transparency, access to data and securing interfaces to the data sensors than in ownership itself[7].

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[5] *Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free movement of such data, http://ec.europa.eu/justice/dataprotection/document/review2012/com_2012_11_en.pdf*

[6] *http://postscapes.com/open-internet-of-things-assembly*

[7] *http://www.hiig.de/en/symp/internet-of-things*

7.5 On Privacy by Design

Article 33 of the ***Data Protection Directive*** (Directive 95/46/EC) should be considered since the design phase of the VITAL platform. This article introduces the obligation of controllers and processors to carry out a data protection impact assessment (DPIA) prior to risky processing operations that could affect users data privacy and regarding the nature, scope and objective of data management and processing.

7.6 Data Protection in the UK: Overview

The Data Protection Act 1998 (DPA) is the primary legislation regulating the collection and use of personal data in the UK. It implements the Data Protection Directive (Directive 95/46/EC) from the European Commission. Secondary legislation addressing specific issues referred to personal data are:

- Privacy and Electronic Communications (EC Directive) Regulations 2003 (PECR), which regulate, among other things, the requirements for use of personal data for direct marketing, location tracking and itemized billing purposes and individuals' rights in those circumstances.
- Privacy and Electronic Communications (EC Directive) (Amendment) Regulations 2011 (PECR Amendments), which regulate the use of technologies for storing information and accessing information stored on a user's equipment, such as their computer or mobile device (see Question 18).
- EU the UK is subject to the European Union's Data Retention Directive. All telecommunications data in the UK is kept for a minimum of 1 year and a maximum of 2 years.

Finally, the proposal for a new European data protection Regulation, released in January 2012 by the European Commission will take direct effect in the United Kingdom.

The DPA is then the framework in which all "processing" of "personal data" must be carried out, and any UK-established entity or individual obtaining personal information is likely to have to operate according to the DPA. This law applies to "data controllers", - those people who either alone or jointly or in common with other persons, determines the purposes for, and the manner in, which any personal data is or is to be processed (section 1, DPA)-. Data controllers decide what to do with personal data and how that activity is to be developed. These decisions can be made with, or at the same time as, another data controller in respect of the same personal data. The main obligations imposed on data controllers by the DPA are those of the eight data protection principles (Principles) (Part I, Schedule 1, DPA). Guidance on the Principles is also provided in Part II, Schedule 1, of the DPA.

Data controllers do not need to hold the personal data or process it. It is sufficient to instruct a third party how to process the personal data to be deemed a data controller- this is the case when considering outsourced business models-. The processing must be carried out under a written contract requiring the data processor to act only on the data controller's instructions and to comply with the security requirements under the DPA´s seventh Principle.

Unless expressly exempt, the Principles apply to all personal data processing and require that personal data must:

- be used fairly and lawfully,
- be used for limited, specifically stated purposes,
- be used in a way that is adequate, relevant and not excessive,
- be accurate,
- be kept for no longer than is absolutely necessary,
- be handled according to people's data protection rights,
- be kept safe and secure,
- not be transferred outside the UK without adequate protection.

Sensitive personal data are specially protected. They could relate to: race or ethnic origin; political opinions; religious and other similar beliefs; trade union membership; physical and mental health; sex life; criminal proceedings and criminal records.

The DPA applies to the following when they are "established" in the UK and if they process data as data controllers in the context of that establishment (section 5, DPA):

- Individuals ordinarily resident in the UK,
- UK-registered companies,
- UK-formed partnerships or other unincorporated associations,
- Persons with a UK office, branch or agency.

Data controllers established outside the European Economic Area (EEA) who process data using equipment located in the UK are also subject to the DPA.

7.7 Data Protection in Turkey: Overview [8]

There is currently no specific legislation on data protection in Turkish law. Data protection in Turkish law is governed by the Constitution and a variety of general and sectorial laws. As part of the process for becoming a member of the European Union, Turkey has introduced a Draft on the protection of personal data, but it has not been adopted into Turkish legislation yet. It is expected that in the course of this year, Turkey will finally have a law on data protection.

[8] References for this section are extracted from the following sites: http://uk.practicallaw.com/7-520-1896 ; http://www.mondaq.com/x/228120/data+protection/LongExpected+Transition+In+Data+Protection+Law; http://uk.practicallaw.com/2-502-1510?qaq=W_q1&qaid=7-520-1896

Data privacy provisions

The actual regulations related to data protection in Turkey are the following:

- ***The Turkish Constitution*** stipulates the protection of personal rights under the title “Privacy and Protection of Private Life” (Section 5, Articles 20 and 22), specifying the right to private life and privacy of communication.
    - Article 20 of the Constitution deals with individual privacy and states that “everybody has the right to demand respect for his private and family life. Privacy of individual and family cannot be violated.” This regulation also states that “every person has absolute freedom to decide whether to provide or not his/her personal data and to not be compelled to do so.”
    - Article 22 states that the secrecy of communication is fundamental and cannot be impeded or violated.
- ***The Turkish Civil Code*** *(Law nº 4721, Articles 23 to 25)* contains provisions that protect personal rights and the privacy of personal informations, and pursuant to Article 24, an individual whose personal rights are violated unjustly may bring a civil action to protect against such violation and/or to claim compensation of damages arising from such violation. Disclosing or misuse of personal and/or confidential data can be considered as an infringement of personal rights according to this rule.
- ***The Law on the Right to Access to Information (Law No. 4982)*** restricts the right to access confidential information (which includes information concerning one's private life and commercial secrets) while at the same time promoting free access to certain information.
- ***The Criminal Code (Law No. 5237, Articles 135, 136 and 138)*** contains provisions concerning the processing and protection of personal data. The unlawful recording (obtaining) of sensitive data such as those related to political or religious views, or racial or ethnic origin is subject to a penalty of imprisonment from six months to three years. In the case of unlawful transmission or reception of personal data, the penalty is increased to imprisonment from one to four years. Furthermore, those who do not erase or destroy the personal data in spite of the expiry of the time period stipulated in the relevant laws for the maintenance of such data shall be punished by imprisonment from 6 months to 1 year.

Finally, Turkey has been signatory to the ***Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data*** in 1981, and the ***Universal Declaration on Human Rights***, that also address the right to privacy.

Apart from the provisions in the abovementioned general Codes, there are many specific laws and regulations dealing directly or indirectly with data protection issues, including: ***the Regulation on Data Protection and Protection of Privacy in Electronic Communication Sector*** (released on July 24, 2012 Official Gazette No. 28363) , Banking Law, Debit and Credit Cards Law, , Electronic Communications Law, Electronic Signature Law, etc.

Draft law on data protection in Turkey

As a part of Turkey's harmonization to EU's *acquis communautaire*, the Draft Law has been prepared in line with the EU Data Protection Directive No.95/46/EC and the Commission Decision 2001/497/EC of 15 June 2001. Preparations for the proposal are at its final stage. The main provisions made by this proposal could be summarized as follows:

- *Individual Rights and fair and lawful processing*: Right of Access, modification and deletion are included. The Bill allows for data to be collected in situations where the individuals have provided consent, to meet legal obligations, or the information collected is in the public interest.
- *Retention*: Data should be anonymized or erased when no legal provisions for the retention exist.
- *Confidentiality*: It must be guaranteed by law if personal information is going to be collected.
- *Data Transfers*: It follows the Data Protection Directive general rule of allowing transfers only to countries with and adequate level of data protection.
- *Penalties and fines*: It introduces jail sentences for collecting personal data in breach of law as well as for disclosing it illegally to third parties.

An autonomous data protection authority is also foreseen, with the power to act independently from the government.

8 CONCLUSIONS

This deliverable has dealt with the specification of reference scenarios and use cases, which will be taken into account during the design and development of the VITAL platform and applications, as well as during their validation and evaluation in later stages of the project. In the context of VITAL WP2, these use cases will serve as input to the VITAL architecture specification, which will be provided as part of the last deliverable of this workpackage (deliverable D2.3). Furthermore, the deliverable has made an initial selection of the platforms that will be (re)used and adapted to the VITAL platform and paradigm, in order to showcase VITAL's ability to support the development of integrated IoT applications spanning multiple IoT platforms and silos. The rationale behind the selection is also presented in the deliverable. Note that the conclusion of this selection is associated with the accomplishment of one of the milestones of the VITAL workplan, given also the fact that the selected platforms are available for reuse and integration within the VITAL developments.

It should be noted that the VITAL use cases specification process has strived to cover/address all the main (envisaged) functionalities of the VITAL platform. Each of the use cases is owned/led by one of the technical partners of the project, notably the partner with the leading role in the research and development processes associated with the functionalities that are used as part of the use case. The specified use cases and their leaders/owners are summarized in Table 18.

Use case / Scenario ID	**Functionality Validated**	**Short title**	**LEADER**
UC01	WP3, specifically the VITAL Ontology and the dynamic platform-agnostic querying for metadata	Developer Reflection Interface	NUIG
UC02	WP3, specifically VUAIs	Mobile Density Map	NUIG
UC03	VITAL Ontology, Discovery Module	Reprogrammable Sensor Discovery	INRIA
UC04	VITAL Ontology, Discovery Module, Data Access, Filtering	Smart Lighting	INRIA
UC05	VITAL Ontology, Discovery Module, Data Access, Filtering	Smart Roads	INRIA
UC06	VITAL Ontology, Discovery Module, Data Access, Filtering	Water network monitoring	INRIA
UC07	WP3, transversal to many features and use cases.	Security policy	REPLY

UC08	WP3, transversal to many features and applications	Authentication and Authorization	REPLY
UC09	Complex Event Processing	Smart Meeting and Mobility	ATOS
UC10	WP 4 – Management and Orchestration of IoT-driven Business Processes	Smart Cities BPM	SiLo
UC11	WP 5 – Cross-Architecture Management Platform	VITAL health map	SiLo
UC12	WP 5 – Cross-Architecture Management Platform	Platform accounting service	SiLo
UC13	WP 5 – IoT Applications Smart Governance Toolkit	City incident reporting demo	SiLo
UC14	WP5, with emphasis on application development environments and tools	Smart Cities Applications Development	AIT
SC01	Integrated City Scenario	Safe and Livable	IMAGES/CTU
SC02	Integrated City Scenario	VITAL Validation Scenario in Istanbul	IMM
EXTENSIONS-CONCEPTS on SC01	Camden «HeatMap» Layered Filtering & Application Queries Traffic and Activity at Camden Patterns of Activities and Impacts Pedestrian Flows and Business Data Waste Management Monitoring Transport Information (smart transport) Citizen security Information (smart security) Stop food waste concept Recycling concept		
EXTENSIONS-CONCEPTS on SC02	Layered Filtering – Application Queries Layered Filtering of Announcement Data		

	Dynamic discovery of sensor data & metadata Fusion of Fleet Management Sensor Data Weather and traffic data correlation Traffic estimation & re-routing Urban-planning queries

Table 18: Consolidated Table of Use cases and Scenarios – Including Owners/Leaders of the Use Cases

Scenarios and use cases identified in this table will serve as a basis for researching, designing, implementing and validating the VITAL platform and associated proof-of-concept applications. As such these use cases represent a critical input for several other tasks of the project's workplan.

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