Stretto di Messina

Concessionaria per la progettazione, realizzazione e gestione del collegamento stabile tra la Sicilia e il Continente Organismo di Diritto Pubblico
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EurolinK

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.

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1 Executive Summary

The Messina bridge is a highly innovative bridge design for the world's longest span (3300m) to link Sicily with mainland Italy. The bridge is to be a suspension bridge formed from 4 main cables, a steel triple box girder, and steel towers that are 399m tall. Not only are the bounds of current bridge experience being pushed to the limit with a structure that is significantly larger than the current world's longest span of 1991m (the Akashi Kaikyo bridge), the aerodynamic stability of the deck structure is reliant on the beneficial characteristics provided by the innovative triple deck box structure. Thus permanent monitoring and maitenance of the structure is desired to ensure that the structure is behaving as intended and remains safe to use. Furthermore a cluster of maintence management systems for maintaining the structure in good condition for a long service life is provided.

In the current Progetto Definitivo project phase, the tender design is further developed in preparation for the subsequent Progetto Esecutivo phase.

The bridge is to be equipped with a WorkSite Management System (WSMS) which will monitor work, materials and equipment for both bridge- and landworks (hereafter named "the worksite") during the construction phase.

A design for the WSMS has been developed based on the technical specifications prepared by Stretto di Messina (2004), and based on the tender submission prepared by ATI Impregilo (2005). In the Progetto Definitivo phase the WSMS design has been updated and refined, taking into consideration - among others - changes in the design of the bridge, and developments in IT technology. The document represents a description of the Worksite Management System on the level of knowledge at the present time.

1.1 WorkSite Management System

The WSMS system consists of a GIS (Geographical Information System) which has a map-based user interface as well as a database containing mainly geographical data - e.g. the layout of the construction site and the main structure of the bridge.

The WSMS will be connected to a number of "data feeder systems" like The General Contractors SAP and Primavera systems in which the majority of the information, presented by the GIS frontend, is registered, maintained and stored. Therefore an extensive data interface between WSMS and the connected systems is required.

In general all attribute data displayed by the GIS are registered, maintained and stored in surrounding systems and not in the GIS database. The GIS accesses these data sources by means of web services or direct database access. If appropriate, selected attribute data can however be stored in the WSMS database. In general Geographical data are stored in the WSMS database.

The GIS will provide a platform which is applicable for both desktop and portable computers like PDA's, Tablet PC's etc. to be used by workforce at work-sites, based on both mobile communications and wireless networks. This in order to improve communications and interactions between the parties involved, e.g. workers, supervisors, managers.

The WSMS contains the following functional modules:

- Worksite infrastructure layout
  Graphical presentation of the worksite on a map together with relevant objects at the worksite such as the location of storage areas, work shops, roads etc.

- Work progress monitoring
  Graphical presentation of construction work progress on a map.

- Materials location and tracking
  Graphical presentation of materials locations on a map

- Transportation tracking
  Graphical presentation of vehicle locations and routes on a map based on their GPS positions.

- Construction equipment tracking
  Graphical presentation of equipment locations on a map based on their GPS positions.

- Environmental monitoring
  Graphical presentation of environment sensor locations.

- GPS tracking server

Server communicating with tracking devices mounted on vehicles and equipment. Collects GPS data from tracking devices. Used in connection with Transportation and Construction Equipment tracking.

This is illustrated in Figure 1 below and will be explained in the following sections.

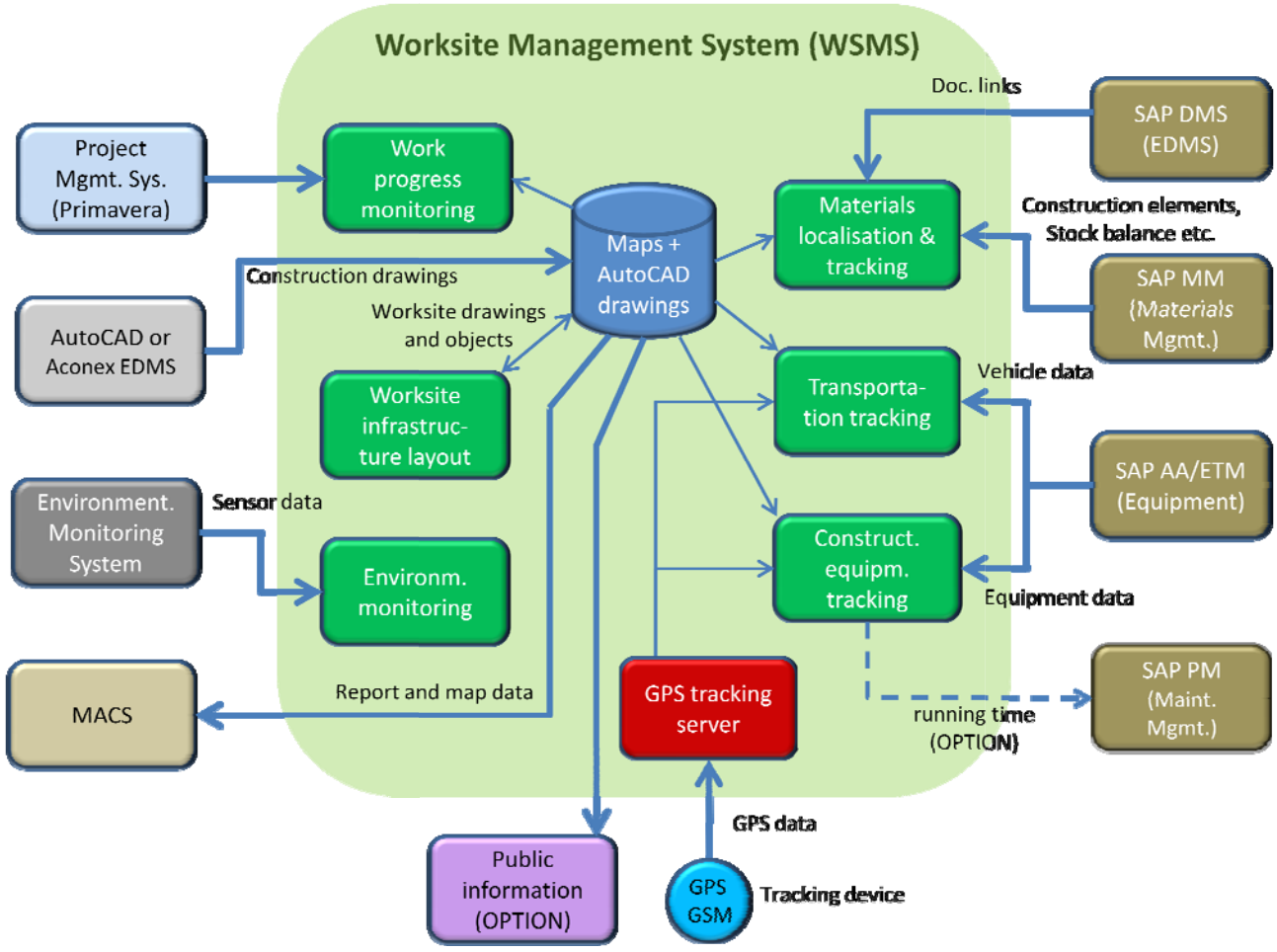

Figure 1 WSMS Functionality, interfaces and interfacing system

2 Introduction

The below document is an IT design specification for a Worksite Management System. The design specification is based on based on the technical specifications prepared by Stretto di Messina (2004), and based on the tender submission prepared by ATI Impregilo (2005). In the Progetto Definitivo phase it has been supplemented with information from a series of meetings with

representatives from EUROLINK. Further a number of requirements and design elements have been developed from the design process itself.

This document represents a description of the Worksite Management System on the level of knowledge at the present time. The document has been elaborated in an iterative process in which the level of details will increase during the Progetto Definitivo and Progetto Executivo phases of the project. A design specification such as this will basically evolve during the entire project - also during the development of the coming system. In this way the document servers two purposes:

- *Specification* of system properties and functions in order to achieve the greatest possible agreement on what the end result of the project should be.
- *Documentation* of the systems capabilities and functionalities. In this way there is a documented basis for implementation, quality assurance and control of the scope and content of the project.

As the document reflects current knowledge of the system there might be differences in the level of detail between sub components.

2.1 List of Actors

The following is a list of identified actors (persons or systems that interact with WSMS):

Actor	Description
Environment Manager	This actor is responsible for handling the generation of different reports based on captured sensor data from ambient sensors.
GIS data administrator	The GIS Data Administrator is responsible for maintaining the integrity of the GIS database, maintaining meta data on geo-data, perform Import and export operations on data and prepare maps and reports for the other users of the system.
GIS user	The GIS User is responsible for maintaining geometry and associated attribute data in several parts of the Work Site Management system. Further the GIS user performs querying of data and preparation and printing of reports on request.
Owner	This user represent aStretto di Messina supervisor who wants to access data on the work site - for instance a report on progress
Warehouse	This actor is responsible for managing the inventory of equipment and materials on the

manager/operative	worksite
Web User	The Web user represents a member of the general public visiting a web site exposing information on work progress
Worksite Manager	The Work site Manager actor represents a user that belongs to the management level of the bridge construction team.
Worksite worker	The Work Site Worker represents any worker participating in bridge construction with a particular need for accessing information from the WSMS. This type of user will often access information through a mobile client. A work site worker can also be a supervisor of specific tasks on the site

Table 1 List of WSMS actors

To a degree some of the above actors might be the same physical persons.

Based on the list of actors, role based user access control is implemented for WSMS. Due to the benefits of "single sign on" the user administration is foreseen to be implemented in the MACS (Management and Control System) for all connected systems - among these WSMS. With regards to user access control reference is therefore made to the design document of MACS.

2.2 Major use cases

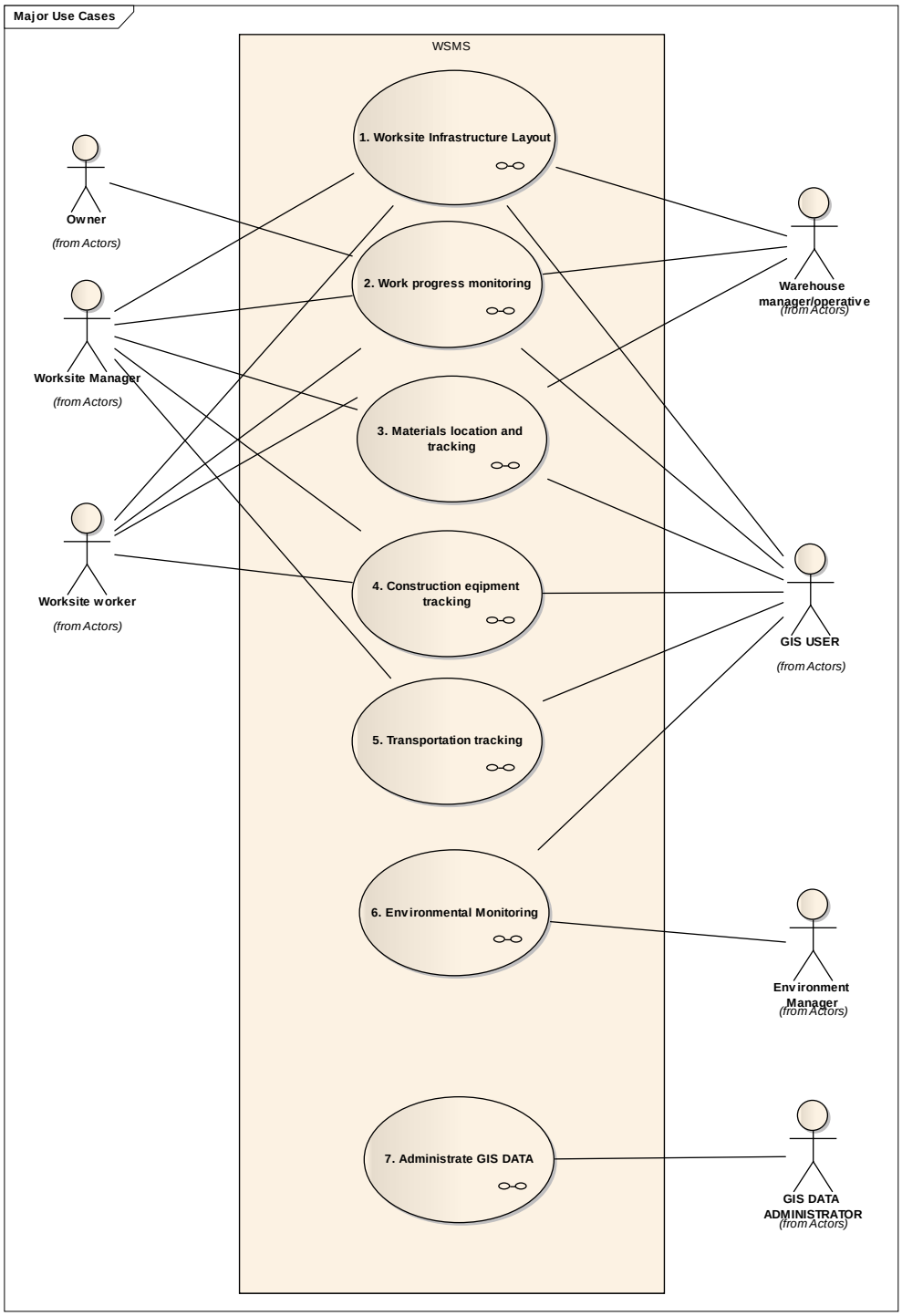

Figure 2 Major use cases

The major use case diagram in essence shows the different sub components of the WSMS. These individual sub components will be elaborated below. One additional use case that traverse all other use cases have been identified - *Administrate GIS DATA.*

3 Worksite infrastructure layout

The Worksite infrastructure layout module offers facilities to display the location of the worksite infrastructure elements like: roads, shacks, workshops, storage areas, power systems, water pipelines, fuel tanks and batch plants etc.

The module reads drawing data describing the worksite infrastructure from either a CAD (Computer Aided Design) system or an EDMS (Electronic Document Management System) system. Since data from either of these systems might be lacking the necessary attributes describing the geometry they will be maintained through the WSMS.

The information is displayed on a 2-dimensional GIS map.

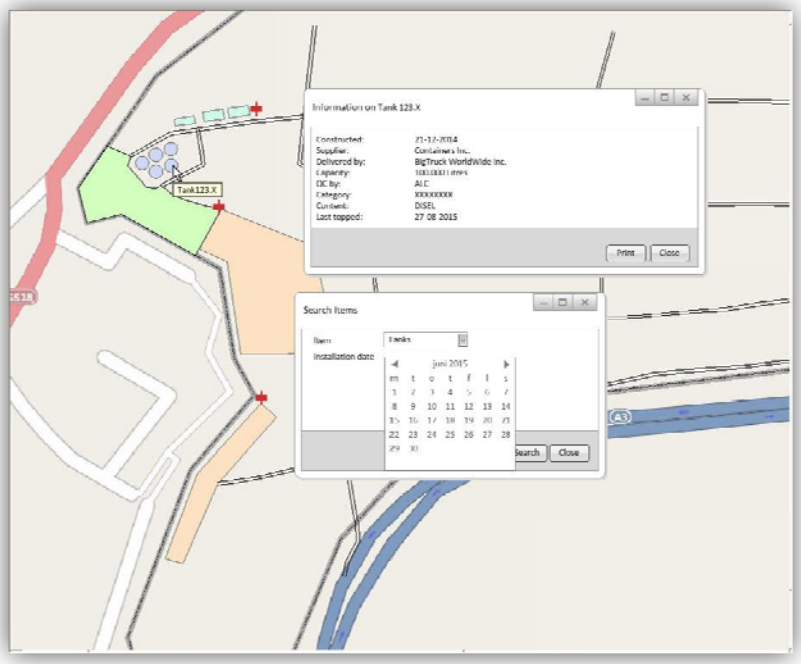

Figure 3 Example screen showing some functionality associated with worksite management

The module offers functionality for drawing points, lines and polygons and to use different predefined symbols in order to add and edit elements of the worksite infrastructure. Similarly these elements can be imported from CAD documents.

By clicking an object on the map, it is possible to gain access to information about the object - e.g. by pointing out a storage area, information regarding area size and materials stored within the area can be displayed and reports printed.

In addition the module contains functionality for maintenance of a topological road network (described by nodes and road segments) covering the worksite. This includes attribute values for road segments such as: length, width, surface type, slope, maximum speed, maximum length, maximum weight etc. The purpose of the topological road network is to provide the necessary data for route calculations.

The worksite infrastructure module also contains route planning functionality in order to calculate the shortest/fastest route satisfying the contraints expressed by the attribute values of the road segments - e.g. constraints like maximum slope for vehicle and/or width of vehicle.

The route planning functionality is able to calculate the route for one (1) vehicle at a time visiting a series of locations (up to 50) on the route. Locations are selected by pointing them out on the map and by picking them from a list. The vehicle is selected from a list. The result of a route calculation is displayed on the map as a route.

It is possible to add the Transportation tracking layer described in section 7 to the route layer in order to match the actual route of the vehicle compared to the calculated route.

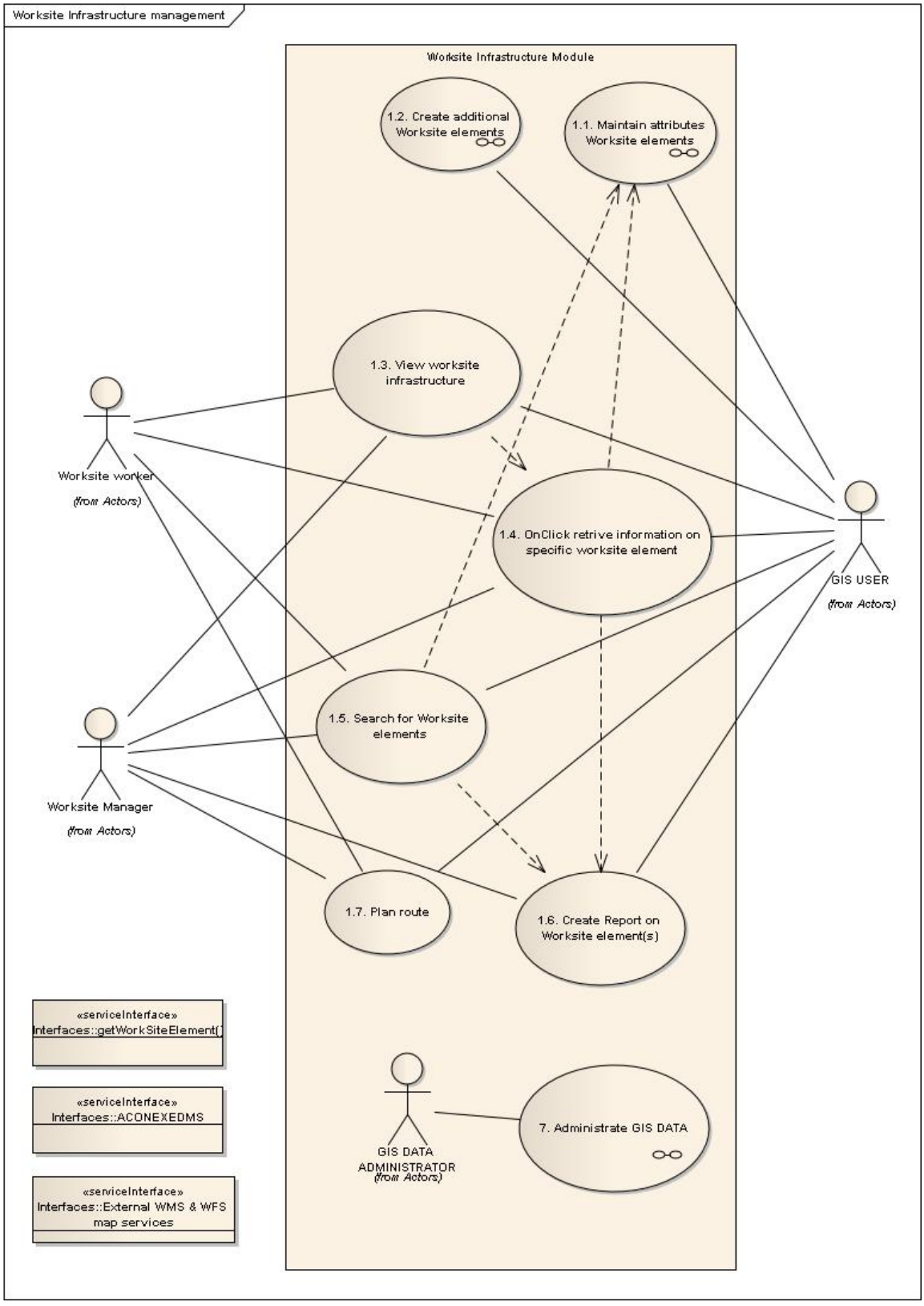
Worksite Infrastructure management
Worksite Infrastructure Module
1.2. Create additional Worksite elements
1.1. Maintain attributes Worksite elements
1.3. View worksite infrastructure
1.4. OnClick retrive information on specific worksite element
1.5. Search for Worksite elements
1.7. Plan route
1.6. Create Report on Worksite element(s)
7. Administrate GIS DATA
Worksite worker
(from Actors)
Worksite Manager
(from Actors)
GIS USER
(from Actors)
GIS DATA ADMINISTRATOR
(from Actors)
«serviceInterface»
Interfaces::getWorkSiteElement()
«serviceInterface»
Interfaces::ACONEXEDMS
«serviceInterface»
Interfaces::External WMS & WFS map services

Figure 4 Use Case 1. Worksite Infrastructure Layout major use case diagram

Use case	Description
Use Case 1.1. Maintain attributes Worksite elements	Maintain the attributes of an existing work site element. Details below.
Use Case 1.2. Create additional Worksite elements	Create a new work site element Details below.
Use Case : 1.3. View worksite infrastructure	The user views all work sites
Use Case : 1.4. OnClick retrive information on specific worksite element	Click a work site element in order to retrieve detailed information on the element
Use Case : 1.5. Search for Worksite elements	Search for a specific work site element
Use Case : 1.6. Create Report on Worksite element(s)	Create a report on the status of a work site element
Use case: 1.7. Plan Route	Plan route for special transports, intra site

Table 2 Worksite Infrastructure Layout use case description

3.1 Use Case 1.1. Maintain attributes Worksite elements

Maintain the attributes of an existing work site element.

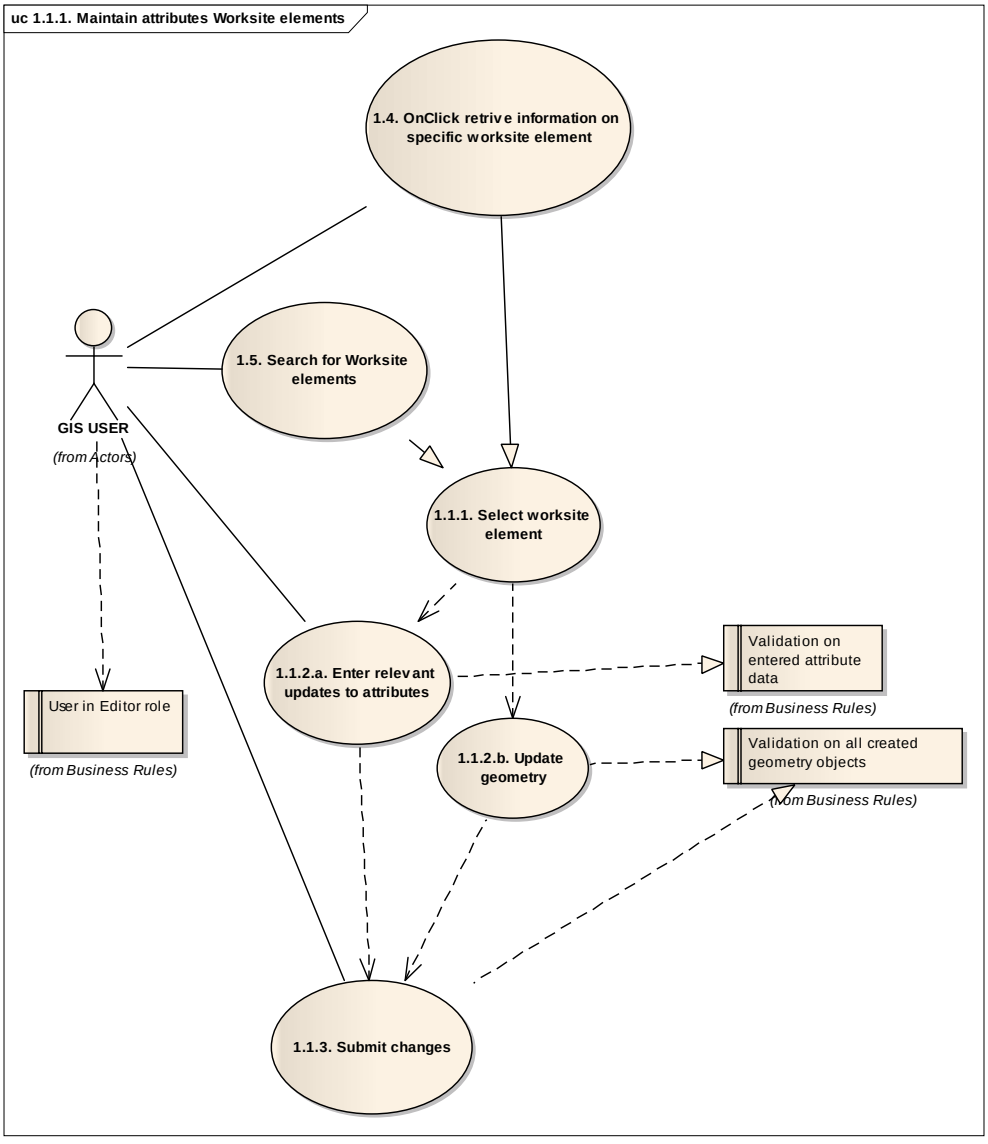

Figure 5 Use Case 1.1 Maintain Attributes Worksite Elements

Use case	Description
Use Case 1.1.1 Select worksite element	A worksite element is selected
Use Case 1.1.2.a. Enter relevant updates to attributes	Update attributes as relevant E.g. constraints on road segments for route planning
Use Case : 1.1.2.b. Update geometry	If necessary geometry can be edited

Use Case : 1.1.3. Submit changes	Submit all changes to database if object attributes and geometry is valid. element

Table 3 Maintain Attributes Worksite Elements use case description

3.2 Use Case 1.2. Create additional Worksite elements

Create a new work site element

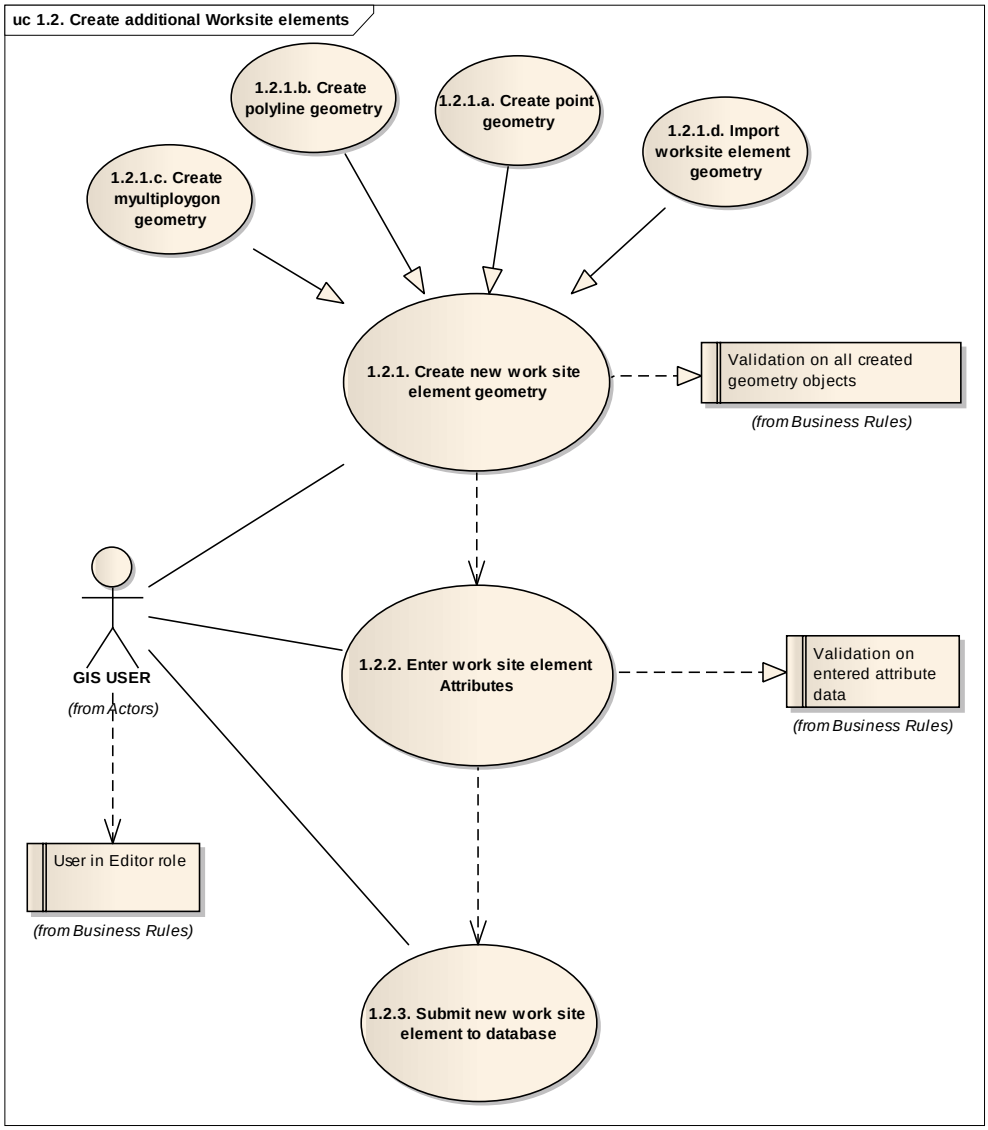

Figure 6 Use Case 1.2 Create Additional Worksite Elements

Use case	Description
Use Case: 1.2.1. Create new work site element geometry	Create a new work site element geometry
Use Case: 1.2.1.a. Create point geometry	Create an object of type point describing a work site element. E.G. a mast or add new sensor
Use Case : 1.2.1.b. Create polyline geometry	Create an object of type polyline describing a work site element. I.e. a fence or road segment
Use Case : 1.2.1.c. Create multiploygon geometry	Create an object of type Multipolygon describing a work site element. I.e. a storage area or work site boundary
Use Case : 1.2.1.d. Import worksite elemet geometry	Work site element geometry is imported from CAD document
Use Case:1.2.2. Enter work site element Attributes	Enter the attributes describing the work site element
Use Case:1.2.3. Submit new work site element to database	The work site element is submitted to database if valid

Table 4 Create Additional Worksite Elements use case description

4 Work progress monitoring

The module produces a graphical presentation of construction work progress. The presentation is made on the basis of a construction drawing of the bridge and land works.

Drawing data is initially imported from the CAD system and subsequently maintained from within the WSMS. As the detailed plan of construction elements are far to complex to present to users with the purpose of presenting progress of work, it will be necessary to aggregate the information into larger units of measurement. This will be done by the GIS user who maintains the aggregation levels. An aggregation level will basically consist of a polygon element (e.g. a rectangular object) that covers several elements of work. Simple spatial query operations can then aggregate information stored on several detailed work elements and persist this information on the aggregation level object.

Data regarding work progress is read from the project management system, Primavera. It is assumed that work progress is reported per construction part which also can be identified from the construction drawings. Work progress is reported in the unit of costs.

Work progress will be displayed as a Choropleth map showing the aggregation level objects with a colour-scale indicating progress. For instance a diachrome scale from red to green where red is equivalent to 0% completed and green equals 100% by normalizing cost.

Due to the 3 dimensional bridge structure the module will either be displayed as 3D GIS or contain functionality for selecting different vertical layers of the construction in order to display progress for the whole construction.

The work progress data is assumed to be an important information part of the WSMS. It is further a data part that can be assumed to be of interest to the general public and the information generated by WSMS is further exposed through OGC(Open Geospatial Consortium) compliant mapping services, thus making the information accessible through a variety of clients (e.g. a web client on a public website).

Progress of work can be reported in a number of ways either with or with out attached maps.

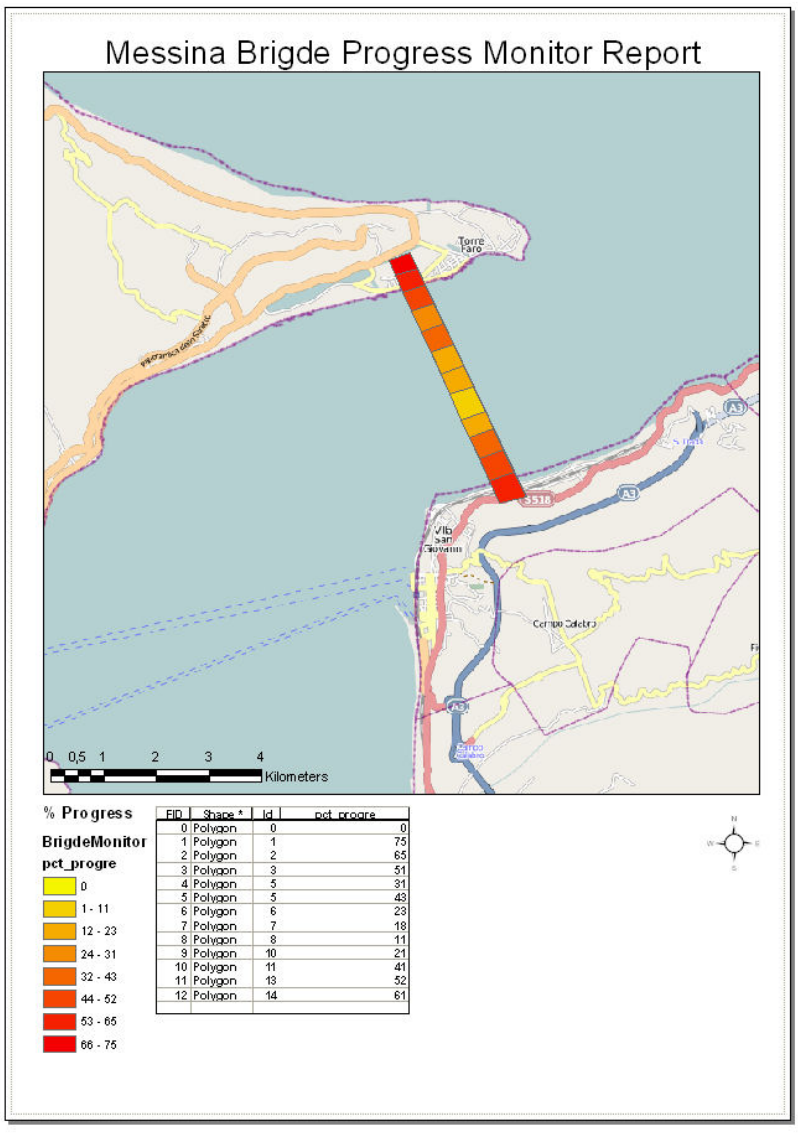

Figure 7 Example report from the progress monitor

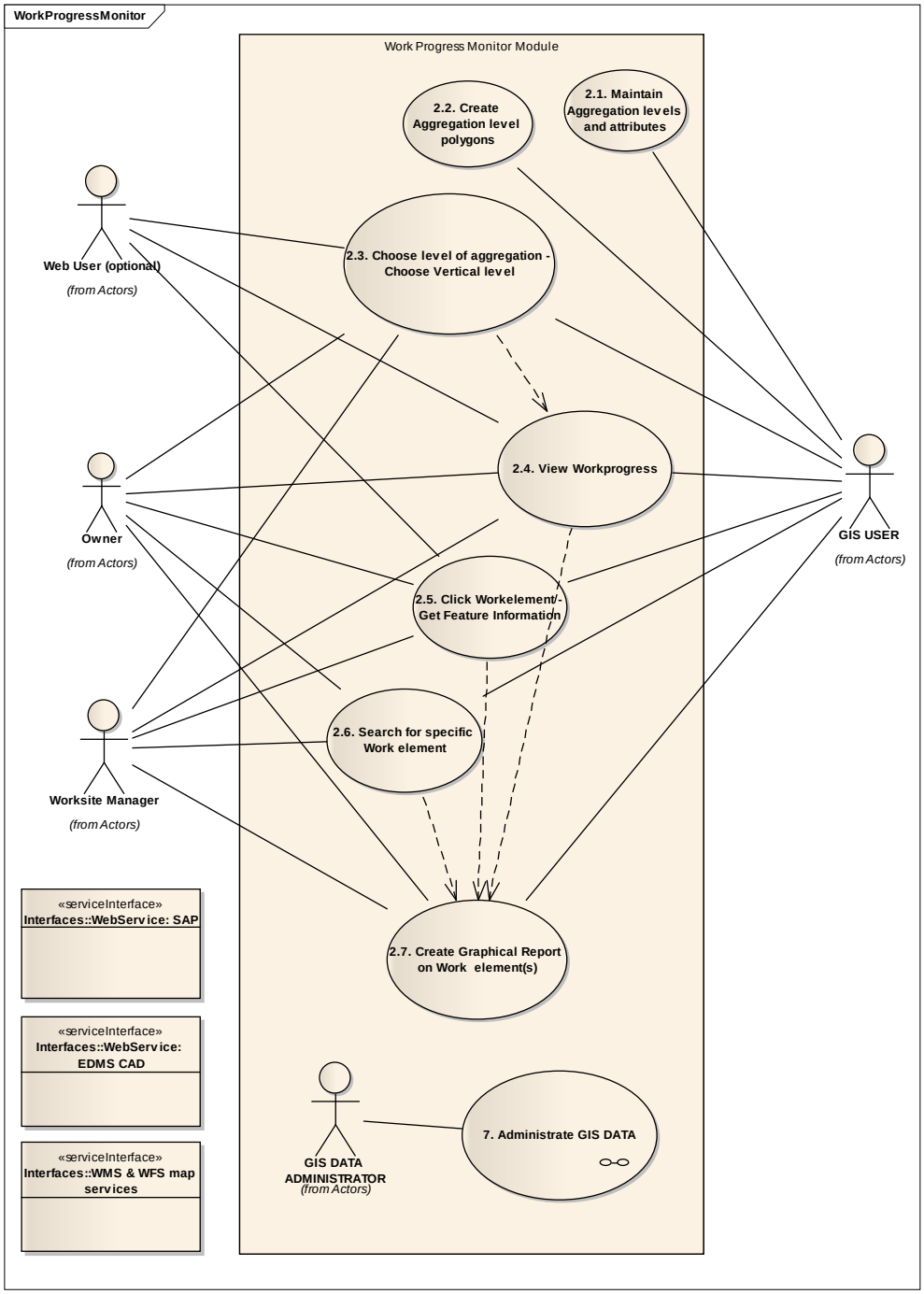

Figure 8 Use Case 2. Work Progress Monitoring major use case diagram

Use case	Description
Use Case: 2.1. Maintain Aggregation levels and attributes	Maintain and update Aggregation level polygons and their attributes
Use Case: 2.2. Create Aggregation level polygons	Create a series of vector polygons covering the entire bridge for a series of predefined vertical levels that will be used to aggregate the work progress as a percentage via input from SAP web service calls. The GIS user uses standard GIS geometry tools for this task.
Use Case : 2.3. Choose level of aggregation	Choose Vertical level
Use Case: 2.4. View Work progress	View an overview of the progress of work for a specific element
Use Case: 2.5. Click Work element - Get Feature Information	Click single work element to get detailed feature information
Use Case: 2.6. Search for specific Work element	Via a special form the user can search for specific work elements and retrieve it's details
Use Case: 2.7. Create Graphical Report on Work element(s)	Create a graphical report based on search criteria.

Table 5 Work Progress Monitoring use case description

5 Materials location and tracking

The module displays information on the current location of materials. The information is displayed on a 2-dimensional GIS map showing the worksite infrastructure layout (see section 3 above). Material depots are one specialized data layer to be incorporated in the system.

Figure 9 Example screen showing information on content of storage area by Click

The lowest level of materials tracking is the level of construction parts (equal to the lowest level of the Work Breakdown Structure defined in the project).

Data is retrieved from The General Contractor's SAP system (SAP MM) which stores all information on materials - e.g. specification, supplier, status (approved/not approved), stock balance and location. Furthermore links to the related documents - e.g. bill of materials and quality certificates are retrieved from the EDMS (SAP DMS).

When materials arrive at the construction site, the quality certificate is checked and - if approved- entered into the EDMS with reference to the materials identification in SAP. Simultaneously the stock balance and the materials specification are entered into SAP - preferably by barcode scanning. The current location of the materials is registered SAP by means of an area code.

When materials are moved to and between storage areas and processing areas the SAP system is updated accordingly: The stock balance of the departure area is reduced with the amount of materials removed and when arriving at the destination the stock balance is increased at the arrival area.

When mounting materials on the bridge structure, the location with reference to the CAD drawings is registered on the material/element in SAP and the stock balance updated accordingly to the same principles as mentioned above.

By pointing out a material-object on the GIS map it is possible to gain access to the information stored in the SAP system for the object (e.g. stock balance and materials specification)

It is not the intention to track materials during transportation, however by marking each vehicle - e.g. by barcode - and scan the vehicle during pickup and delivery of materials, it will be possible to track materials during transportation by means of the vehicles tracking device. (OPTION)

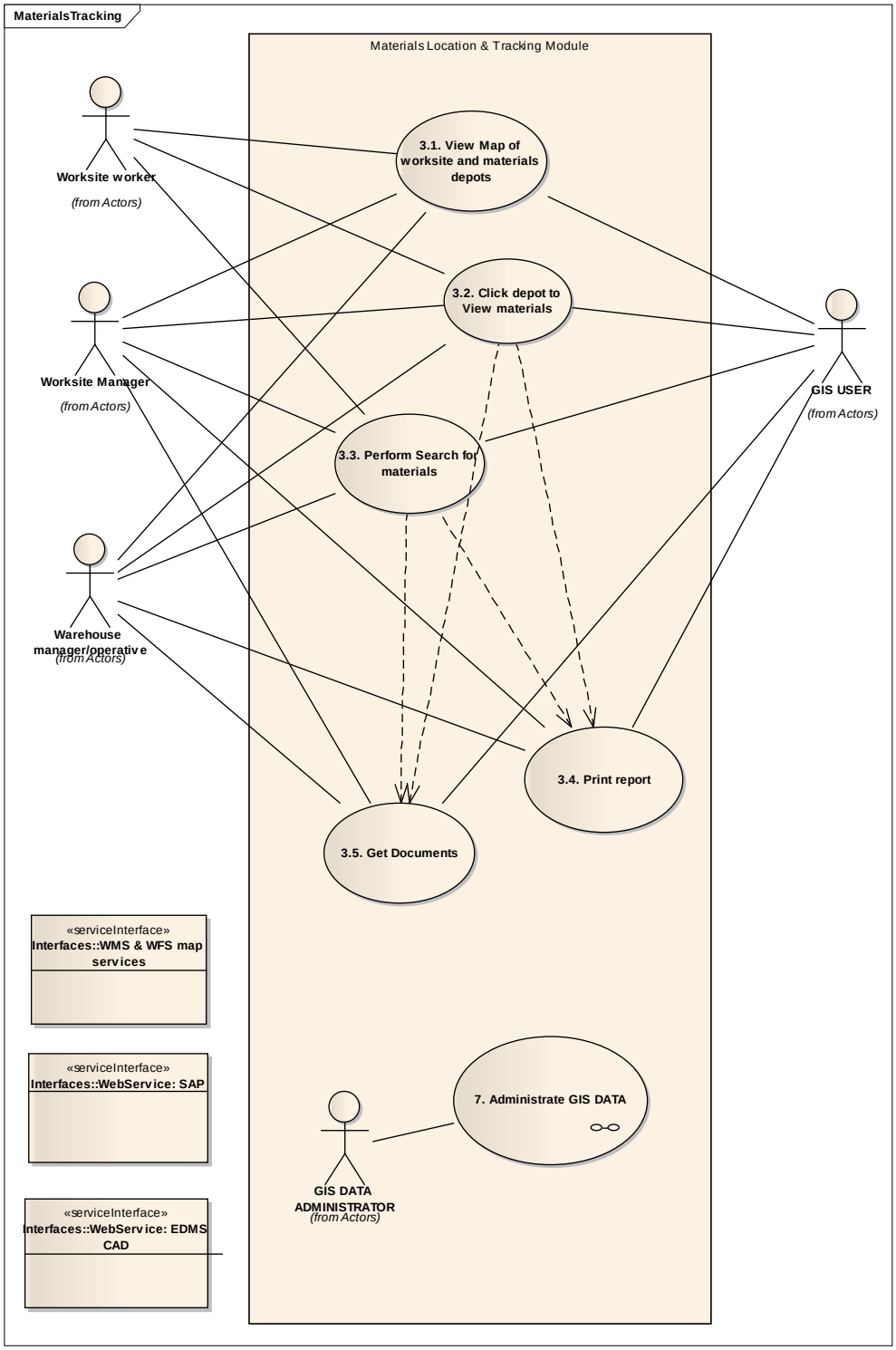

Figure 10 Use Case 3. Materials Tracking and Location Monitoring major use case diagram

Use case	Description
Use Case: 3.1. View Map of worksite and materials depots	The User activates a layer in the GIS system that shows materials depots
Use Case: 3.2. Click depot to View materials	The user uses a special info tool to click a depot and views detailed data on the depot and it's content via a specialized form.
Use Case : 3.3. Perform Search for materials	As an alternative to UC. 3.3 the user Opens a Materials Search form and performs search for specific materials. The search results are displayed in a specialized form
Use Case: 3.4. Print report	From UC.3.2. or 3.3 the user can produce a graphical report.
Use Case: 3.5. Get Documents	From UC.3.2. or 3.3 the user can retrieve documents on materials from SAP.

Table 6 Materials Tracking and Location Monitoring use case description

6 Construction equipment tracking

Construction equipment tracking concerns location of equipment within the worksite - e.g. cranes, generators and dumpers. The module displays information on the current location of construction equipment and is continuously updated. The information is displayed on a 2-dimensional GIS map showing the worksite infrastructure layout (see section 3 above).

Relevant equipment will be equipped with GPS receivers and mobile data communication (the entity consisting of both these elements is hereafter referred to as "tracking device"). The tracking device is powered by an integrated chargeable battery which can be charged by means of the equipments power supply. The tracking device will continuously send the current GPS position by means of mobile data communication to a server (hereafter referred to as "tracking server").

The frequency for registering and sending the GPS positions will be adjustable within the range of 15 sec. to 30 minutes.

OPTION: In case the tracking device is detached from the vehicle, an alarm will be activated and sent to the tracking server together with the current GPS position.

By pointing out construction equipment on the GIS map it is possible to gain access to information on the equipment (e.g. equipment ID, equipment type, latest GPS position and date time for latest GPS position). Furthermore it is possible to load the GPS log files from the tracking server within a given time range and plot the GPS trace on the GIS map.

Basic data on the individual equipment is stored in the SAP system (SAP AA/ETM). This includes tracking device ID number and equipment ID number. The equipment tracking module reads this information from SAP.

The equipment tracking module will also monitor the movement of equipment within the worksite and activate an alarm (visual and sound) in case any equipment moves out of the bounding area of the worksite (or a predefined part of the worksite). The definition of which equipment to monitor and assignment of bounding area to equipment is done by means of the equipment tracking module.

OPTION: It is possible to extend the tracking devices with relays coupled to the ignition of the equipment and thereby register the start and stop of equipment. In this way it will be possible to monitor each equipments running time in order to respect the service intervals for the equipment. This information will be stored in SAP PM.

For example screen shots, see section 7 below.

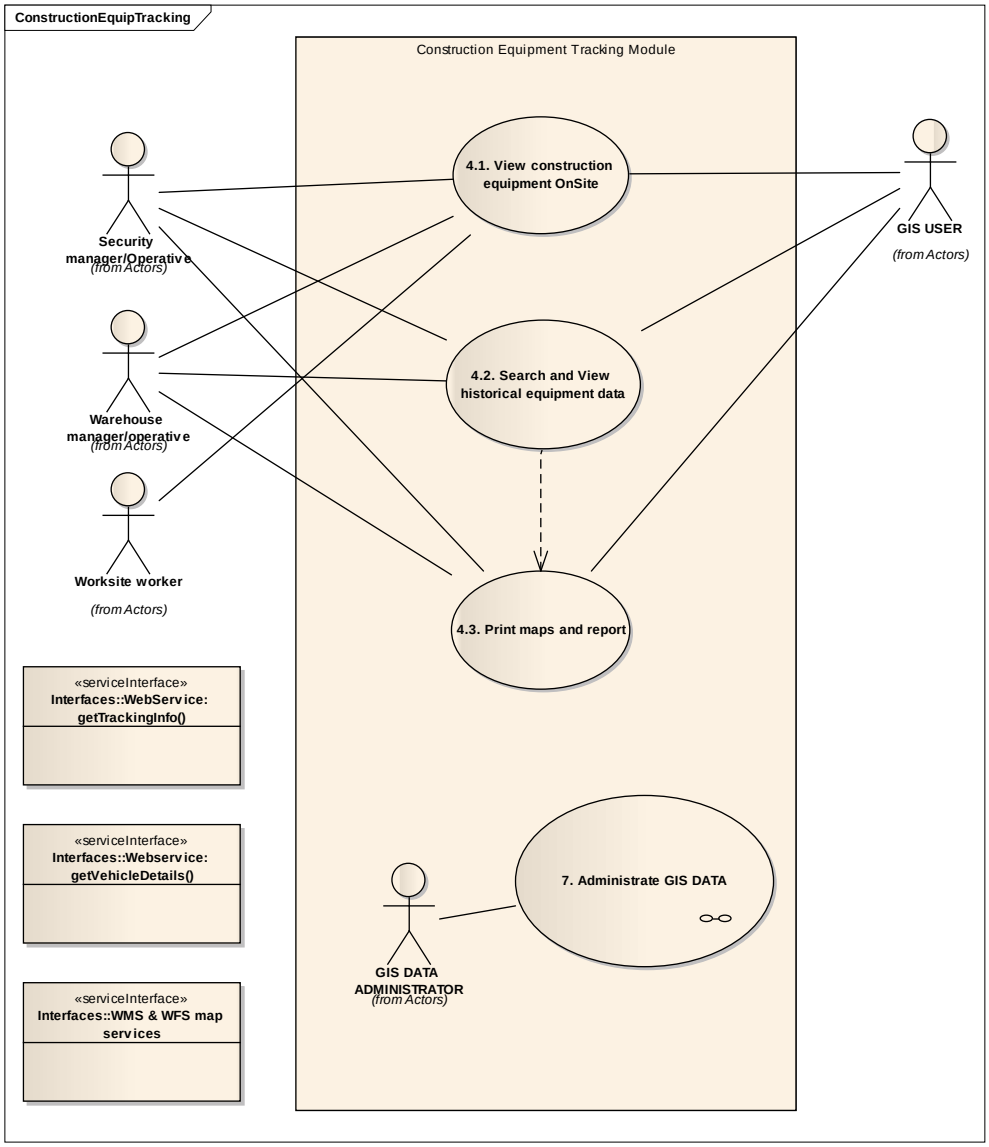

Figure 11 Use Case 4. Construction Equipment Tracking major use case diagram

Use case	Description
Use Case: 4.1. View construction equipment On Site	The user views a map with the work site layout and current position of construction equipment
Use Case: 4.2. Search and View historical equipment data	A search form allows the user to find information on particular equipment and its history of movement.

Use Case: 4.3. Print maps and report	The printing of Maps and Reports

Table 7 Construction Equipment Tracking use case description

7 Transportation tracking

The module displays information on the current location of transportation vehicles and is continuously updated. The information is displayed on a 2-dimensional GIS map showing the worksite infrastructure layout (see section 6 above) combined with other maps for tracking outside the worksite.

Relevant vehicles will be equipped with tracking devices. The tracking devices will continuously send the current GPS positions by means of mobile data communication to the tracking server. The frequency for registering and sending the GPS positions will be adjustable within the range of 15 sec. to 30 minutes.

OPTION: In case the GPS unit is detached from the vehicle, an alarm will be activated and sent to the tracking server together with the current GPS position.

The tracking server will create and maintain a logfile for every vehicle, making it possible to trace vehicle movements within a certain period of time. Logfiles will be kept for 1 one year.

Vehicles assigned to the project for a longer period of time or for especially valuable transports will be equipped with fixed tracking devices. Vehicles assigned to the project from time to time could instead be equipped with detachable tracking devices.

By pointing out a vehicle on the GIS map (or an associated list) it is possible to gain access to information on the vehicle (e.g. vehicle ID, vehicle type, latest GPS position and date+time for latest GPS position). Furthermore it is possible to load the GPS logfiles from the tracking server within a given time range and plot the GPS trace/route on the GIS map.

Basic data on the individual vehicle is stored in the SAP system (SAP AA/ETM). This includes tracking device ID number and vehicle ID number. The transportation tracking module reads this information from SAP.

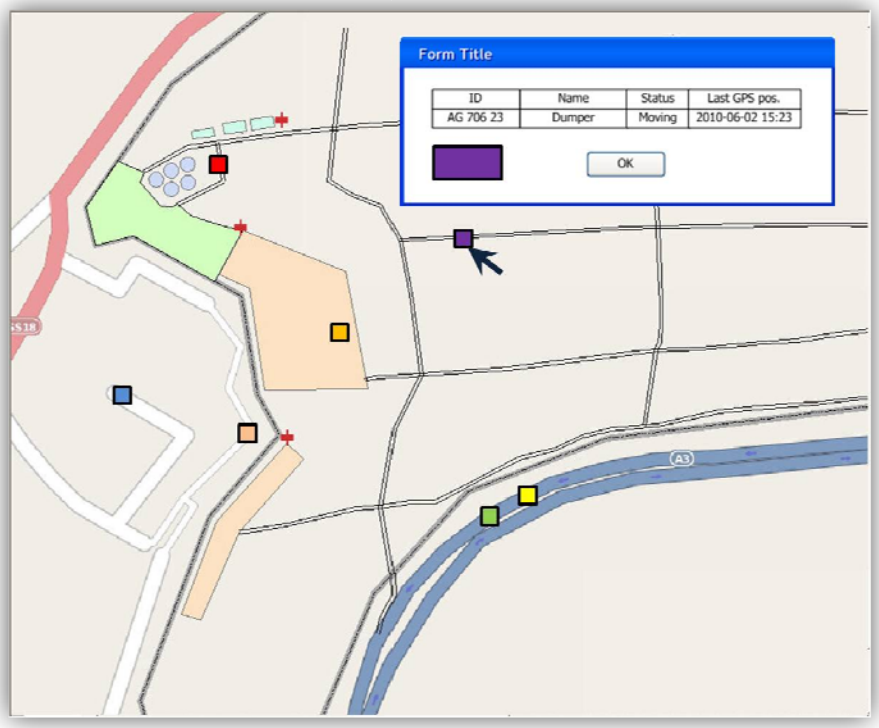

Figure 12 Example screen showing Vehicle current position and all vehicles

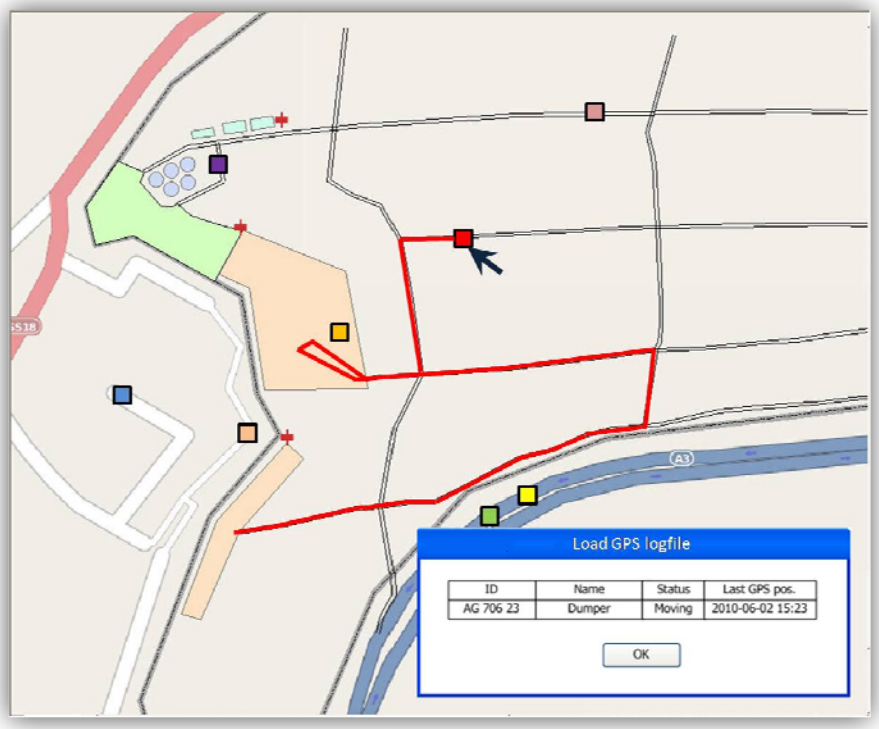

Figure 13 Example screen showing historical GPS data for selected vehicle

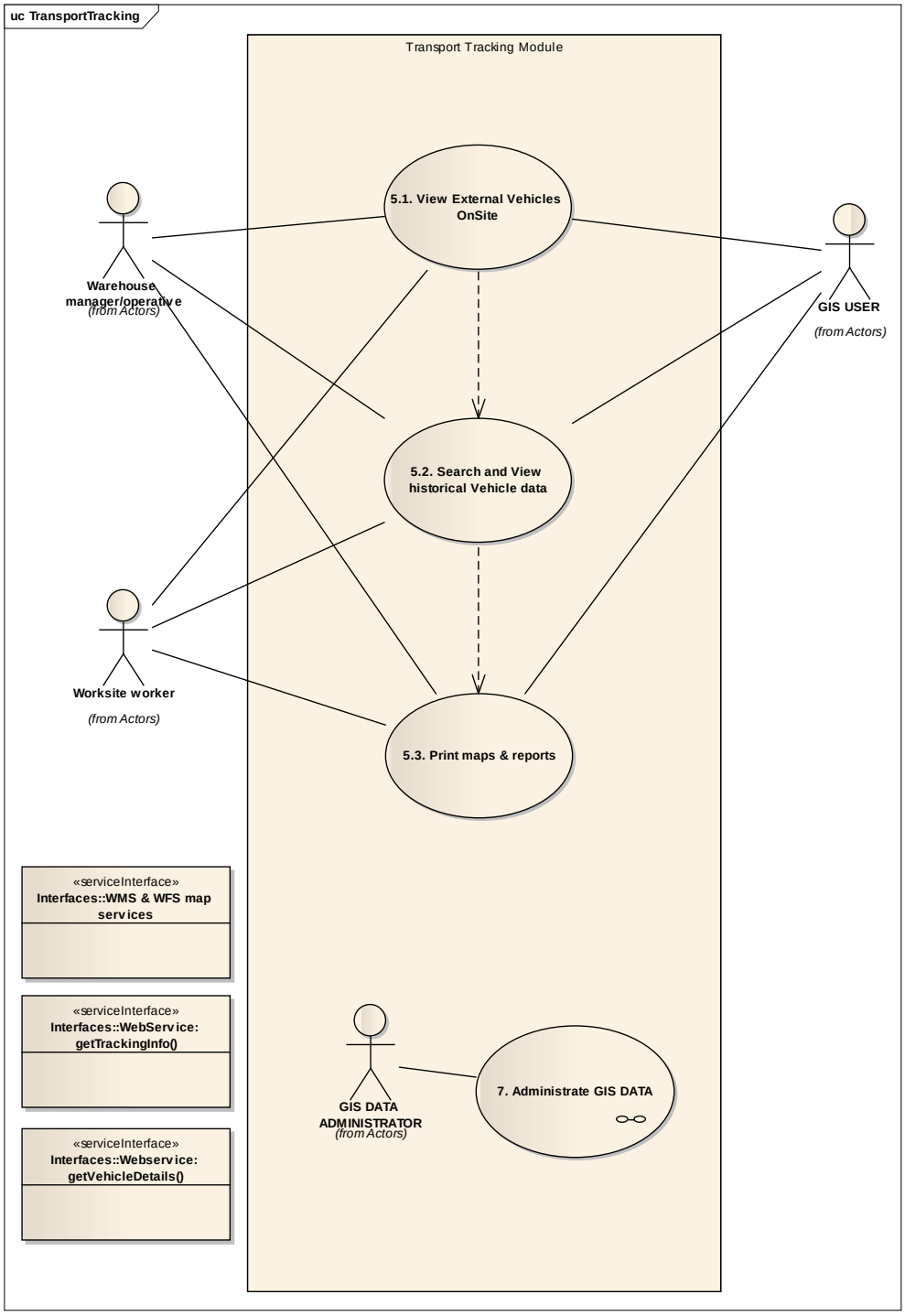

Figure 14 Use Case 5. Transportation Tracking major use case diagram

Use case	Description
Use Case: 5.1. View External Vehicles On Site	The User views a map showing transport infrastructure and vehicle position
Use Case: 5.2. Search and View historical Vehicle data	The user activates a search form in order to view a particular vehicle and/or it's history of movement
Use Case : 5.3. Print maps & reports	The user prints a map and/or report

Table 8 Transportation Tracking use case description

8 Environmental monitoring

Monitoring of environmental impact during the construction phase will be carried out by ambient environmental monitoring systems. Environmental data is complex and diversified and cannot be analyzed or viewed outside of context. For this reason specialized data handling and functionality is necessary. The environments monitoring system itself is not part of the WSMS but the data exposed by the environment monitoring system should be viewable and possible to query from inside WSMS clients.

The Environment Monitoring System must expose its data in the form of OGC compliant services SOS (Sensor Observation Service) and SES (Sensor Event Service) (see 12.2). These services will then be consumed in different client applications. In WSMS clients the data from environment monitoring should be present at the WSMS desktop client and possible the mobile client as well. The client application must expose methods to interactively request data from the sensors either as current readings or as time series of historical data. Further it should be possible to report the data in different formats with or without accompanying maps and to receive live alerts.

Specific thematic information from the environmental system will be presented by the WSMS on a 2-dimensional GIS map in order to provide an overview of the environmental impact and issues.

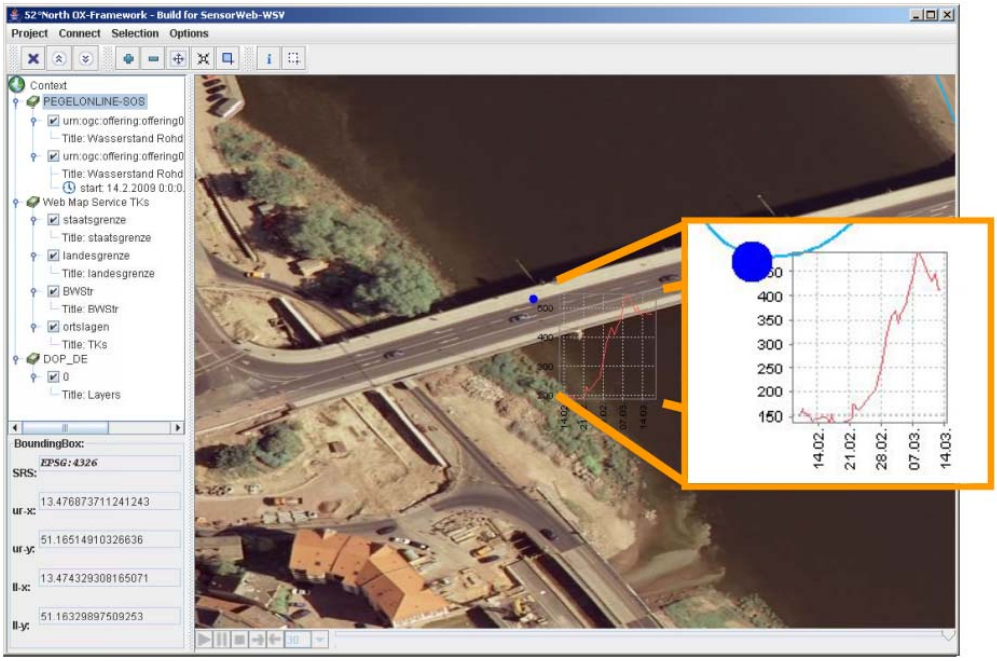

Figure 15 an example desktop client displaying sensor data presented via SOS. (52^{0}N OX Framework)

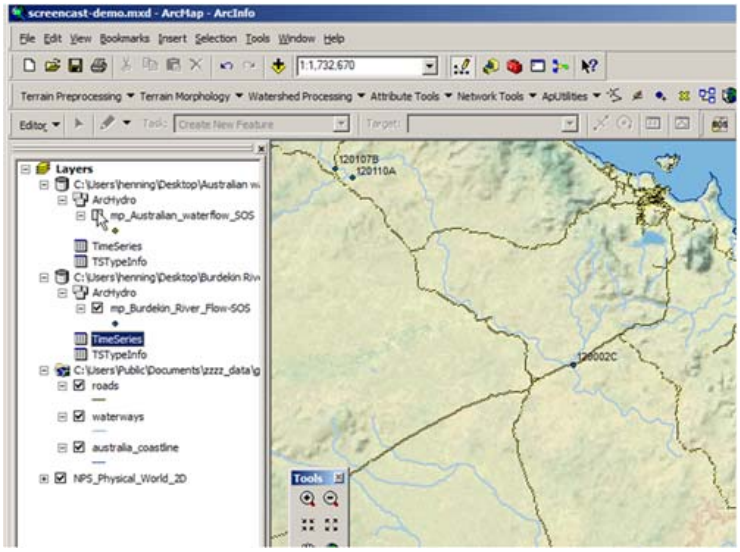

Figure 16 An ArcGIS desktop extension showing Sensor data through SOS/SES

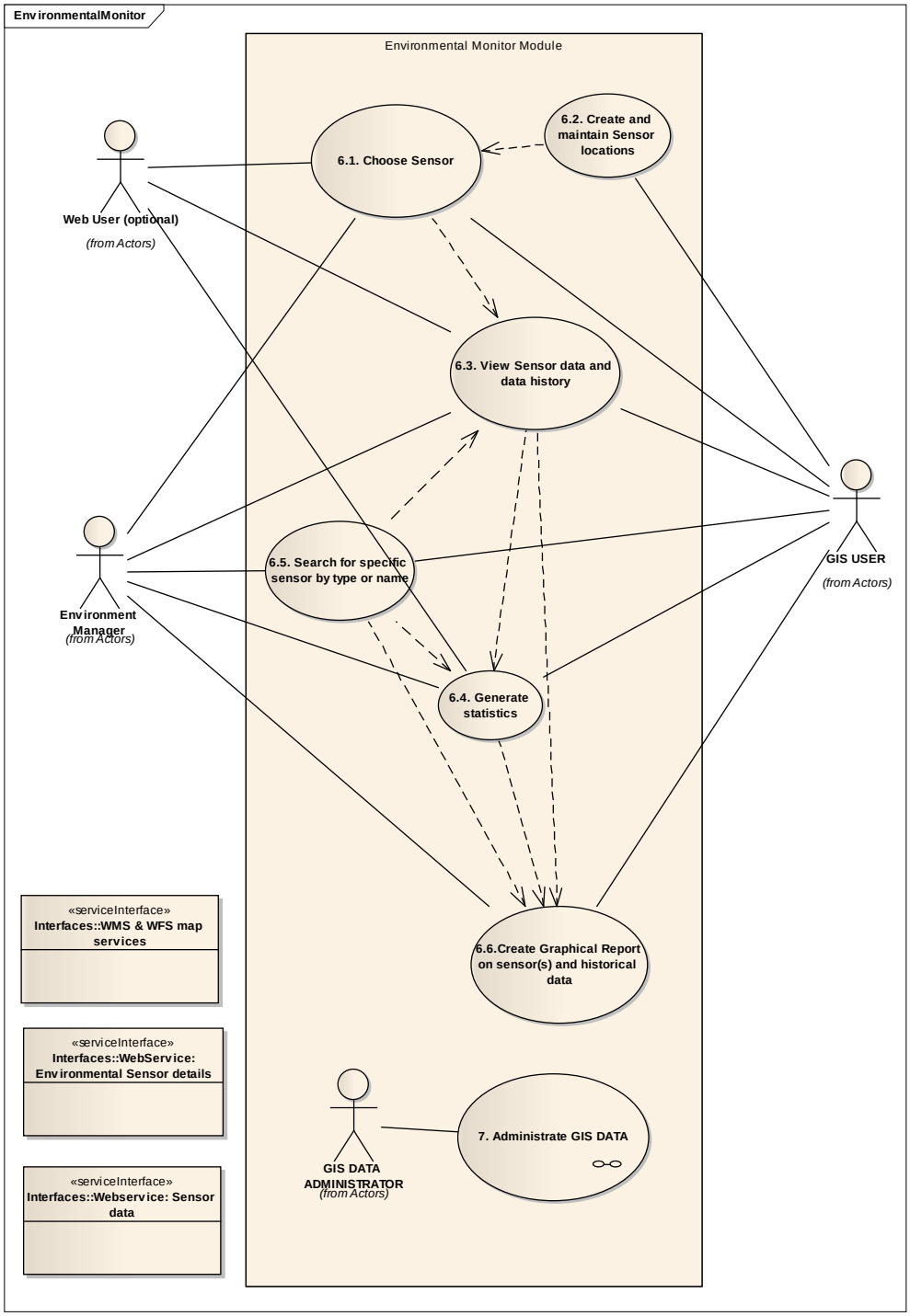

Figure 17 Use Case 6.Environmental Monitoring major use case diagram

Use case	Description
Use Case: 6.1. Choose Sensor	The user clicks a particular sensor in the map
Use Case: 6.2. Create and maintain Sensor locations	The user either creates a sensor representation on map or maintains the information on the sensor
Use Case : 6.3. View Sensor data and data history	The user is presented with a detailed view of the sensor and it's history
Use Case: 6.4. Generate statistics	The user can caulate a number of statistics based on date interval
Use Case: 6.5. Search for specific sensor by type or name	The user is presented with a search form and searches for sensor of specific type, name or other relevant attribute
Use Case: 6.6. Create Graphical Report on sensor(s) and historical data	Create a graphical report on the sensor and optionally some statistical information

Table 9 Environmental Monitoring use case description

9 Administrate GIS Data

This use case is different from the above described use cases which are sub modules of the worksite management system. This use case is however involved in all other use cases and consequently described separately.

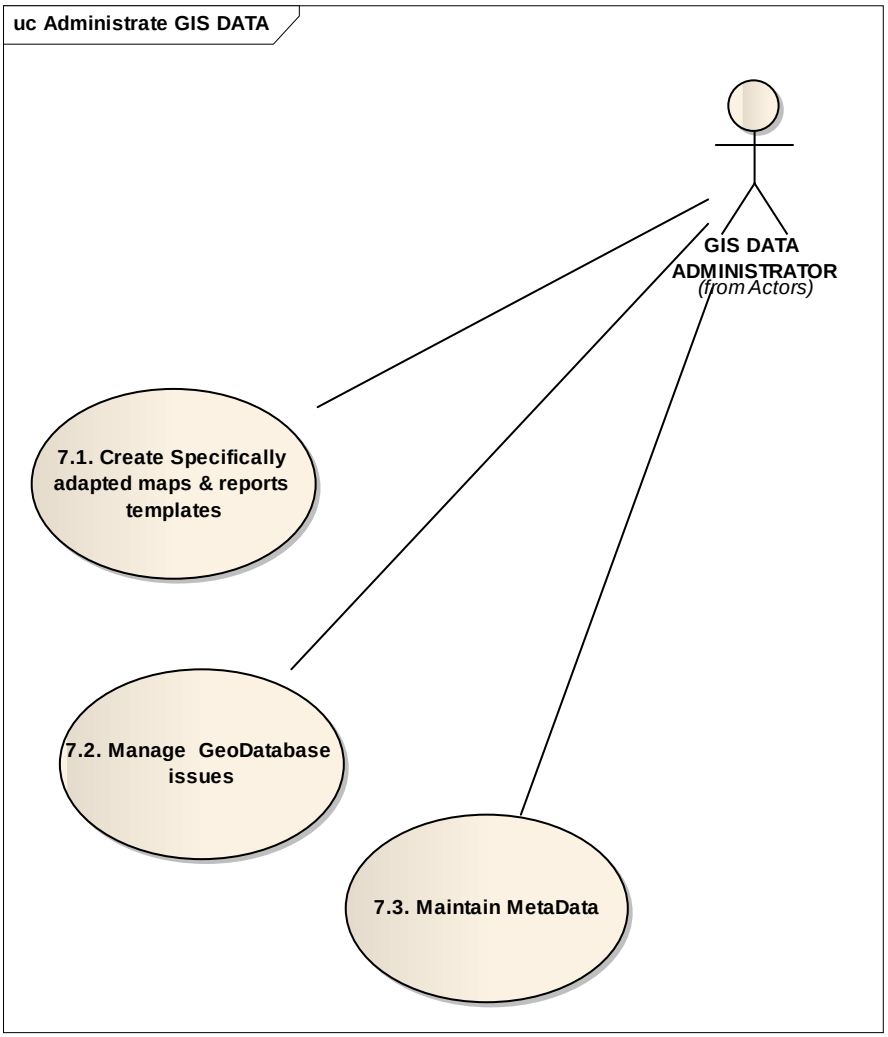

Figure 18 Use Case 7. Administrate GIS Data major use case

Use case	Description
Use Case : 7.1. Create Specifically adapted maps & reports templates	The user creates map templates and report templates to be used by other users
Use Case : 7.2. Manage GeoDatabase issues	The user maintains the integrity of data in the geodatabase, Imports or exports data and deals with other related geodata base issues like bulk import of data from other systems
Use Case : 7.3. Maintain Meta Data	The user maintains metadata on the data in the GIS Data Base.

Table 10 Administrate GIS Data use case description

The task of administrating GIS data is central to the WSMS as a whole.

10 Report data for MACS and MMS systems

WSMS contains webservices for delivering data from the WSMS database(s) to the MACS system (Management and Control System) as well as the MMS (Maintenance Management and Simulation system).

These services will deliver data in the form of maps and alphanumerical data to be used by MACS and MMS for reporting purposes.

11 Existing systems at The General Contractor

The following section describes existing systems used by The General Contractor which are of relevance for WSMS.

11.1 SAP

In the following a summarised list of the characteristics of The General Contractor's existing SAP system, which will be one of the data supplying systems for the Worksite Management System:

- SAP R/3 is an integrated system for managing all business processes.
- The release of SAP in use by is 4.6.C1
- The SAP system consists of a development environment, an environment for testing and a clustered environment for production.
- The numbers of users are about 800.
- The SAP main modules used are: Materials management, purchasing and inventory (MM), Managing invoicing (SD), Accounting (FI), Asset management (AA), Project Management (PS), Operational management and equipment and distribution costs (ETM), Controlling (CO), Workflow (WF), Maintenance Management (PM), Documentation management (DMS). SAP DMS is only utilized for material related documents. All other documents are handled by Aconex (see below).

- SAP has a native interface with M.S. WORD and M.S. Excel and Lotus Notes.
- SAP is a multilingual system. The SAP installation currently implemented supports the following languages: Italian, English, German, French, Spanish and Portuguese. For this project English will be used.
- The General Contractor will develop webservices in order to provide the necessary data from SAP to WSMS.

11.2 Primavera

Primavera is the project planning/-management tool used during the construction phase. Among others it keeps track of activities and their progress. The General Contractor will develop webservices in order to provide the necessary data from Primavera to WSMS.

11.3 Aconex

Aconex is utilized as a document management system for all documents except, material related documents (handled by SAP DMS). Among others Aconex contains CAD drawings. The General Contractor will develop webservices in order to provide the necessary data from Aconex to WSMS.

12 General System architecture

The General System Architecture can be described as consisting of 3 basic layers:

A data layer that consist of a series of components in the form of relational databases containing information on necessary geographical data, alpha numerical data and data captured from different sensor platforms like GPS tracking data or data from Ambient Environmental sensors.

A service layer, which handles all communication to and from the data layer. These services will employ a number of different standards making the data available to other applications in a disjoint fashion avoiding any hard couplings between applications

A Client layer with different clients that allows display and administration of WSMS data.

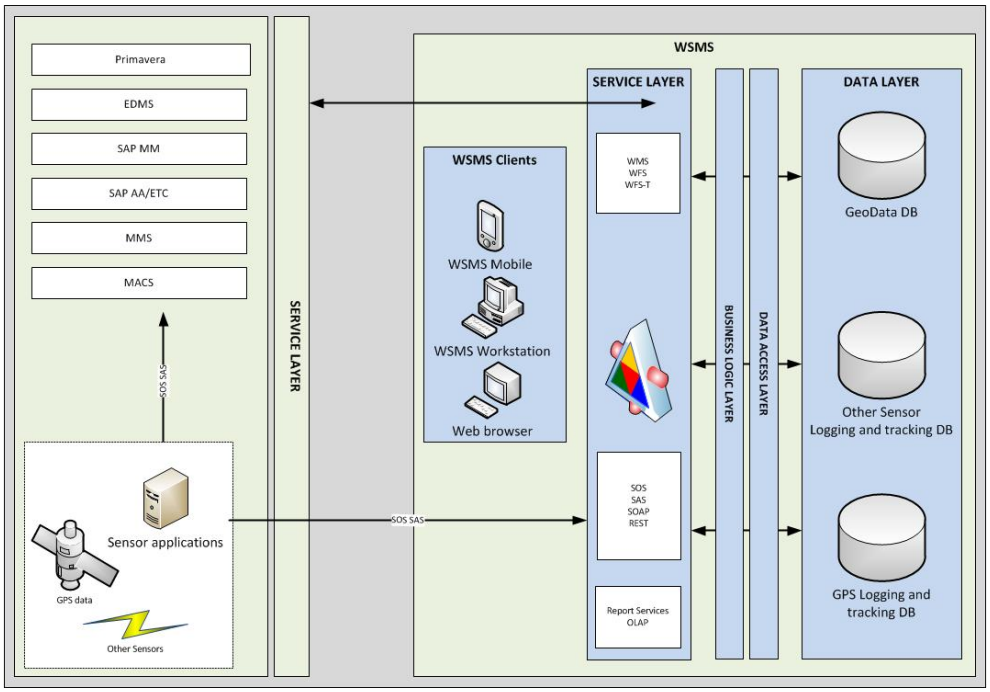

Figure 19 General system architecture

12.1 GIS data backend and data distribution

In more detail the GIS backend can be shown as in the below diagram.

One or more database servers running spatially enabled RDBMS, holds data pertaining to the work sites themselves for instance Fences, Roads, tanks, buildings etc. Most, if not all these data elements will have a quite simple data structure, they will primarily be represented as flat tables with one or more geometric attributes per table.

Data in these databases can be accessed in a number of different ways:

1 Through a GIS application server that contains one or several middle tier components. The middle tier consists of a GIS Data Server component capable of processing several different data sources into OGC standard Web services (WMS, WFS etc.). Server components such as these usually have advanced capabilities in terms of access control to data, Web Processing capabilities, the ability to cascade external WMS or WFS services and the ability to cache tiles representing static map data in order to provide high performance mapping.

2 Directly if the GIS clients supports such access. Many desktop GIS components can access spatial databases in this way.

3 Through standard web services. By developing web services one can interact with data in the database in a standard Client Server setup.

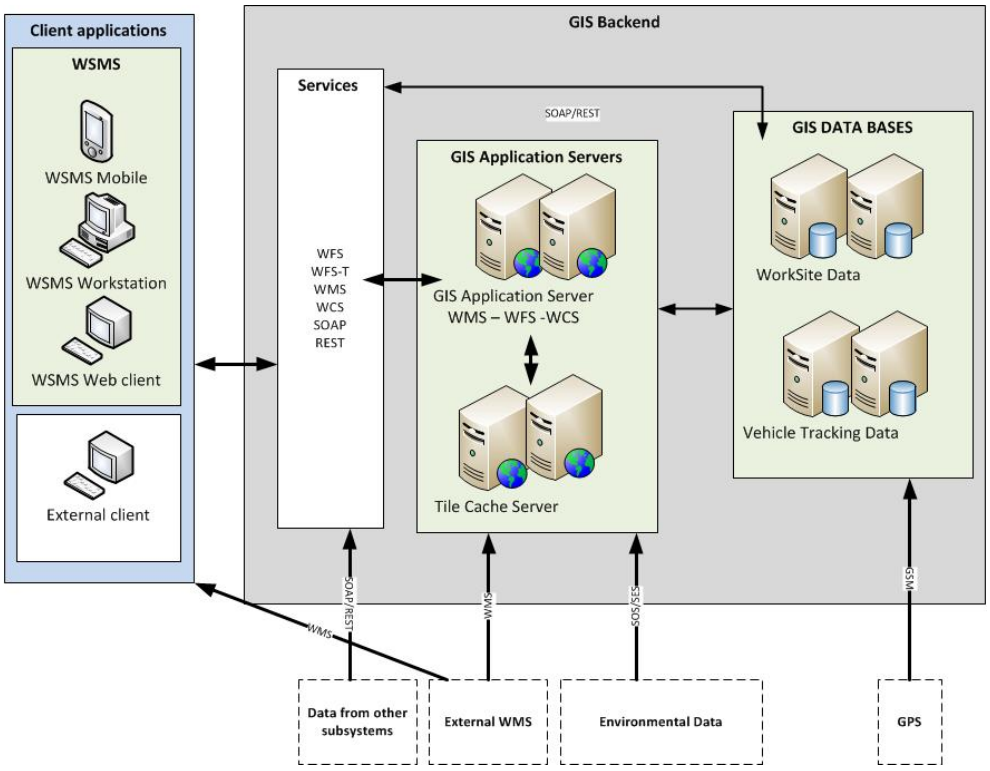

Figure 20 Schematic representation of the GIS Data Backend

12.2 Web enabling sensor data

A special problem in this respect is the standardized presentation of data from a multitude of different sensor platforms. The below diagram tries to describe a way to avoid hard coupling between many different data formats and the client applications that needs to interact with sensor data.

It is assumed that all sensors can send their raw data via LAN to a central server. On this central server a number of parser applications have to be constructed, one for each proprietary sensor output format. These parsers take the raw sensor data and transform it into a standardized format that can be uploaded to a central data repository via a web service. For some sensor the

registered amount of data can be very high and the data consequently needs to be simplified. Again, this data simplification process can take place at the parser level.

Lastly the aggregated simplified sensor data is presented to client applications via OGC standard services specifically designed to web enable sensor data: SOS (Sensor Observation Service) and SES (Sensor Event Services).

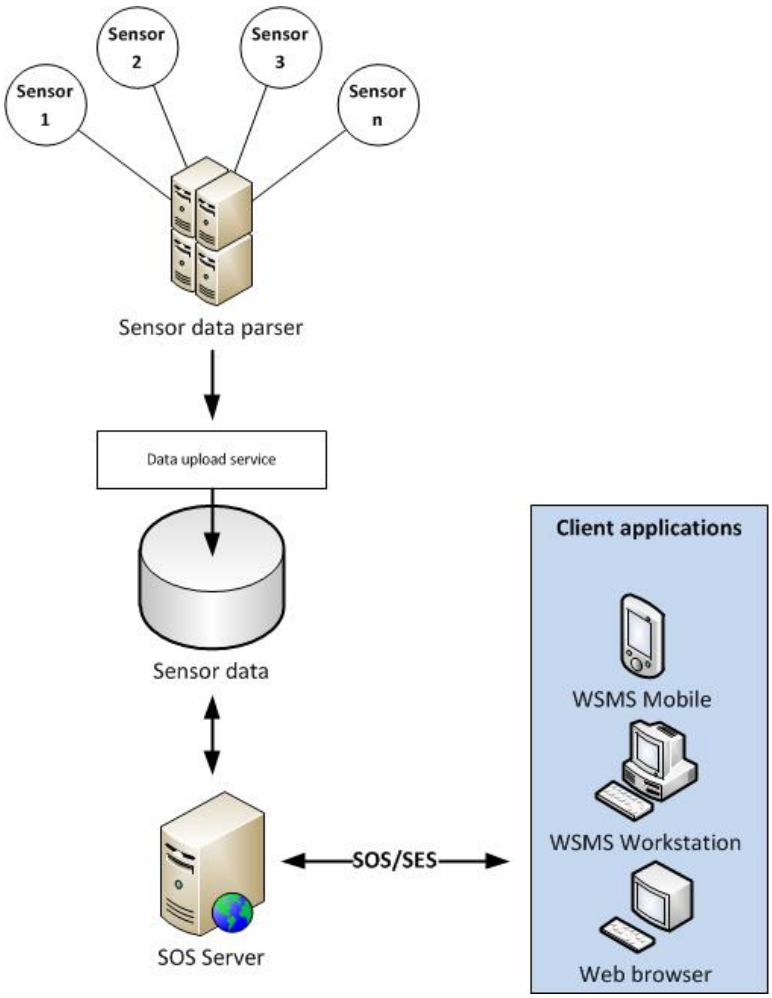

Figure 21 Recommended sensor data processing setup

Client components for consuming and displaying sensor data in this way already exist for different platforms. In cases where this is not the case the SOS/SES standards are well documented and relatively easy to build custom components for.

12.3 GPS tracking information

GPS tracking uses GPS receivers in combination with GSM (cellular network) communication in order to transmit positioning data from vehicle and equipment. The technology is supported by of-the-shelf units powered by either batteries or power supplies. Furthermore data transmission takes place using standard GSM networks with GPRS (General Packet Radio Service) which provides data packet transmission. The technology has shown well proven for fleet management systems and similar appliances.

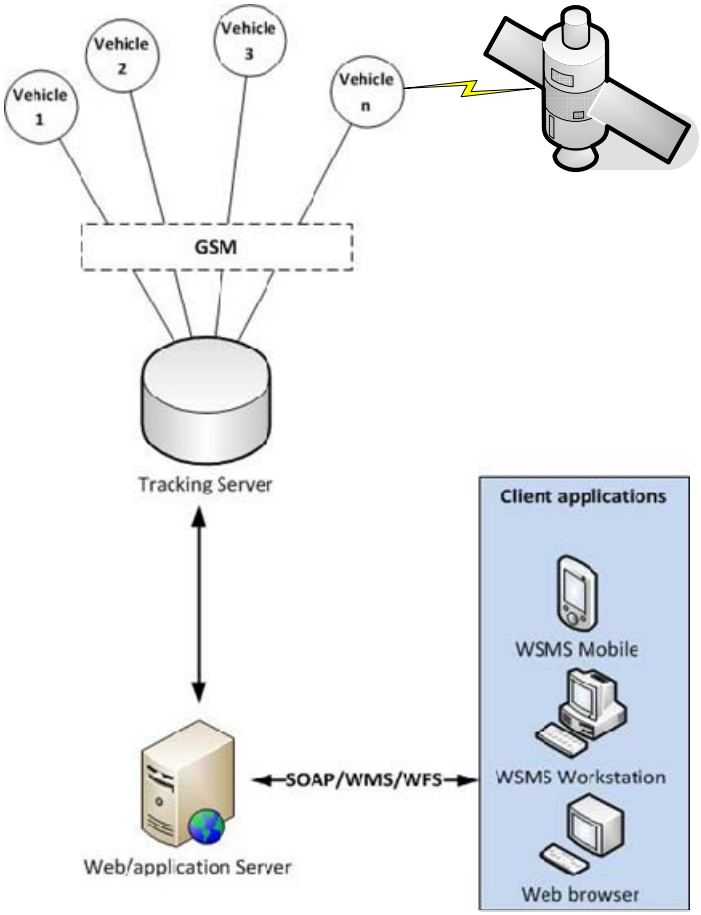

Figure 22 Schematic representation of components in a tracking system

The GSM module establishes a GPRS connection on the GSM network. Thereafter a TCP/IP socket connection to the tracking server is established making it possible to send IP package data between vehicles/equipment and the tracking server. The GPS receiver captures satellite radio

signals from which it calculates longitude and latitude. This information is passed on to the GSM module which sends the information as IP packages over the GSM network to the tracking server.

When a tracking device connects, the tracking server will authenticate and acknowledge the tracking device. Then, the tracking server receives the longitude and latitude data from the tracking device and stores the information in it's database from where the information is available to the different modules of the WSMS.

13 Data

In the following the presently identified data elements needed for the WSMS to solve its task will be shown. Additionally these data elements are show realized as service interfaces allowing WSMS to easily consume data and/or events from other parts of the system or exposing data integral to WSMS itself so that other subcomponents can consume these.

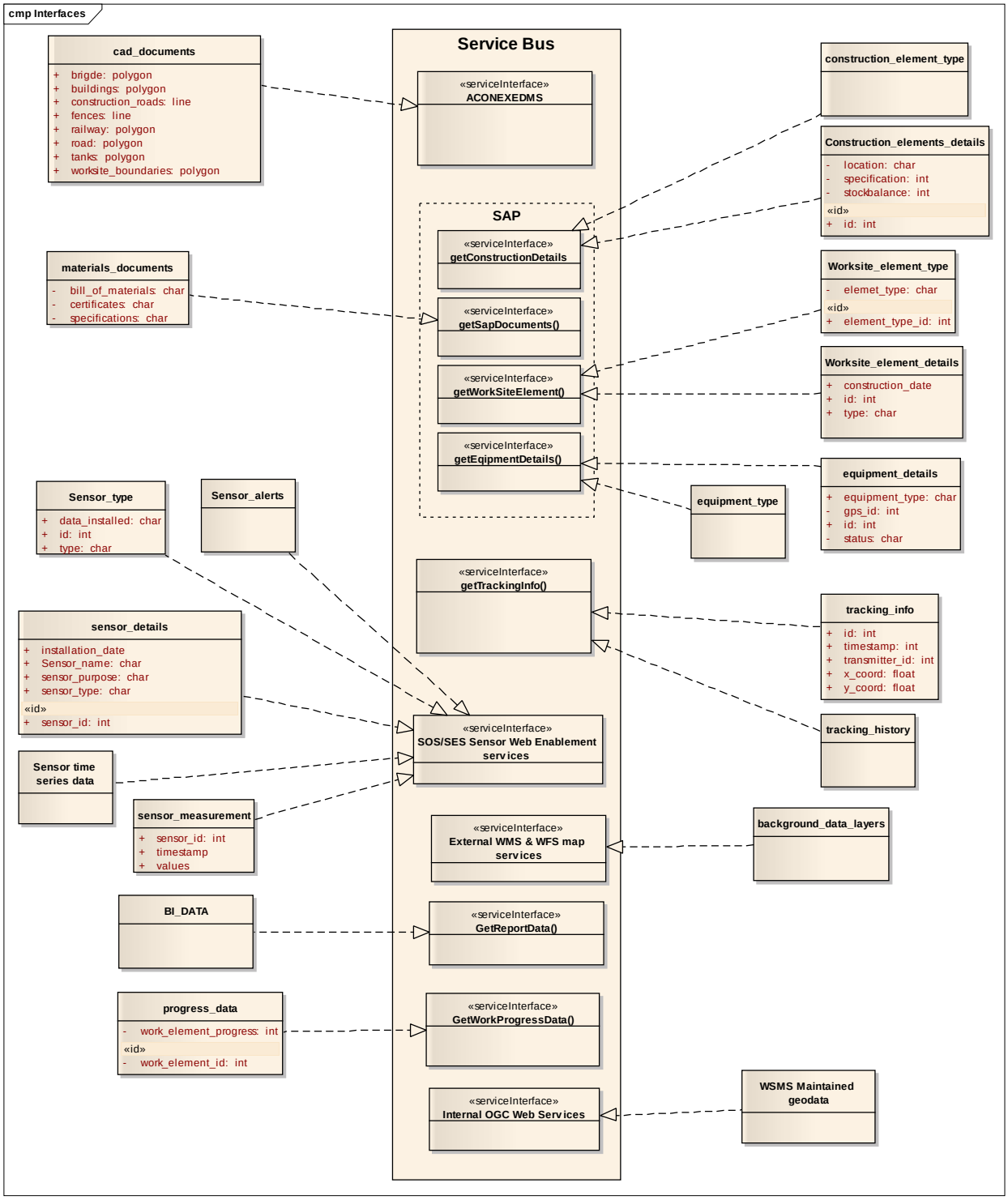

Figure 23 An overview of the data elements as they can be defined at the present stage of the design process. Notice that the data elements are realized as service interfaces. In other words the

above data is from the perspective of WSMS expected to be present as services.

Data Element	Description
BI_DATA	Generic class that holds Business Intelligence data that other components may require from data contained in WSMS.
Sensor time series data	This class represents the output of a time series request to a SOS enabled service
Sensor_type	This class illustrates data needed in order to describe a sensor: Sensor Meta data
Sensor_alerts	This class represents alerts from a sensor
sensor_measurement	This class represents live measurement data
sensor_details	This class illustrates data needed in order to describe a sensor: Sensor Meta data
WSMS Maintained geodata	Meta class that represents individual classes of information maintained by the WSMS. These are all represented as map layers and will take many different forms both geometrically and in terms of stored attributes.
Worksite_element_details	Class to hold information from SAP MM on work site element details. Allows WSMS to perform search Operations and retrive details including document references..
Worksite_element_type	Controlled list of work site element types managed by SAP
background_data_layers	Generic class that illustrates data from external data providers like the Italian National Mapping Agency, Google and/or other providers of web based mapping services.
cad_documents	Class that represent basic CAD documents. - These will form initial input to the base data creation in WSMS
progress_data	Class that holds information on work progress for a work element.
tracking_info	Class that holds information on vehicle current posistion.
Tracking_history	Class for holding a history of records for a particular vehicle
equipment_details	Class that holds information on equipment and vehicle details. Data comes from SAP
Equipment_type	Controlled list of different types of equipment

Construction_elements_details	Class that holds details on construction elements
Construction_elements_type	Controlled list to hold construction element type
Materials_documents	Class that holds information on documents regarding materials

Table 11 List of data elements needed for the operations of WSMS. The list is not exhaustive.

The principle for data ownership is: Data is owned by the system which creates data. In this way the external interfacing systems owns the data used by WSMS with the exception of WSMS maintained geodata and BI data (business intelligence data) (see Figure 24)

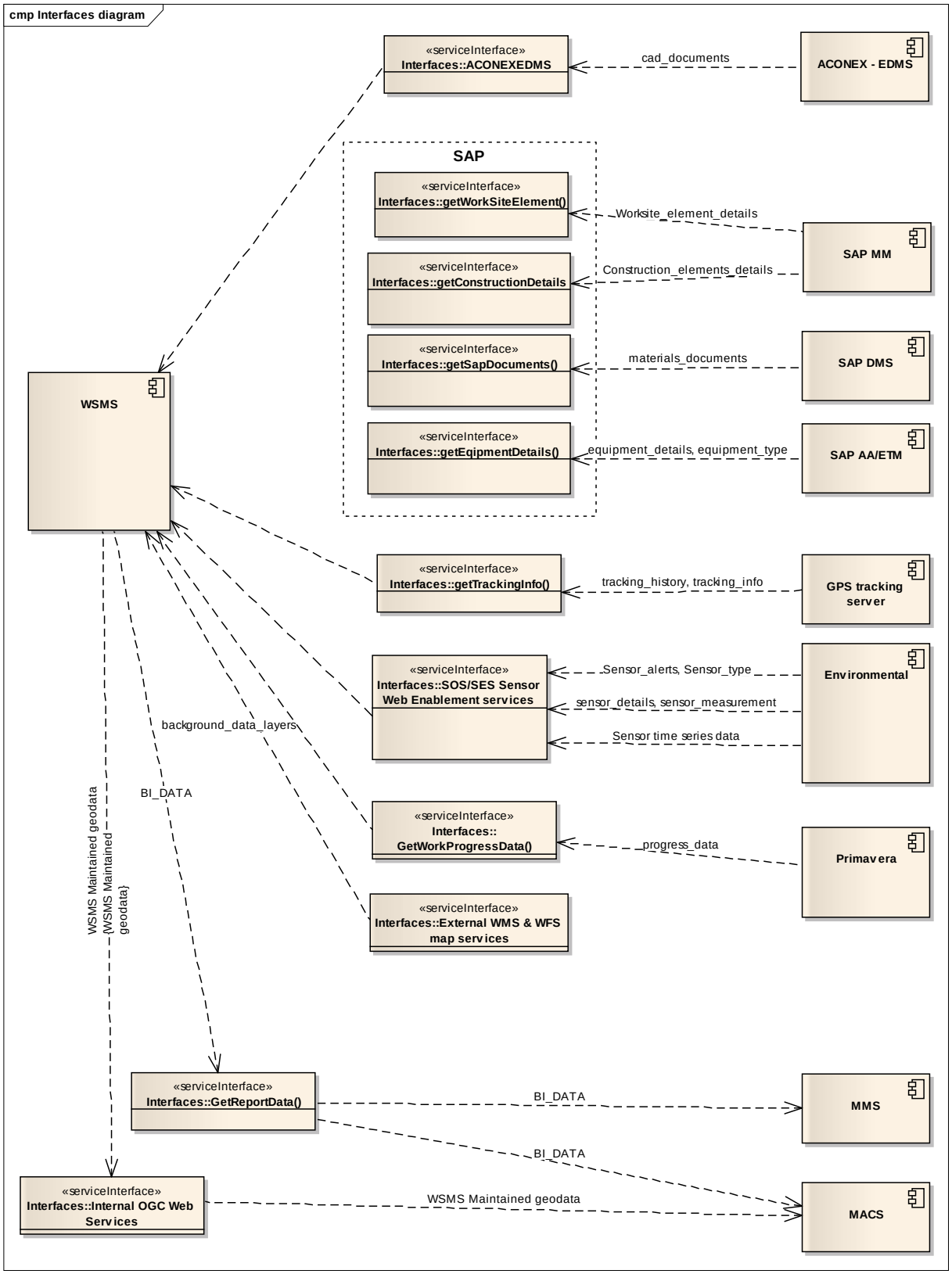
cmp Interfaces diagram
«serviceInterface» Interfaces::ACONEXEDMS
cad_documents
ACONEX - EDMS
SAP
«serviceInterface» Interfaces::getWorkSiteElement()
Worksite_element_details
SAP MM
«serviceInterface» Interfaces::getConstructionDetails
Construction_elements_details
«serviceInterface» Interfaces::getSapDocuments()
materials_documents
SAP DMS
«serviceInterface» Interfaces::getEqipmentDetails()
equipment_details, equipment_type
SAP AA/ETM
WSMS
«serviceInterface» Interfaces::getTrackingInfo()
tracking_history, tracking_info
GPS tracking server
«serviceInterface» Interfaces::SOS/SES Sensor Web Enablement services
Sensor_alerts, Sensor_type
sensor_details, sensor_measurement
Sensor time series data
Environmental
background_data_layers
BI_DATA
WSMS Maintained geodata {WSMS Maintained geodata}
«serviceInterface» Interfaces:: GetWorkProgressData()
progress_data
Primavera
«serviceInterface» Interfaces::External WMS & WFS map services
«serviceInterface» Interfaces::GetReportData()
BI_DATA
MMS
BI_DATA
«serviceInterface» Interfaces::Internal OGC Web Services
WSMS Maintained geodata
MACS

Figure 24 An overview of services to be consumed or is exposed by WSMS

Interface	Description
External WMS & WFS map services	This interface is a generic representation of different external map services. The map services can come from public providers of such services like for instance Google or Bing maps or they can come from the National Mapping Agency I.e. Detailed Ortho photos of the area
GetReportData()	A generic service that provides business intelligence data from WSMS to other components.
Internal OGC Web Services	Represents a series of OGC compliant web services exposed by WSMS. These services can take many forms but will mainly be in the form of WMS (Web Map Services) and WFS(Web Feature Services). Depending on the chosen middleware (i.e. GeoServer) the data can have a series of different additional output formats like KML, GML, MapInfo TAB, Shape files, PDF etc. The WSMS client applications will also consume these services.
ACONEXEDMS	Provides access to relevant CAD documents in the Electronic Document Management System. These form the basis of the geometric representation of Work Site element... It is still unclear in what form these will be displayed.
getTrackingInfo()	Web service interface that allows clients to retrieve information on specific vehicle positions either realtime or in time/date interval (historical).
Environmental Sensor details	Webservice: SOS/SES Sensor Web Enablement services OGC SOS/SES Standard services that allows WSMS to gather realtime or historic data on different environmental sensors. The service exposes functions: SOS: • GetCapabilities, for requesting a self-description of the service. • GetObservation, for requesting the pure sensor data encoded in Observations & Measurements (O&M) • DescribeSensor, for requesting information about the sensor itself, encoded in a Sensor Model Language (SensorML) instance document. • GetFeatureOfInterest, for requesting the GML encoded representation of the feature that is the target of the observation. • GetResult, for periodically polling of sensor data SES: • getCurrentMessage() • Subsribe()
getConstructionDetails	Exposes deatiled information on construction elements

getEqipmentDetails()	Web service interface that allows the Construction equipment module and Vehicle tracking module to get information on available vehicles and details for each vehicle.
getSapDocuments()	An interface that returns documents attached to materials, construction equipment etc. from SAP EDMS

Table 12 List of interfaces needed for the operations of WSMS. Please note that this list is preliminary.

14 Client applications

The WSMS will need several different client applications to provide users with the ability to interact with the system.

- a thick client for performing Vector editing and more complex operations in terms of data management, metadata management, advanced map report printing, spatial analysis, etc.

  The thick client is envisioned to be based on COTS (Commercial of the shelf software) that is extended with a series of specifically developed modules each representing Use Cases 1-6. Use Case 7 would usually be covered by already present functionality of such a system.

- a mobile client for consumption in mobile devices on site of information and functionality from WSMS and allowing user to query information and possibly update or add system information. At the present level of design it is not known exactly which functionality should be presented on a mobile device.

- One or more web applications that expose data and functionality to a wide variety of separate applications depending on purpose. E.g. Parts of the Construction progress data may be made public and Viewable from any web browser or might be displayed in Google Earth as a simple link to a service (KMZ/KML) exposed by the system.

For additional details on the components that might be chosen as the basis for client applications see 16 below.

15 Software development Principles

From a perspective of ease of software maintenance it is important to demand of any contractor that has to deliver specially developed software for the system (i.e. a web service or custom modules for desktop GIS applications), that certain principles are followed in this software development.

All specially developed software must be multi tiered and object oriented in its nature whatever the technological platform used. An example of such an approach is given below.

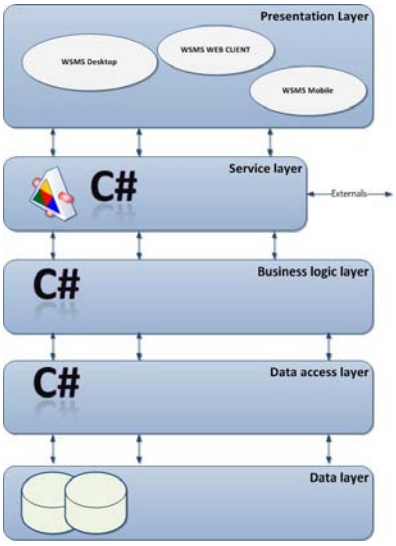

Figure 25 Example of a multilayered software architecture using C#

- From the bottom up we have the *Data Layer* that in this case consists of some relational database, some external web map services and possibly files stored on the server storage system.
- Second we have the *Data Access Layer* which is the segment of the software system where all the logic to read and write from some persistent storage is concentrated - often, but not necessarily, a relational database.
- Third, comes the *Business Logic Layer* which generally speaking contains the domain-specific model and logic that justify the building of the system.

- Handling all communication between the *Presentation Layer* and the *Business Logic Layer* is a *Service Layer*. The service layers only role is to expose elements of the business Logic layer thus making the degree off abstraction between any client and the logic and data of the application absolute. The service layer further gives the advantage that elements of the application can be easily exposed to any external clients (other "In Office" software or altogether external stakeholders (i.e. request for information on bridge progress)).
- Last we have the *Presentation Layer* which contains components for pre- and post-processing the action the user requested through the user interface.

The main reason for adopting such architecture and principles is to provide clear abstraction and separation between elements of code. This gives several advantages among which maintenance of code base is very important. For instance, in the event that the DBMS is to be changed from SQL server to Oracle, the only two parts of the code that would need to be changed would be the Data Layer and the Data Access Layer, the rest of the code could ideally be left unchanged.

Further it is important that any specially developed code is documented to a degree where other developers from other contractors can understand the code and extend it with new functionality. This means that all deliveries must include source code with inline code comments and a comprehensive code documentation document that aggregates this information.

16 Technology

There is a need for several different types of software to be implemented in the WSMS (Server and client operating systems omitted):

- **DBMS platform**
  The DBMS system should be a database system that supports Geometry/geography data types and have a full set of spatial operations available.
  examples:
  - Oracle 11G
  - Microsoft SQL Server 2008 R2
  - PostGreSQL/PostGIS 9/1.5.2

- **GIS middleware**

  In order to present data from the data base in the form of OGC standards like WMS and WFS there is a need for some sort of middleware between the DBMS and the Client software. Again several different options are available:

  - ArcGIS server 10.0 - ArcSDE
  - GeoServer 2.1
  - MapServer 5.6.5
  - MapDotNet

- **GIS desktop software components**

  Advanced GIS capabilities are best achieved through customisation of COTS (Commercial Of The shelf Software). Several different software packages exist that allows this:

  - ArcGIS desktop 10.0
  - MapInfo Professional 10.5

- **GIS web components**

  There is a great many web client software components available. The most elaborate are mentioned here:

  - ESRI Web ADF (comes bundled with ArcGIS server)
  - OpenLayers
  - MapDotNet

- **GIS mobile components**

  In terms of mobile GIS development several possibilities exist. One is to develop a web based client that is specially designed to be shown on mobile devises. The other is to develop specific applications to run on the device. The choice depends on the specific needed functionality and cannot be determined at this stage of the design process.

- **Sensor observation components**

  Server components and different clients are available from a number of suppliers as of the shelf products. Most important is to ensure the compliance with the OGC standards.

  - 52^{o}North
  - 1 Spatial Group ltd.

- Deegree

- **GPS tracking components**
  As mentioned earlier GPS tracking devices are off-the-shelf products. Therefore numerous suppliers of components are available. Elements of importance are: GPS accuracy, alternative positioning on the basis of GSM triangulation, rechargeable backup battery, charging by vehicle power supply (12 og 24 Volts DC), resistance to humidity, temperature and shock, GSM/GPRS communication and available data formats
  Tracking servers are either custom built or available as standard server applications.

  GSM networks are usually public cellular phone networks.

17 List of requirements

The following is a list of requirements gathered through:

- The technical specification from Stretto di Messina
- The Contractors tender design
- Meetings with EUROLINK
- Meeting with designers of other subsystems
- Inferred from the design process itself

ID	Requirement	Requirement Reference
1.	Tracing of transports from pits and construction sites to dumps and components and materials identification and classification.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
2.	Localisation and tracing, from origin to assembly, of materials and related documents by the WSMS and EDMS. The traced route of information shall be possible to display by the MCS. The same shall apply for classification of incoming materials to the work site and handling of related documents.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
3.	Monitoring and evaluation of works' progress.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
4.	A Geographical Information System based on MapInfo or similar will be part of the WSMS in the construction phase	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
5.	Location of all major construction equipment, both at the work site and when pending to external facilities through attaching GPS transmitters to such equipment.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
6.	Location of the perimeter of the worksite at all times, including video flow from security cameras. *(Note by COWI: requirement concerning security camera monitoring will be satisfied through a dedicated security and anti-sabotage system outside WSMS)*	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
7.	Location of all worksite infrastructure, roads, shacks, workshops, electrical systems, water	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI,

	pipelines, fuels tanks, batch plants etc.	pg. 8-9
8.	Mapping of the current state of the bridge construction.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
9.	Monitoring of environmental impact during the construction phase will be carried out by ambient environmental monitoring system.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
10.	Through the GIS the GIS operator will be able to report the current position for all construction equipment at all times.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
11.	There will be established an interface based on the GIS, allowing the WSMS and MCS to pull status reports from the GIS database with attached colour coded maps.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
12.	A Geographical Information System based on MapInfo will interact with the management system SAP and the CAD system based on AutoCAD. This will be organized so the GIS can keep track of all construction assets registered in the management system.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 8-9
13.	The work site management will: Establish and implement effective information handling and knowledge management tools to support e.g. the on site workers, decision makers. project manager, site manager etc.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 15-16

14.	The work site management will: Establish and implement suitable systems, software and intelligent wireless interfaces, e.g. portable intelligent systems to be used by workforce at work sites, based on mobile communications and interacting with sensoring networks, etc.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 15-16
15.	Establish and implement solutions to control security/safety supporting both the working environment and the health of the workforce as described in Doc. No. DC-1102 monitoring, Part D. *(Note by COWI: requirement concerning security/safety will be satisfied through a dedicated security and anti-sabotage system outside WSMS).*	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 15-16
16.	Establish and implement a learning environment by means of intelligent workplaces integrated with learning facilities which have the capabilities to collect - accumulate - store and present experience gained.	Messina Strait Bridge tender Design, Technical Design Change No. 11 - 03, March 2005, COWI, pg. 15-16
17.	The purpose of the system is: monitoring the building phase of the Work	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 5
18.	The information collected shall be stored to build a historical database of the work.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 6

19.	It shall also be possible to compare and/or overlap the results obtained to the data collected on the large scale with general information about the area (e.g. orthophoto, satellite images) by means of a GIS environment for geographical data management.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 7
20.	In the building phase, the following areas will be managed: • tracing of transports from the mines and sites to the discharge • revision of transported loads and manufactured/semi-finished products by scanner • localization and tracing of materials and related documents from the origin to the Work • monitoring and management of suppliers' progress statements	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 8
21.	The data will be transmitted where possible via radio by means of TETRA network.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 11
22.	The data collected and processed shall be displayed as a report (charts, graphics) or as a georeferenced map. All the critical data and the essential and useful data shall be displayed in order to access the Work status, and several scenarios must be represented (current, estimated, "historical") by means of a GIS interface.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 15
23.	The visualization on a geo-referenced map	Technical Specification for Maintenance

	shall show the Work (current and estimated) status by means of the localization and representation of the systems, equipment, phenomena and events to which all useful and necessary information will be associated.	Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 16
24.	The data for the arrangement of moving bodies (both personnel on foot or vehicles) will be transmitted by means of TETRA radio network.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 16
25.	The users' interface shall also allow the spatio-temporal analysis of available data, by means of the reconstruction, also three-dimensional, of different scenarios and their evolution and of what supports management, maintenance and planning	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 16
26.	The mobile radio system TETRA shall allow operating and service communications among the different users and external organisations involved in safety control and management operations, both in mobile mode and in data mode, so as to effectively integrate into other communication/coordination structures already carried out.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 17
27.	Each monitoring device (piece of equipment, system) must be localized, addressable and able to send/receive data to/from a central database server.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 20
28.	There must be a GIS interface by means which	Technical Specification for Maintenance

	the operators can visualize in real time on the geo-referenced map the position and status of the sensors and where at least it must be shown when the threshold values are exceeded.	Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 21
29.	The policies for storage, management, research, data display, and of data and procedure protection must be illustrated in the detail and approved by the customer.	Technical Specification for Maintenance Engineering and Control and Management Systems, Management and Control System, GCG.F.06.01, rev. 0, 12th October 2004, Stretto di Messina, pg. 21
30.	Mapbased user interface (GIS)	Progetto Definitivo, Worksite Management System Annex, CG1000-P-RG-D-P-CG-XX_A_01_WSMS_ANX.doc, Rev. A-01, 26-07-2010, Eurolink
31.	Graphical presentation of work progress by means of colour-codes on three-dimensional bridge and landworks drawings.	Section 4 Work progress monitoring
32.	Webservice interface to existing project management system (Primavera) including data content listed in section 13 Data.	Section 4 Work progress monitoring
33.	Progress reporting for each construction part.	Section 4 Work progress monitoring
34.	Access to information on each construction part by selecting it on the map.	Section 4 Work progress monitoring
35.	Data import from AutoCAD or Aconex EDMS including data content listed in section 13 Data.	Section 4 Work progress monitoring
36.	Maintenance of a topological road network described by nodes and road segments covering the worksite including attribute values	Section 4 Work progress monitoring

	for road segments.	
37.	Route planning functionality in order to calculate the shortest/fastest route satisfying the contraints expressed by the attribute values of the road segments.	Section 4 Work progress monitoring
38.	Calculate the route for one (1) vehicle visiting a series of locations (up to 50) on the route.	Section 4 Work progress monitoring
39.	Add the Transportation tracking layer described in section 7 to the route layer	Section 4 Work progress monitoring
40.	Graphical presentation of materials locations on map	Section 5 Materials location and tracking
41.	Webservice interface to existing materials management system (SAP MM) including data content listed in section 13 Data.	Section 5 Materials location and tracking
42.	Webservice/Electronic document link interface to existing electronic document handling system (SAP DMS) including data content listed in section 13 Data.	Section 5 Materials location and tracking
43.	Access to information on each material object by selecting it on the map.	Section 5 Materials location and tracking
44.	Graphical presentation of vehicle locations on map.	Section 7 Transportation tracking
45.	Continous updating of vehicle locations.	Section 7 Transportation tracking
46.	Chargeable GPS receivers and mobile data communication for vehicles.	Section 7 Transportation tracking
47.	Tracking server for continous collection of GPS	Section 7 Transportation tracking

	data from vehichles.	
48.	Webservice interface between GIS application and tracking server including data content listed in section 13 Data.	Section 7 Transportation tracking
49.	Continous updated logfile for every vehicle	Section 7 Transportation tracking
50.	Access to vehicle information and logfile by selecting it on the map.	Section 7 Transportation tracking
51.	Plot GPS trace from vehicle logfile on map within selected time range.	Section 7 Transportation tracking
52.	Webservice interface to existing SAP AA/ETM system including data content listed in section 13 Data.	Section 7 Transportation tracking
53.	Graphical presentation of Construction equipment locations on map.	Section 6 Construction equipment tracking
54.	Continous updating of Construction equipment locations.	Section 6 Construction equipment tracking
55.	Chargeable GPS receivers and mobile data communication for Construction equipment .	Section 6 Construction equipment tracking
56.	Tracking server for continous collection of GPS data from Construction equipment .	Section 6 Construction equipment tracking
57.	Webservice interface between GIS application and tracking server including data content listed in section 13 Data.	Section 6 Construction equipment tracking
58.	Continous updated logfile for every Construction equipment	Section 6 Construction equipment tracking
59.	Access to Construction equipment information	Section 6 Construction equipment tracking

	and logfile by selecting it on the map.	
60.	Plot GPS trace from Construction equipment logfile on map within selected time range.	Section 6 Construction equipment tracking
61.	Webservice interface to existing SAP AA/ETM system including data content listed in section 13 Data.	Section 6 Construction equipment tracking
62.	Activation of alarm when defined bounding area is crossed by equipments GPS position	Section 6 Construction equipment tracking
63.	Creation of multiple bounding areas	Section 6 Construction equipment tracking
64.	Assignment of bounding area to equipment	Section 6 Construction equipment tracking
65.	OPTION: Collection of equipment running time	Section 6 Construction equipment tracking
66.	Registration of environmental monitoring sensor locations	Section 8 Environmental monitoring
67.	Presentation of environmental sensor data	Section 8 Environmental monitoring
68.	Webservice interface to environmental monitoring system including data content listed in section 13 Data.	Section 8 Environmental monitoring
69.	Create specifically adapted maps and report templates	Section 9 Administrate GIS Data
70.	Management of geo database issues	Section 9 Administrate GIS Data
71.	Maintenance og metadata	Section 9 Administrate GIS Data
72.	3-layer architecture: Data layer, Web service layer and Client layer	Section 12 General System architecture
73.	Thick, mobile and web client applications	Section 14 Client applications

74.	DBMS platform	Section 16 Technology
75.	GIS middleware	Section 16 Technology
76.	GIS desktop components	Section 16 Technology
77.	GIS web components	Section 16 Technology
78.	GIS mobile components	Section 16 Technology
79.	Sensor observation components	Section 16 Technology
80.	GPS tracking components	Section 16 Technology