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REPUBLIC OF MACEDONIA

PUBLIC ENTERPRISE FOR STATE ROADS

Terms of Reference

Procurement of the RAMS Software, Road Measurements and Consultancy Services for Public Enterprise of State Roads

A. Background

The World Bank (WB) is supporting the Public Enterprise for State Roads (PESR) in Macedonia in their efforts to establish a Road Asset Management System (RAMS). The Public Enterprise is mandated to plan, construct, reconstruct, and rehabilitate the National and Regional roads in the country. Roads are broadly categorized as follows: (1) National roads (these are roads primarily connecting to neighbouring countries but also to the largest regional centers in the country), (2) Regional roads (connecting two or more municipalities and securing critical in-country connectivity) and (3) Local roads (serving municipal traffic). The current road network in Macedonia includes a mileage of 14,159km, among which, 1,112km are National roads (consisting of 236.5km highways and 876km National roads), 3,721km are Regional roads, and the remaining 9,240km are Local roads. At the moment the Macedonia is the phase of intensive road construction.

The RAMS which PESR is developing will cover the National and Regional Roads. So far, the next activities regarding RAMS implementation are finished or are in the process:

- The Road Reference system for main and regional road network was already defined in 2009/2010, under an EBRD technical assistance study, through traffic nodes, road sections and roads. According to the existing Reference system there are 422 traffic nodes and 583 road sections covering the entire main and regional road network. This study also produced the following documents tailored to Macedonian conditions: (i) Road Database and Systems Analysis of available systems and recommendation for system configuration and selection of users; (ii) Road Database and Systems - Proposal of database structure; (iii) Road Database and Systems — Guide on Road Data Collection and Management; and (iv) Road Database and Systems — Guide to Pavement Condition Survey and Evaluation.

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- In 2015 the PESR with the help of consultancy services executes preparation activities for introduction of RAMS. The main tasks were: (i) establishing and strengthening the RAMS Unit in PESR, (ii) detailing a roadmap for introduction of RAMS, (iii) supporting the procurement of a RAMS software (road database and evaluation tools), and (iv) evaluating the available road network data to compute monitoring indicators and statistics and perform a macro evaluation of the network to support planning and programming purposes.
- PESR is in the process of setting up a RAMS unit, consisting of four people (RAMS unit leader, civil engineer, traffic engineer and IT specialist) who will be also assisted by economist. In 2015 RAMS unit members finished initial training on RAMS concepts, road data organization and analyzing and using HDM-4 to prepare different programs of road preservation work for different budget scenarios.
- The existing basic road data (road reference system data, road length, number of lanes, Carriageway Width, Surface Type Information, Roughness (IRI), Rutting, and Average Annual Daily Traffic for 2013) was collected from different sources and arranged in MS Access database according to the road reference system. The collected data are not complete (all data set are not collected for the whole road network) and the quality and reliability of data should be checked with the future road measurements. In 2015 the PESR Unit finished road condition survey with the equipment already owned by PESR (Dynatest Road profiler and FWD).
- At the end of 2015, based on the collected road data, the road network evaluation was done with HDM-4; a 3 year rolling program of preservation works for different budget scenarios was prepared for monitoring, planning and programming purposes.
- The RAMS unit is in the process of performing a visual pavement condition rating of the road network and it will be finished in the first half of year 2016.
- The PESR is in the process of upgrading of existing IT infrastructure (servers, MS SQL Server licenses, workstations, ESRI ArcGIS for Desktop, etc.) to be prepared for delivery and installation of RAMS SW.

Through the project the RAMS SW must be delivered and implemented including Road Data Bank (RDB) integrated with GIS and HDM-4. Existing road data must be filled to RDB according to road reference system; digital spatial presentation of existing road reference system as core of RDB and GIS data must be prepared in form of nodes and road centrelines with road section identifiers and chainage. Also, additional road data collection must be done -ground penetrating radar for complete road network and weighing of commercial vehicles in motion to assess traffic loading and heavy vehicle characteristics for HDM-4 on 20 typical road sections.

B. Objective

Public Enterprise for State Roads (PESR, the Client) is establishing a Road Asset Management System (RAMS). The objective of the project is establishment of RAMS system with delivery of RAMS software, missing road data collection and consultancy services needed for the RAMS implementation.

The delivered RAMS software must cover the next basic components:
- Road Data Bank (RDB) database,
- RDB application for data management and HDM-4 use,
- GIS for data management and data presentation.

All components must be integrated in common IT solution and must be integrated with HDM-4 as data analysing tool. The client already has HDM-4 licence and Client's RAMS team had already some training to work with HDM-4.

Detailed requirement for RDB and GIS are specified bellow including consultancy services regarding supply, installation, user training, existing road data input to RDB and GIS, and HDM-4 utilization to support programing of road works.

Also, the Consultant must provide RAMS SW maintenance and user support for two years after the initial 12 months of system development.

IT infrastructure (hardware and system software) needed for the installation and operation of RAMS software will be provided by the Client and is not a part of this project.

The Consultant has to check and upgrade the existing location reference system for public roads that includes permanent reference points at appropriate intervals along each facility. This location reference system will include, as a minimum, identification and geographic coordinate location of the reference points and identification, geographic coordinate location and definition of the length of the road and sections between appropriate reference points. The Consultant must establish a digital spatial presentation of the road reference system as base of RDB and GIS in form of digital geodatabase including road centrelines with road section identifiers and chainage and corresponding reference points (nodes). The deliveries include preparation of methodology, data digitalization, establishment of the environment inside the GIS Desktop tool for reference system spatial data maintenance and RAMS users training.

Also, the Consultant must perform missing road data collection for RAMS. This includes measurement of all Macedonian state roads with flexible pavement with ground penetrating radar for determination of pavement layer thickness and weighing of commercial vehicles in motion to assess traffic loading on 20 typical road sections and average equivalency factors of vehicle fleet in Macedonia for the HDM-4 purposes. In addition, the Consultant has to use HDM-4 with the road network data collected during the assignment to support programming of road works.

C. Scope and Deliverables of Tasks

There will be the next main tasks under this assignment:
- delivery and implementation of RAMS software,
- establishment of digital spatial database of road reference system,
- providing ground penetrating radar measurements,
- providing weighing of commercial vehicles in motion,
- RAMS SW maintenance and user support.

1   TASK 1 - DELIVERY AND IMPLEMENTATION OF RAMS SOFTWARE

1.1   RAMS Software Overview

The delivered RAMS software must cover the next basic components:

- Road Data Bank (RDB) database,
- RDB application for data management,
- integrated GIS for data management and data presentation,
- integrated HDM-4 as data analysing tool,
- use of HDM-4 for programming purposes.

RAMS software components should be logically divided in the following groups:
- RDB database
  - store all the roads data in standardized relational database according to road reference system (road section and chainage) and geometry (coordinates) simultaneously and care for data history,
- Data maintenance tools;
  - RDB application for maintenance of the road data (import, input, edit, delete) is the core of the system; the RDB application must be strongly integrated with GIS and must enable automatic transformation of data between the road reference system and geometry and must include utilities for data transformation when road reference system is changed;
  - data preparation for HDM-4 must be supported as part of RDB application; based on the collected and processed data different homogenous sections (links) for different HDM-4 analyses have to be provided; appropriate software for defining a homogenous sections and importing to HDM4 software have to be developed/provided. In addition, the average characteristics of a matrix of road classes should be computed and exported to HDM-4 to be able to perform an HDM-4 network strategic analysis.
  - The RDB should be able to export the road network data per km, per homogenous road sections or for a matrix of road classes to Excel for further analysis.
  - GIS Desktop tool for road reference system and other GIS data management,
- Data analysing and presentation tools;
  - HDM-4 will be used as basic analysing tool for preparation, by the Consultant and the PESR RAMS unit, of plans for road construction, reconstruction, rehabilitation and maintenance.
  - The GIS Desktop application will be used for spatial analyses and data preparation for further analyses in HDM-4 and preparation of specific reports on road maintenance plans calculated by HDM-4
  - The system will produce standard reports and maps for monitoring the network and presenting the results of the HDM-4 evaluation.
  - WEB GIS system is the core system for all RDB data presentation to all PESR users.

The basic components of RAMS software that must be implemented through this project are shown in Figure 1.
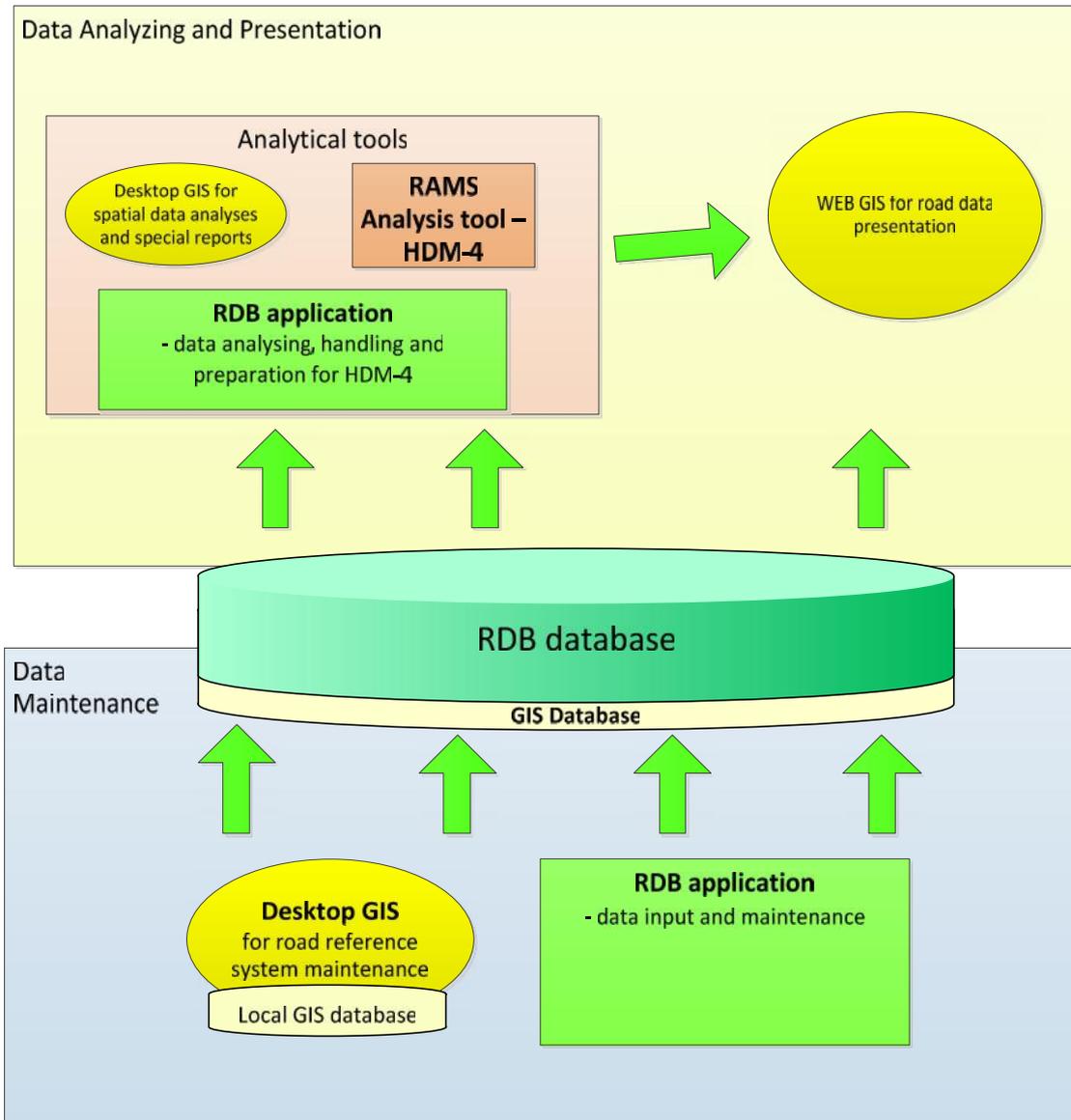
Figure 1.   General concept of RAMS database and applications

All components must be integrated in common IT solution.

RAMS software should be based on standard technologies and application tools and the system should be open and flexible enough, so that can be adjusted to PESR specific needs and integrated with other PESR IT systems. RDB and GIS system should be designed not to serve exclusively for RAMS needs but to serve other PESR units as well.

Detailed requirement for RDB and GIS are specified below including supply, installation, user training and existing road data input to RDB and GIS. Delivery of HDM-4 licence is not part of this project – the client already has HDM-4 licence. The Client's RAMS team is already trained to work with HDM-4, nevertheless, the Consultant will provide additional HDM-4 user trainings and user support for HDM-4, particularly on the interface between the RDB and HDM-4 and the HDM-4 evaluation to support programming of road works.

IT infrastructure (hardware and system software) needed for the installation and operation of RAMS software will be provided by the Client and is not a part of this project.

RAMS software requirements are divided in next groups:
- General Technical Requirements
- RAMS Portal Requirements
- RDB Database Requirements
- RDB Application Requirements
- RDB Data handling tool Requirements
- GIS Requirements
- HDM-4 Requirements
- Consultancy services regarding RAMS software Requirements

1.2   General Technical Requirements

[Mandatory Req. 1] Compatibility with PESR IT infrastructure
Consultant must provide RAMS software solution that will be fully compatible with PESR hardware and system software. Virtual environment VMware will be used on servers with MS Windows servers and MS SQL Server Spatial Database will be used as PESR central database for RAMS. Test and production environment will be provided by the client.

Workstations will use MS Windows operating system and MS Office Professional.

ESRI ArcGIS for Desktop Basic will be provided by the client (for road reference system and other GIS data management and for specific spatial analyses, data preparation for further analyses in HDM-4 and preparation of specific reports on road maintenance plans calculated by HDM-4).

If any other licences will be needed they must be delivered by the Consultant.

[Mandatory Req. 2] Multilanguage support
All RAMS software must have Multilanguage support. For the implementation of RAMS software the Macedonian and English language is requested.

[Mandatory Req. 3] RAMS SW Warranty Service
Warranty Service for all delivered RAMS software is 12 months from the date of operational acceptance.

1.3   RAMS Portal Requirements

[Mandatory Req. 4] Establish the specified RAMS Portal
Consultant must deliver RAMS portal that will support the use of RAMS software for different users. RAMS portal must enable at least the next functionality:
- single entry point to all RAMS components (RDB, GIS, metadata catalogue, etc.) integrated with PESR Active Directory single sign on system
- connection and log-on to all RAMS system components
- publishing news regarding the RAMS software
- questions and answers
- user documentation

[Mandatory Req. 5] Single Sign On for intranet/internet users
The Single Sign On is the single entry point for the intranet/internet users based on web portal and security mechanisms for the end user and it enables an overview of user access

information and a regulated access to RAMS components. The RAMS portal will integrate all of the sub-systems (components) into one integral solution and single sign on will enable the authentication and authorisation of the user. The final solution must be integrated with Active Directory system implemented at PESR for all PESR users.

[Mandatory Req. 6] User administration
User administration for all RAMS SW must be supported – users, user groups, user rights based on modules, functions, data or data group, etc.

[Mandatory Req. 7] Metadata catalogue
Component will provide catalogue that describes the basic data about the data that are included in RDB. By seeing this catalogue, the end user can have a better understanding of what the data mean and what their characteristics are (content, range, quality, etc.).

The component for managing metadata must have the following functionalities:
- View in metadata in accordance with ISO standards and the INSPIRE Directive
- Searching through metadata (graphic and attribute parameters)
- Editing metadata (manual entering, data acquisition from other metadata systems based on ISO standards)
- Linking metadata from other systems (harvesting)

1.4   RDB Database Requirements

[Mandatory Req. 8] Relational database with option for storing spatial objects
The RDB Database must be open standard relational database with additional option for storing spatial objects. MS SQL Server Spatial Database must be used.

The RDB database should be implemented as one central database for the whole PESR. Separate databases must be used for test and production environment. Licences of MS SQL database will be provided by the client.

[Mandatory Req. 9] Integrated road reference system and geometric data model
The RDB structure for road data should be based on the relative positioning principle (chainage on road sections) but all data also should have absolute geographic location (coordinates of each object should be stored in database). The GIS technology with dynamic segmentation should support the transformation between road reference system and absolute geographic location. All information, alphanumerical (descriptive/textual) and geometric (spatial) must be stored in an integrated object-relational database, providing a relational and secure approach for all data sources.

[Mandatory Req. 10] History of data
RDB Database must be designed to store history data for all data tables, so for each data is known the period of validity.

[Mandatory Req. 11] Content of RDB data
RDB Database must be designed to store any road data based on road reference system. For the purpose of the RAMS implementation at least the next entities (tables) must be included:
- Reference system
  - elements (nodes, sections) including their spatial presentation
  - road routes (road categorization)

- o division of network by municipalities and maintenance regions
  - Road geometry
    - o superelevation (%)
    - o horizontal alignment
    - o vertical alignment
    - o altitude - elevation points (m)
  - Road cross-section profile
    - o width and length of lanes
    - o number of lanes
    - o shoulders width
    - o drain type
  - Pavement structure
    - o pavement type
    - o material type
    - o history of pavement structure
  - Pavement condition
    - o longitudinal evenness
    - o transverse evenness
    - o pavement strength
    - o skid resistance
    - o texture depth
    - o pavement distresses (all structural cracks, wide structural cracks, thermal cracks, ravelled area, number of potholes, edge break area, bleeding)
    - o surface deformation
  - Drainage condition
  - Traffic
    - o traffic counter and other traffic counting locations
    - o traffic counting data (source data)
    - o WIMs measurement data
    - o traffic volume (AADT by vehicle)
    - o speed limit (km/h)
    - o speed limit enforcement
    - o traffic flow and speed parameters
    - o traffic accidents
    - o traffic fatalities
    - o traffic injuries
    - o vehicle fleet calibration parameters
  - Road works (planned, executed)
  - Road data collection works (planned, executed)
  - Video recording and photo documentation

1.5 RDB Application Requirements

The RDB beside the storing data includes also appropriate applications for data maintenance (entering/importing, updating, exporting, control and verification, data management, …) and road data presentation for different users (from data administrator to other PESR users). The management of road data must be primarily based on road reference system with road section identifier and chainage.

The main functionalities of RDB application are:

- controlled access to application and user rights administration,
- dataset organized by tree structure,
- each data stored with road reference system data and its spatial (geometry) presentation,
- automatic calculation of data location from road reference system position to absolute geographic position and vice versa,
- enables importing of collected data,
- enables maintenance of stored data (adding, updating, deleting with locking of data when processing)
  - where control on fields value must be integrated inside of each record and
  - other contents validation with other data records are integrated (overlapping segments, missing data for part of road segments, etc.),
- automatic care for data history and data time validity
- enables linking with DMS to store additional documents, pictures, video, etc.
- efficient searching based on location of data or content of data,
- enables integration with WEB GIS for presentation of data location,
- analyses of data,
- reporting,
- homogenization of road data,
- data export.

[Mandatory Req. 12] RDB Application architecture
RDB application must be delivered in 2 versions:
- as client/server application with full functionality for advanced users and
- as WEB application for data browsing and simple data entry for other users

Both applications must be designed to use 3 level architecture:
- the data are stored in RDB database (MS SQL Server Spatial Database),
- connection to the database is implemented through the middleware layer (web services) and no direct access from client to database is possible
- light user interface is used for data manipulation

For both version of RDB SW, client/server and WEB, the bidder must provide licences to meet PESR resources (no limitation to user access or number of server processors where application is deployed).

[Mandatory Req. 13] RDB Application updating
For C/S version of application automatic update for all client installation must be provided. Prior to system updates or version updates, users must be notified in order to confirm or reject the updates/upgrades. Notification must inform user about the type and purpose of update/upgrade. If update/upgrade is rejected by user, notification will appear each time user logs-in into the system.

[Mandatory Req. 14] Application users management
The RAMS unit is to be responsible for the entire RDB. Maintenance of data in RDB must be strictly controlled; responsibility of each person must be defined for data entry and maintenance into the RDB. Other users may only retrieve data from the RDB for different

purposes. The system should be capable of delegating various access rights to users. The next functionality must be available:

- Data access must be controlled:
    - entering Username and Password
    - Domain log-in
- Password modification must be allowed after user logon to the application
- Application must have integrated tool for users management actions as follow:
    - adding/deleting users and user groups
    - adding/deleting user in/from users groups
    - editing rights for user groups (data/data group, functions/modules)
    - definition of limited area for data access based on road sections and chainage
- Data access controlled using user groups, which define user rights (data access, view, edit).
- Each user must be defined in at least one user group with permissions to access selected data with rights for:
    - access to all or limited content.
    - data viewing
    - data editing, deleting and adding data
- System log file must be automatically created, recording application access, data tables access, record creating, editing, deleting for each user, recording time and type of actions.

[Mandatory Req. 15] RDB Application working environment
Due to expected large number of tables, large number of fields of data tables, application must allow dynamic settings of application widows by user.

Users must be allowed to store application settings and use it in the next session.

Users need to be available after enter the system:
- receiving notifications about application and data contents updates,
- access to digital application documentation (users manual).

[Mandatory Req. 16] RDB Application data access
Access to data must be organized through the hierarchical structure:
- data access with tree structure menus (unlimited levels) to allow access to data/table structure
- data tables organized within tree structure by common topics (i.e. ROAD GEOMETRY: horizontal alignment, vertical alignment, etc.)
- tabbed or shifting of multiple data tables views simultaneously to enable efficient work
- each data table to allow review of relationally linked data tables (master–detail) where interface displays a master list and the detail fields list for the currently selected item; selecting an item from the master list causes the details of that item to be populated in the detail area, using same rules as on master tables

[Mandatory Req. 17] RDB Application data view
Data viewing must enable the next functionality:
- Datasheet view (multiple records) and column view (single record) of data tables must be supported
- Software must allow hiding/un-hiding of selected data columns/fields from the data

table to allow efficient work:
- o data sheet view: moving, hiding, un-hiding of data fields
- o single record (column) view: grouping of fields into groups, to enable hiding/un-hiding of selected groups or fields
- Datasheet view must allow »single selection« or »multi-selection« of records to perform desired activity (i.e. exporting or printing selected records only)
- View of related data tables must be allowed, from selected record in master table to related records in detailed/related table (i.e. for selected road section user can browse all road condition data from different tables)
- connection with WEB GIS must be implemented: for each objects or selected group of objects inside RDB application display of this objects in WEB GIS must be possible.

[Mandatory Req. 18] RDB Application data view basic functions
By data viewing the next functionality must be enabled in datasheet view in order to data explore and analyse:
- sorting (ascending, descending) of data in selected data field
- simple data filtering (by selection or by value)
- advanced filtering (by user defined criteria)
- grouping (by on or many selected fields)
- efficient searching based on location of data or content of data is required

[Mandatory Req. 19] RDB Application data entering
Data entering must enable the next functionality:
- data locking/unlocking system must be used to allow editing, deleting or inserting data within data tables, as a second level security not to change data by chance
- required data fields must be marked. The edited record cannot be stored unless all data in required fields is entered
- system fields, calculated fields or other fields, that are not allowed from user to edit, must be marked
- all data fields must be accompanied with detailed description, containing measurement unit, if applicable, shown also as a »tool tip«
- entering standardized data fields using drop-down lists and control on fields value entered must be integrated inside of each record
- contents validation with other data records must be integrated (overlapping segments, missing data for part of road segments, etc.)
- copy/paste function on complete records to enter data of similar entities to enable faster data entry
- enables adding equal values in to selected records and selected fields
- enables linking with DMS to store additional documents, pictures, video, etc.

[Mandatory Req. 20] RDB Application support for data location entering
Road data location is based on road section identifiers and chainage and entering of data location must be supported with the next functionality:
- entering the section-id and chainage:
  - o chainage must be given as 1 field in case of point entities and with starting and ending chainage (2 fields) in case of line entities
  - o automated location data entry controls of reference system of section-id and

chainage to enter entities on specific road section within the length of section
- o spatial coordinates must be automatically calculated based on GIS presentation of road reference system (point on road centreline line for point object, polyline on road centreline for line objects)
- o geometry data must be stored in geometry field in data table
- entering the coordinates of point objects:
  - o coordinates will be stored as attribute data in table,
  - o road section and chainage must be automatically calculated based on GIS presentation of road reference system; the user must have possibility to change the data
  - o spatial coordinates of point on road centreline line must be automatically calculated and stored in geometry field in data table
- automatic calculation of data location from road reference system position to absolute geographic position and vice versa

[Mandatory Req. 21] RDB Application support for road reference system changes

Road data location is stored in RDB database with road section identifiers and chainage and with spatial geometry. In the case when road reference system changed (new roads, new alignments od roads after reconstruction, changed categorization, lengths, etc.) the existing data regarding the road section identifiers and chainage could become invalid. In this case the update of this data must be done from geometry data whenever possible. For this operation the next functionality is needed:

- recalculate all RDB data stored as spatial objects according to new reference system to get correct road segment and chainage
  - o exact rules must be defined in which cases this can be done automatically regarding the geometry deviations, road section identifiers and chainage
  - o list of object must be prepared where this recalculation can not be done automatically and data should be marked to be manually corrected
- review of data position for each data layer before recalculation and after recalculation must be possible through the GIS

[Mandatory Req. 22] RDB Application support for road works

RDB must have a special module for storing and management of data about planned and executed road works (maintenance, rehabilitation, reconstruction and improvement works). Road work has big influence on data collection:

- mass road data collection should be planned after the conclusion of road works on that sections,
- new data collection must be done on sections where road works are finished.

For this reasons simple workflow for road works data must be supported inside RDB application:

- the prepared and accepted program of road work for each year must be put in RDB (location, type of work, planned time schedule, short description of planned works, etc.)
- management of changes of the plan must be supported through the application
- road works monitoring must be supported (location, type of works, works start date, short description of works, status, etc.)
- data about execution of road works should be separated by data of planned work, so that comparison between plan and execution is possible
- regular reporting on road works progress from side of each project leader must be

supported
- connection with WEB GIS must be enabled to show location, status and other information on planned and executed road works

[Mandatory Req. 23] RDB Application support for road data collection works
RDB must have a special module for storing and management of data about planned and executed road data collection.

Simple workflow for road data collection plans and execution must be supported inside RDB application:
- entering the plan of road data collection for each year: type of data, location of data collection (road sections), planned time schedule, who is responsible for this data collection, way of execution (PESR internal collection, outsourcing), etc.
- management of changes of the plan must be supported through the application
- reporting on road data collection works must be supported (location, type of data collected, period of data collection, short description of executed data collection, equipment used, who was done the data collection, etc.)
- data about execution of road data collection works should be separated by data of planned data collection, so that comparison between plan and execution is possible
- connection with WEB GIS must be enabled to show location, status and other information on planned and executed road data collection works

[Mandatory Req. 24] RDB Application support for data history
RDB application must be designed to take care about data history whenever data are changed, so for each data in the RDB database is known the period of validity. For this operation the next functionality is needed:
- by data editing date of data entity validity must be requested to enter by user - start date of entity validity (date of data change is normally not the same as data validity date).
- previous data must be automatically stored in data history with entered date of data validity as end date
- relation between records regarding the same object through time should be managed, using id system to allow viewing whole lifecycle of object
- by viewing data filtering of data on selected date must be enabled: viewing actual data on selected date.

[Mandatory Req. 25] RDB Application support for data import
RDB application must support importing of road data for all types that are normally collected by other systems (i.e. road condition measurement data, traffic counts, etc.). For this operation the next functionality is needed:
- procedure to import data to RDB from described format and structure
- integration with existing data – replacement of existing data or adding to existing data
- using all the mechanisms (data control, data location calculation, history management, etc.) that are requested for manual entering of data

[Mandatory Req. 26] RDB Application support for data export
RDB application must support exporting of road data:
- simple export of data – export data of selected table for all or selected object with the format (XLS, TXT) and structure (list of fields) defined by user

- predefined exports – export of data of single or multiple relation connected tables on base of predefined condition and data operation (grouping, summing, counting, etc.)

[Mandatory Req. 27] RDB Application support for reporting
Data and data queries presentation using reports must be supported in different ways:
- Simple records set reports – print and export to Excel of the data set/ table content with selected fields defined by users
- Pre-prepared standard reports – print and export to Excel of query results based on pre-defined data selection and data operation
- Pre-prepared road network monitoring, planning and programming reports – print and export to Excel of standard reports to be included on the annual report of PESR to characterize the road network and the results of the planning and programing of road works evaluations.
- storing of reports as PDF files (without additional SW tool like Adobe, PDF_Creator, etc.)

1.6 RDB Data handling tool Requirements

Road data sets collected are normally stored in RDB in source format and usually in this format do not fit directly to analysis tools (like HDM-4), where specific data format is required for the analysis. The RDB software should be able to export the road network data to HDM-4 for its evaluation. For this reason, preparation of data for the input into the analysing tool must be done. Definition of "homogenous road sections" on the basis of RAMS expert's defined criteria and transformation of the data onto homogenous sections (either with appropriate routines within the RDB, using RDB management tools and GIS) is the basic process of data handling to get data in formats suitable for HDM-4.

The process of homogenization of road data must be supported with appropriate tool integrated in RDB application as independent module of road data maintenance. The module must support homogenization of each of the pavement characteristics on base of user defined criteria.

The next functionality is needed for at least for the Data handling tool:
- an automatic sectioning/dividing routine (Homogenizing Tool) which will divide a specific set of data on a section to a number of relatively homogeneous sections for data analysis or modelling based on criteria defined by users; criteria for breaking into sections could be based on: fixed length, fixed interval of data item(s), change in value to certain threshold, deviation in values,
- interface to refine the automatically generated sections,
- a dynamic segmentation and transformation routine to automatically transfer data from one form (perspective) to another using mathematical calculation criteria defined by the user,
- routines to prepare different data sets for direct import into HDM-4.

The RDB should also be able to compute the average road characteristic of a matrix of road classes to be defined by the user for exporting to HDM-4 and Excel.

The Data handling module must enable to store all results of data handling into RDB. Also through the Data handling module the RDB should be able to import the HDM-4 results of a an HDM-4 evaluation to update the RDB database with the HDM-4 results. All calculated

data – results of Data handling module and HDM-4 results must be able to show on GIS maps.

After RDB completion and software implementation it is expected that connection between RDB and HDM-4 have to be established (input/output options) and Client staff have to be trained to export data for HDM-4 and import results from HDM-4 to RDB and GIS for presentation.

[Mandatory Req. 28] Homogenization module
The process of homogenization of road data must be supported with appropriate tool integrated in RDB application as independent module of road data maintenance.

[Mandatory Req. 29] Definition of "homogenous road sections"
Definition of "homogenous road sections" on the basis of RAMS expert's defined criteria and transformation of the data onto homogenous sections is the basic process of data handling to get data in formats suitable for HDM-4.

The module must support homogenization at least of each of the following:
- profiler measurements (IRI and Rutting)
- FWD measurements
- SCRIMTEX measurements
- pavement structure
- pavement distresses
- road width.

There are several methods available for automatic sectioning. At least the following methods must be implemented:
- Cumulative Differences [1]
- Absolute Differences in Sliding Mean Values[1]
- Bayesian Segmentation Algorithm[1]

Methods must be able to consider additional criteria such as minimum length, fixed interval of data item(s), change in value to certain threshold, deviation in values etc.

[Mandatory Req. 30] Network overlay
As in general section brakes of each data set, generated in homogenization, will not be coincident, we need tool to merge (overlay) them. The result is one table with the merging chainage and data from all input data sets.

Aggregate measurements and RDB tables containing data about
- o Geometry
- o Cross-section composition
- o Pavement structure
- o Pavement condition
- o Traffic

have to be merged (overlaid) into final table.

Beside the specified overlays the network overlay routine must enable of merging any two RDB tables.

[Mandatory Req. 31] Section aggregation
As so generated sections can be too small for practical use user must be able to aggregate them manually or on certain criteria. Tool and interface for this must be developed.

[Mandatory Req. 32] Calculation of geometry data from GPS measurements
RDB data handling module must support calculation of geometry data needed in HDM-4 for each section in aggregate measurements.

This data can be calculated from GPS measurements stored in RDB:
- rise + fall (m/km), No. Of rises + falls [no/km]
- average horizontal curvature (deg/km),
- altitude (m).

[Mandatory Req. 33] GIS interface
The Data handling tool must be connected to GIS for graphical presentation of data for plausibility checks. GIS must present any result of data handling stored in RDB Database and must allow selection of versioning (each data can exist in multiple versions). Automatic symbology must be supported according to data classification.

[Mandatory Req. 34] Export to HDM-4 sections
Finally, a tool for export to HDM-4 must be developed. Module must be able to connect HDM-4 network export database and transfer all needed data (selected version) in HDM-4 SECTION and TRAFFIC tables.

[Mandatory Req. 35] Implementation issues
As different methods of segmentation and with different parameters are possible and some manual work is expected it is vital that we don't introduce chaos into basic RDB. All tables generated with data management tool must be stored in separate database scheme, some kind of versioning must be implemented and tools for database maintenance / cleaning must be provided.

1.7   GIS Requirements

The GIS application is normally the central point and basic tool for each PESR employee, where she/he can find all data about road, not only data regarding RAMS. Huge amount of road data collected in RDB can be effectively presented only through the visualization of this data on road network. The GIS application must cover also the presentation of results of data analyses made by RDB data handling module and with HDM-4 prepared programs of road maintenance works. The GIS is also entering point for access to other road documentation, pictures, video, etc.

[Mandatory Req. 36] WEB GIS
The GIS application must be developed as WEB application with 3 level architecture:
- the data are stored in RDB database with spatial extension (MS SQL Server Spatial Database),
- application server part should be implemented as WMS and WFS server and
- light user interface is used for data presentation that can be used in any standard WEB browsers (MS Internet Explorer, Mozilla Firefox, Google Chrome, Opera, etc.).

The RAMS WEB GIS should be based on off the shelf or equivalent software standard solutions (GeoServer, MapServer, or equivalent), that request no additional licensing for the services. Also the off the shelf solution must meet licence requirements (no limitation to user access or number of server processors where application is deployed).

[Mandatory Req. 37] GIS implementation in compliance with OpenGIS® and OGC
GIS must be developed in compliance with OpenGIS® and OGC standards.

[Mandatory Req. 38] GIS infrastructure - configuration
GIS infrastructure (GIS Server Engine and GIS services) must enable advanced configuration for all elements (OGC services, layers, SLD styles, monitoring, etc) via web interface.

[Mandatory Req. 39] GIS infrastructure - scalability
GIS infrastructure must enable scalable deployment (deployed to multiple application server instances and load balanced environment in PESR Data Centre). Application server instances must be configured in HA mode with session replication over clustered instances.

[Mandatory Req. 40] WEB GIS dynamic segmentation support
The road data in RDB database are stored according to the relative positioning principle (chainage on road sections) and the GIS dynamic segmentation technology must be used to display RDB data according to road network centrelines.

Even if all road data have also geographic location stored in RDB database and presentation is made on base of stored spatial objects, the dynamic segmentation technology must be implemented for other purposes like searching of the location on base of road section and chainage, presentation of road section and chainage of the selected location on the map and most important for data maintenance, where geographic location of each object entered in RDB on base of road section identifier and chainage will be calculated with the dynamic segmentation technology on GIS layer of road centrelines.

[Mandatory Req. 41] WEB GIS Type of data
The WEB GIS application must support display of the next type of data:
- RDB data from RDB database stored in MS SQL Server Spatial Database based on road section identifier and chainage (and with the geographic position),
- other spatial vector format data stored in MS SQL Server Spatial Database or on file system (SHP files),
- raster data (topographic maps, digital orthophoto, satellite images, etc.); raster data could be tiled or organized in pyramid structure,
- data sources stored on other location through the WMS and WFS.

[Mandatory Req. 42] WEB GIS user rights
The WEB GIS application will be used by different type of users with different user rights. So the WEB GIS application must consider user rights according to:
- user and user group rights,
- access to data layer or group of data layers,
- available functionality or module.

Logon to application is requested (user name and password or SSO through the RAMS Portal).

[Mandatory Req. 43] WEB GIS graphical window and navigation tools
Graphical window for data displaying must enable to be stretch across the entire browser window, stretch to any extend, return to the initial size, minimized, etc.

WEB GIS must provide the following navigation:
- zoom in
- zoom out
- zoom to shown extent
- pan
- left, right, up, down
- zoom to full extend (area of Macedonia),
- zoom to minimum scale of selected layer
- zoom to maximum scale of selected layer

At the bottom of the window must be displayed:
- the scale of map – numeric and graphic display of scale,
- the coordinates of cursor position on map.

[Mandatory Req. 44] WEB GIS – selection of data layers to be displayed
The number of GIS data layers in WEB GIS can be quickly huge (more that 100 layers) and user must be able to select the data layers of interest. List of data layers must be organized hierarchically (tree structure) where appropriate data group are defined with data layers. User can select for display whole group or each data layer.

From the list of data layers user also select the data layer where the object will be identified or graphical select through the graphical window.

From data layer list link to metadata catalogue with data layer description must be enabled. Also display of legend for this data layer must be enabled.

Data selection should be realized in pop-up window that can be closed/hidden by the user.

[Mandatory Req. 45] WEB GIS –date of data to be displayed
When WEB GIS displays data from RDB database where data history is implemented, shows the data that are valid on current day by default. User can select any date from past or future to display data that are valid on that date.

[Mandatory Req. 46] WEB GIS –data display setup
Symbology and other setting for each data layer display must be defined in setup file in form of XML. A special tool must enable administrator of system to define at least the next parameters:
- name of group for display,
- name od data layer for display,
- attribute to be used for classification for display,
- graphical symbol for each class of objects displayed,
- attribute to be used for label of each displayed object,
- display name of each class,
- list of attributes to be displayed when identify to object id done
- minimum and maximum scale of data layer display (to avoid display of detailed data at very small map scales and to avoid display of general data at big map scales).

[Mandatory Req. 47] WEB GIS – legend of data displayed
The user must have possibility to display legend of data layers displayed on the maps. The creation of the legend must be dynamic:
- only data layer selected for display on the map are included in the legend,
- classification and symbology according to data layer display setup file must be considered.

[Mandatory Req. 48] WEB GIS tools – Identify
WEB GIS must enable 2 type of identify functions:
- basic identify that display attributes of selected objects according to the definition in setup file for data layer display
- smart identify that display prepared display of data; normally user for complex data display when data from connected tables are displayed.

[Mandatory Req. 49] WEB GIS tools – measurement of distance and area
WEB GIS must enable measurement of:
- distance: length of drawn line is measured
- area: area of drawn polygon is measured

[Mandatory Req. 50] WEB GIS tools – printing
WEB GIS must enable printing through the WEB browser functionality.

[Mandatory Req. 51] WEB GIS tools – searching of location
WEB GIS must enable searching the location through the attribute data of spatial objects. At least the next searching must be supported:
- location on the road: input parameters are road section and chainage,
- coordinates: input parameters are X and Y coordinates,
- land and buildings cadastre: input parameters are cadastral community and parcel/building number.

[Mandatory Req. 52] WEB GIS tools – graphical data selection
WEB GIS must enable graphical data selection. Selection of object of selected data layer must be possible on next way:
- all object inside or partial inside of drawn polygon
- all object inside or partial inside of point and specified distance (point buffer)
- all object inside or partial inside of drawn line and specified distance (line buffer)

Browsing of attribute data of selected objects must be enabled in tabular form.

[Mandatory Req. 53] WEB GIS – road video integration
WEB GIS must enable integration with road video captured at road measurements. The integration must enable starting video of road at the location selected on the WEB GIS map and in selected direction. The location of video picture must be displayed on the map when video is displayed along the road.

[Mandatory Req. 54] WEB GIS tools – data export
WEB GIS must enable data export of each vector data layer in SHP form. Export of selected data layer must be possible for whole area or for the selected objects.

1.8 Consultancy services regarding supply, installation, user training and existing road data input

In this chapter the requirements for the consultancy services regarding supply, installation, user training and existing road data input to RDB and GIS are described. These tasks are strictly connected with delivery and implementation of RDB and GIS at PESR.

[Mandatory Req. 55] RDB and GIS SW development specification and test protocols
In the phase of RDB and GIS development the Consultant must prepare exact functional and technical description of proposed solution for each requirements defined in documentation delivered. Also the Consultant must prepare test protocols that cover all the requirements defined in documentation. All documentation must be harmonized and confirmed by PESR.

Before the delivery of SW the Consultant must execute the prepared test protocols in test environment of Consultant. When all test protocols are successfully passed the presentation of SW to PESR must be done and PESR must confirm that the development is finished and that the SW should be installed on IT infrastructure of PESR.

[Mandatory Req. 56] Installation of RDB and GIS software, configuration and optimizing for production work
Consultant must install delivered RDB and GIS software on PESR test and production IT infrastructure. Consultant must configure and optimize all components for production work.

Consultant must deliver technical documentation on installation, system configuration and RAMS software system administration.

Consultant must provide at least 3 days training for IT experts of PESR for installation and system administration of RAMS software.

[Mandatory Req. 57] RDB and GIS SW acceptance
Consultant must deliver RDB and GIS software that is fully functional and corresponds to all requirements defined in documentation. Final version of RDB and GIS will be installed in PESR test environment first, where acceptance test by side of PESR will be done. When all test protocols are successfully passed the delivered SW will be installed in PESR production environment.

[Mandatory Req. 58] RDB and GIS SW source code delivery
Consultant must delivered RDB and GIS software complete source code to the client. The client can use the applications for his use and modify the source code with no limitation at his own risk. The Consultant stay the owner of the source code and application and the client has no rights to distribute the source code or application to other users.

[Mandatory Req. 59] RDB and GIS documentation
The documentation process of the project should centre on producing high quality printed and online help text deliverables. It produces the entire user and technical documentation for the project. The User Guide should be based on the Module Process Model (e.g. use cases), and seeks to guide each user role in using the application to carry out business processes. The Technical Reference describes the technical aspects of the application. The next documentation and manuals are deliverables for the project:
- Operational Documentation: All operational documentation must be tailored to each category of user as applicable, and must cover:

- o User guide – based on the processes supported by the system, i.e. a process - oriented user manual;
- o User manual – detailed system function descriptions based on the menus within the system.
- Technical Documentation:
  - o Data model documentation
  - o Functional specification
  - o System configuration management instructions:
    - Setup procedures and configuration instructions for Database servers (all server and database parameters)
    - Setup procedures and configuration instructions for Application servers (all server and database parameters)
    - List of critical parameters on Database and Application servers for regular monitoring for prevention of malfunction
  - o System maintenance and updating instructions:
    - Setup procedures for maintaining the system and debugging the system
    - Setup procedures for updating the system, for example, by adding new road data items or new reports
  - o Complete Source code – representation of system operation for computing devices.

The Consultant must provide:
- All documentation must be to the point, comprehensive, understandable, accurate and appropriate to the needs of its target audience.
- The documentation must be in English and Macedonian language.
- Delivery - All documentation, updated with the latest changes following the customization, must be delivered within 2 weeks after the final operational acceptance.
- Amendment - All changes or corrections must be incorporated into the documents without extra cost to Client in warranty period,
- The Consultant must deliver the documentation in 1 hard copy as well as in soft copies (disks, CD's, DVD's).
- Electronic media, used for soft-copies of documentation, must be clearly marked with regard to contents, version, formats etc.

[Mandatory Req. 60] RDB, GIS and HDM-4 User training
The Consultant must provide user training for RDB and GIS SW and HDM-4 interface and use. Training must provide the knowledge and skills necessary to operate and maintain the delivered solutions with maximum efficiency to users – trained personnel. Beside the basic functionality of each module the training must cover the whole road data evaluation cycle including RDB, GIS, Data handling and HDM-4.

The next trainings should be performed:
- RDB:
  - o detailed training for RAMS unit members (4 people, 10 days),
  - o overview of RDB for other PESR personnel (20 people,1 day),
  - o RDB data maintenance for other PESR personnel (5 people, 1 day),
- GIS:
  - o detailed training for RAMS unit members (4 people, 5 days),
  - o overview of RDB for other PESR personnel (20 people,1 day),

- RDB and GIS management:
  o installation, configuration and supervision of system for IT experts (2 people, 5 days),
  o user management administration (2 people, 1 day)
- RDB and HDM-4 Interface and Use:
  o RDB interface with HDM-4 for RAMS unit members (4 people, 2 days)
  o Application of HDM-4 for planning and programming purposes for RAMS unit members (4 people, 3 days)

Trainings will be performed in the training centre of PESR.

[Mandatory Req. 61] Existing road data transformation and importing to RDB

Consultant must establish initial status of RDB database on base of PESR existing road data in digital form and road surveys done in this project.

At least the next existing data must be input to RDB:
- data on road reference system: roads, road sections and nodes including their geometry ,
- road geometry data: rise and fall, horizontal curvature (data should be calculated from available GPS measurements),
- road cross-section composition data: length of sections, width of sections, number of lanes,
- pavement structure data: pavement type(asphalt, macadam, …), pavement structure (data collected by ground penetrating radar),
- pavement condition data: roughness and rutting data,
- pavement condition rating (e.g. good, fair, poor);
- traffic data: traffic volume (AADT by vehicle), traffic parameters (free flow speed, hourly traffic volume factors-hourly flows, etc.),
- traffic accident data if available,
- existing road videos and images should be integrated in RDB.

All existing data must be arranged according to road reference system (road sections and chainage) before they will be inserted to RDB.

The existing data are available in different digital formats and some processing and data transformation will be needed before the data can be imported to RDB database:
- transformation to road reference system: the road reference system was not strictly used when data ware collected. Some data have reference to GPS coordinates, some refers to road numbers and chainage instead of road sections identifiers, for some data old reference system was used, etc.
- some road measurement data refers to specific traffic lane: the interpretation and data reorganization is needed to get proper information for RDB,
- the structure of data should be harmonized with RDB structure,
- for each data object beside the road reference system data the geometric presentation of object must be calculated on base of road centrelines data.

First detailed analysis of existing data must be done and proposal for data transformation prepared. After the confirmation of methodology from the client the transformation and importing to RDB will be done.

[Mandatory Req. 62] GIS data collection, transformation and importing to RDB

Consultant must establish initial status of GIS database on base of road reference system presentation in form of road centrelines with road section numbers and chainage (see chapter 2) and other GIS data from sources outside PESR.

Consultant should include the next data into GIS database:
- centrelines of road network
- topographic maps of different scale,
- digital orthophoto and satellite images,
- territorial units,
- land and building cadastre,
- land use data,
- environmental data,
- population data,
- etc.

The data will be provided by the client, the Consultant must support the client to collect the available data.

While the existing data are available in different formats some processing and data transformation will be needed before the data can be imported to RDB database:
- transformation to appropriate data format to be stored in GIS database,
- preparation of image data catalogues of raster data,
- preparation of raster data pyramids,
- etc.

[Mandatory Req. 63] Initializing GIS with existing data
Consultant must prepare initial configuration of GIS with all collected data – RDB data layers and GIS data. Initial status must also provide solution for presentation of results of data handling module and HDM analyses. Mode of presentation of each data layer (classification, symbology, labelling, scale of presentation, etc.) must be harmonized with PESR.

[Mandatory Req. 64] HDM-4 Road Network Evaluation
Consultant must use the road network data collected during the assignment to evaluate, together with the PESR RAMS unit, the road network using HDM-4 to support programming of road works and the preparation of the PESR annual report.

[Mandatory Req. 65] RDB, HDM-4 Interface and GIS support
Consultant must provide support to client for using of RDB, HDM-4 and GIS systems in initial phase. The support is estimated to 400 hours in the period of 4 month. The support is expected to be done mostly on-site.

2 TASK 2 - ESTABLISHMENT OF DIGITAL SPATIAL DATABASE OF ROAD REFERENCE SYSTEM

The Reference system for main and regional road network was already defined in 2009/2010, within an EBRD study "Technical Assistance to the Agency for State Roads to implement the new law on public roads" (TA IRD), through traffic nodes, road sections and roads.

Reference system of Macedonian roads is in details described in the document "Rulebook on the method for identification of state roads with appropriate reference system and chainage".

The Consultant has to check and upgrade the existing location reference system for public roads that includes permanent reference points at appropriate intervals along each facility. This location reference system will include, as a minimum, identification and geographic coordinate location of the reference points and identification, geographic coordinate location and definition of the length of the road and sections between appropriate reference points. The Consultant must establish a digital spatial presentation of the road reference system as base of RDB and GIS in form of digital geodatabase including road centrelines with road section identifiers and chainage and corresponding reference points (nodes). The deliveries includes preparation of methodology, data digitalization, establishment of the environment inside the GIS Desktop tool for reference system spatial data maintenance and RAMS users training.

At the moment the PESR does not have any GIS data of spatial presentation of road network. So the tasks of Consultant are:
- to establish methodology for GIS presentation of road reference system based on road centrelines with road section identifiers and chainage,
- to verify existing data about road reference system,
- to collect cartographic data needed for road centrelines digitalization,
- digitalization of road centrelines and attributing with road section identifier and mileage
- import of prepared data to RDB,
- preparation of IT environment at PERS for reference system data maintenance,
- user training for reference system maintenance.

[Mandatory Req. 66] Methodology for road reference system GIS presentation

Consultant must establish methodology for GIS presentation of road reference system based on road centrelines with road section identifiers and chainage. The exact rules must be defined how the centrelines are digitized according to:
- 1, 2 or more traffic lanes roads
- ramps of motorway connections
- virtual connection in road crossings, motorway connections, etc.
- additional chainage – roundabout, 4 lane roads with single road segment code, etc.
- noncontinuous road sections,
- numbering of subsections,
- rules on generalization,
- rules on topology of the road network,
- etc.

[Mandatory Req. 67] Collecting of existing road reference system data

Consultant must help PESR to establish accurate tables of basic road reference elements – road sections, nodes and roads with relations to road sections. All data must be verified especially:
- road section identifiers,
- starting and ending nodes of road sections (road section orientation),
- length (formal) of road sections,
- relations between roads and roads sections.

The data must be prepared in form that can be imported in RDB – attribute data of road reference system.

[Mandatory Req. 68] Preparation of cartographic data needed for road centrelines digitalization
Consultant must help PESR to collect cartographic data (digital ortophoto, topographic maps, territorial units, etc.) needed for road centrelines digitalization. Consultant must prepare the collected data in the form that can be used in Desktop GIS tool (ESRI ArcGIS Desktop Basic).

[Mandatory Req. 69] Digitalization of road centrelines
ConsultantConsultant must make digitalization of road centrelines and attributing with road section identifier and mileage. The digitalization of all state roads must be done according to defined methodology. Any deviations from road reference attribute data or defined methodology must be harmonized with the client.

The GIS presentation of road reference system should be made as geodatabase with linked entities road centrelines and nodes.

[Mandatory Req. 70] Import of prepared road reference system data to RDB
Consultant must import prepared road reference data to RDB where attribute and geometry data are presented as single object.

[Mandatory Req. 71] Preparation of IT environment for reference system data maintenance
ConsultantConsultant must prepare complete IT environment at PERS for reference system data maintenance. ESRI ArcGIS Desktop Basic on workstations of RAMS unit members should be used for maintenance of road reference system data. Consultant must install all input data and last version of road reference geodatabase on central server including background cartographic data, where all users can access the data. Consultant must create ArcGIS mxd file and deliver all additional ArcGIS procedures that are used in the process of road reference system data maintenance (subsection chainage calculation, controls of topology, etc.).

[Mandatory Req. 72] User training for reference system maintenance
Consultant must provide user training for road reference system maintenance. Training must provide the knowledge and skills necessary to operate and maintain the road reference system geodatabase with ESRI ArcGIS Desktop Basic.

The training for road reference system maintenance should be performed in the premises of RAMS units for 2 people 3 days.

[Mandatory Req. 73] Road reference system maintenance support
Consultant must provide support to client by road reference system maintenance in initial phase. The support is estimated to 240 hours in the period of 6 month.

[Mandatory Req. 74] Road reference system property
All road reference system data, methodology and procedures for data maintenance shall be the property of the Client. The Consultant shall not be allowed to use the collected data for their own purposes or independently submit or provide the data to the interested third parties without Client's prior consent.

3 TASK 3 - GROUND PENETRATING RADAR MEASUREMENTS

Ground Penetrating Radar (GPR) is a pulse-echo method for measuring pavement layer thickness and other properties. It works like ultrasound, but uses radio waves rather than sound waves to penetrate the pavement. Antennas mounted on a moving vehicle transmit short pulses of radio wave energy into the pavement. As this energy travels down through the pavement structure, echoes are created at boundaries of dissimilar materials (such as the asphalt–base interface). The arrival time and strength of these echoes can be used to calculate pavement layer thickness and other properties, such as moisture content.

GPR systems collect pavement layer thickness data quickly, unobtrusively and with minimal traffic disruption and safety risks. Using GPR, pavement management engineers can survey subsurface conditions at a small fraction of the cost of conventional core sampling and gather data for network-level pavement management.

The PESR as a manager of the national road network in Macedonia wishes to determine pavement structures (material type and thickness of pavement structure layers) of state roads for planning and programming of maintenance treatments in RAMS.

[Mandatory Req. 75] Scope of services
The pavement structure (material type and thickness of pavement structure layers) of state roads[1] in Macedonia must be taken with the density of at least 1 result per meter for driving lane on motorways and for right lane (in the direction of chainage) on other state roads in right wheel path.

[Mandatory Req. 76] Technical requirements
Technical requirements:
- measurement in free traffic flow,
- productivity of at least 100 km per day,
- identification of the embedded materials and layer thickness on sections with a length of less than 1 m along chainage,
- vertical resolution at the thickness measurements better than 4 cm,
- the accuracy of measured thickness of individual layers in the pavement structure must be greater than 10%,
- system requires no core drilling for calibration,
- measurements to a depth of at least 1 m using multiple antennae,
- record of chainage and GPS coordinates for every measurement,
- recording or imaging (JPG format) during the measurements.

[Mandatory Req. 77] Deliverables
The Consultant must deliver:
- time plan of road measurements for all locations; the plan must be approved by the Client,
- database of raw measured data (see Table 1);

Table 1: Structure of the database of raw data:

Column	Data	Unit	Format

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[1] State Roads include:motorways,highways, national and regional roads

Road	Road number		Text
Section	Section number		Text
Chainage	Chainage of the measurement	m	Integer
X	X coordinate	m	Single
Y	Y coordinate	m	Single
Date	Date		YYYY-DD-MM-HH-MM-SS
Thick_C	Thickness of concrete layer	mm	Integer
Thick_AC	Thickness of asphalt layer	mm	Integer
Thick_ST	Thickness of cement stabilized layer	mm	Integer
Thick_U	Thickness of unbound layer	mm	Integer
Str_No	Structural number of the pavement	cm	Single
Picture	Name of the picture		
Comment	Other relevant data (condition of the pavement, bridging structure...)		Text

- relational database of homogeneous sections of equal pavement structure, stating the road number, section number, chainage and GPS coordinates of the beginning and end of a homogenous segment with the representative types of material and thicknesses of the pavement layers (see Table 2);

Table 2: Structure of the database of homogenous sections:

Column	Data	Unit	Format
Road	Road number		Text
Section	Section number		Text
From_m	Chainage of the beginning of the homogenous section	m	Integer
X	X coordinate of the beginning of the homogenous section	m	Single
Y	Y coordinate of the beginning of the homogenous section	m	Single
To_m	Chainage of the end of the homogenous section	m	Integer
X	X coordinate of the end of the homogenous section	m	Single
Y	Y coordinate of the end of the homogenous section	m	Single
Length	Length of homogenous section	m	Integer
Thick_C	Representative thickness of concrete layer	mm	Integer
Thick_AC	Representative thickness of asphalt layer	mm	Integer
Thick_ST	Representative thickness of cement stabilized layer	mm	Integer
Thick_U	Representative thickness of unbound layer	mm	Integer
Str_No	Representative structural number of the pavement	cm	Single
Date	Date of measurement		YYYY-DD-MM

- database of pictures of measurement locations equipped with location data – road segment and chainage and/or GPS coordinates

- user interface for viewing and displaying the obtained data; viewer of the measured parameters will allow simultaneous display of measurement, measurement results

(thicknesses of layers), images of the measurement sites, and the drilling results (if available for the purpose of calibration) with the possibility of exporting data and images. The viewer of the measured parameters must be installed on 2 Client's computers.

-   a final report on the measurement and analysis; the final report shall contain results of the measurements and presentations with graphs and tables.

The Consultant must deliver the reports in 2 hard copies as well as in soft copies (disks, CDs, DVDs). The databases must be delivered on DVDs. Electronic media, used for soft-copies of reports and database, must be clearly marked with regard to contents, version, formats etc. Also, the database of homogeneous sections of equal pavement structure must be imported to RDB.

[Mandatory Req. 78] GPR data property
All of the data obtained with the measurements shall be the property of the Client. The Consultant shall not be allowed to use the measured data for their own purposes or independently submit or provide the data to the interested third parties without Client's prior consent.

4   TASK 4 - WEIGHING OF COMMERCIAL VEHICLES IN MOTION

Heavy traffic is the main cause of pavement deterioration and traffic loading is the main information for maintenance planning and pavement design. Therefore traffic loading is beside pavement condition an essential part of Life Cycle Cost Analyses (LCCA) in Road Asset Management System (RAMS) planning and programming of maintenance treatments and maintenance costs.

The impact of an axle load to the pavement fatigue rises with the fourth power (according to AASHO Road Test the damage caused by a particular load is roughly related to the load by a power of four), which means that the axle weight increase of 10% (11 tons instead of 10 tons per axle) increases the Equivalency Factor (EF) of that axle (and consequently the traffic loading) for 46%. The ratio between a properly loaded and overloaded truck can reach 10 or more, that means that the overloaded truck causes 10 times bigger damage to the pavement structure than the properly loaded one.

Therefore it is very important to know the EF of vehicle fleet in Macedonia for the input into RAMS HDM-4 to calculate accurate traffic loading from the number of vehicles AADT (Annual Average Daily Traffic).

AADT by traffic classes is usually determined with traffic counters. The traffic loading, expressed with the number of passes of the Equivalent Single Axle Load (ESAL) is then calculated as a sum of products of the number of the vehicles and their average EF. For the definition of the average EF for a certain vehicle class a large number of vehicles should be axially weighed.

For axle weighing the static scales can be used but more productive are High Speed Weigh-In-Motion systems (HS WIM), which axially weigh every vehicle that passes the weighing station in a free traffic flow.

The Public Enterprise for State Roads (PESR) as a manager of the national road network in Macedonia wishes to determine traffic loading (ESAL) information on most trafficked road sections in the year 2016 for planning and programming of maintenance treatments in RAMS.

For the calculation of real traffic loading the average Equivalency Factors for the individual vehicle classes in Macedonian State Roads need to be determined. Therefore HS WIM measurements on 20 most trafficked road sections will be performed.

[Mandatory Req. 79] Scope of services
The scope of the project assignment is the performance of 20 fortnight HS WIM measurements in free traffic flow on most trafficked road sections by Client selection. Appropriate measuring sites on those road sections shall be determined with the chosen Consultant in a mutual agreement immediately after the conclusion of the respective Contract.

[Mandatory Req. 80] Preparation activities
The Consultant must perform the next preparation activities:
- Visit the envisaged road sections and propose appropriate site locations – to be able to assure satisfactory HS WIM measurements – to the Client for approval;
- Determine spatial coordinates for all locations on which measurements shall be performed and prepare the pertaining pictorial material;
- Prepare a timetable for fortnight measurements, taking into consideration seasonal traffic, national holidays, reduced traffic of heavy loads vehicles, vicinity of construction sites and other.

[Mandatory Req. 81] Installation of HS WIM system and measurements
The Consultant must perform the next activities for each of 20 measurement location:
- Arrange power supply for the system (from the electrical network, the public lighting system or from batteries);
- Install HS WIM systems, on 5 locations install external camera unit for the data control and further analyses; HS WIM system must be installed over all of the traffic lanes, that means in both directions on regional roads and on driving, overtaking and slow lane (if exists) on motorway sections; the installation of all equipment must be done without making any damage to the road surface.
- Calibrate the HS WIM systems; the system on every site must be calibrated with the r1 conditions (fully repeatability conditions), which means with one typical example of a heavy loads vehicle per selected road section. The minimum total number of drives of the calibration vehicle shall be 13 per traffic lane.
- Perform fortnight HS WIM measurements on all 20 sites on all traffic lanes in free traffic flow.

The Consultant shall provide appropriate equipment for measurements, trained personnel and calibration of the system on every site. Malfunction of the measuring systems shall not present a reason to extend the contractual period; therefore, the Consultant must have a service centre available.

In the event the setting up or removal of the WIM system obstructs the traffic, the traffic shall not be obstructed for more than 1 hour with the half-closure of the road. The Consultant is obliged to obtain a permit before setting up a half-closure of the road.

The measurements must be performed with the equipment, which has to comply with the European WIM specifications (COST 323, Weigh-In-Motion of Road Vehicles, Final Report, Paris, 2002), and a team of selected specialists for measurements and analyses.

[Mandatory Req. 82] Technical requirements
With the HS WIM system the next data must be collected:
- the speed, number of axles, axle loads, axle distances, total mass and Equivalency Factor of every vehicle over 3,5 tons total mass;

  The Equivalency Factor of a vehicle must be calculated applying the OECD method, which is widely used in Europe and converts axle loads into the Equivalent Single Axle Loads (ESAL) using an 80 kN reference axle load and the power of 4 by the formula:

$$FE = 10^{-8} \cdot \sum_{i=1}^{N} f_a \cdot (f_k \cdot P_i)^4$$

  where

  FE traffic loading of a vehicle, expressed as the sum of individual nominal (equivalent standard) axle loads of the vehicle

  f_a axle factor which depends on the type of the axle and the reference axle load $f_a = 2{,}4415$ for single axles, $f_a = 0{,}216$ for double axles $f_a = 0{,}0533$ for triple axles

  f_t type of the tyre and on the axis $f_t = 0{,}9$ for double tire $f_t = 0{,}97$ for super single tire $f_t = 1{,}0$ for single tire

  P_i axle loading of axle i (kN)

  N number of axles of the vehicle

- Classify every vehicle from Class 5 to Class 8 according to the European Union EEC 1180/70 Directive, shown in table 3:

Table 3: Vehicle Classification scheme (8 vehicle classes + 1) compliant with the European Union EEC 1180/70 directive

Class	Vehicle type
1	Motor bikes
2	Passenger car
3	Lightweight truck (< 3,5 tons)
4	Car + trailer
5	Truck (> 3,5 tons)
6	Truck + trailer
7	Tow
8	Bus, bus + trailer
X	Unclassified vehicle

- Weighing of vehicles in motion must meet the accuracy class at least C – see Table 4. If the prescribed accuracy cannot be ensured due to the poor condition of the pavement, the Consultant shall choose another location in agreement with the Client or obtain a written consent to perform measurements with lesser accuracy.

Table 4: Assessment of the accuracy of weigh-in-motion measurements according to the European WIM specifications (COST 323):

Class	Gross vehicle weight	Axle loads	Confidence interval	Intended use of the results
A	5%	8%	≈ 98%	Penalties, when legally allowed
B+	7%	11%	≈ 95%	Intermediary phase to class A
B	10%	15%	≈ 95%	Specific controls for the industry Traffic safety
C	15%	20%	≈ 95%	Classification of vehicles, pre-selection of vehicles for statistical weighing
D+	20%	25%	≈ 95%	Classification of vehicles, pre-selection of vehicles for statistical weighing
D	25%	30%	≈ 95%	Rough estimate of traffic flows
E	>25%	>35%	≈ 95%	Rough estimate of traffic flows

- The system must weigh at least 95 per cent of all vehicles with gross weight more than 3,5 tonnes. In the event the system does not meet that condition on a particular day, the Consultant shall repeat the measurement at his own cost on the same day in the week when this error has occurred or extend the period of measuring accordingly.

[Mandatory Req. 83] Deliverables

The Consultant must deliver:
- time plan of road measurements for all locations; the plan must be approved by the client,
- database of raw measured data for each individual vehicle; data for every vehicle over 3,5 tons total mass must be stored in a database with the structure, defined in Table 5.

Table 5: Structure of the database of HS WIM measurements:

Column	Data	Comment/format
1	Code of site	Text
2	Time	YYYY-DD-MM-HH-MM-SS-mmm
3	Lane	1 – right lane in the direction of chainage on 2 lane roads 2 – left lane in the direction of chainage on 2 lane roads 3 – driving lane on motorways 4 – overtaking lane on motorways 5 – slow lane on motorways

4	Speed	km/h
5	Number of axes	Format: Single
6	Vehicle class according to FHWA vehicle classification	5 to 8
7	Axle configuration	11 or 12 or 13 or 123 or 12111 or …
8	Gross vehicle weight	kN
9	Axle load 1	load of 1 axle [kN]
10	Axle load 2	load of 2 axle [kN]
11	Axle load 3	load of 3 axle [kN]
12	Axle load 4	load of 4 axle [kN]
13	Axle load 5	load of 5 axle [kN]
14	Axle load 6	load of 6 axle [kN]
15	Axle load 7	load of 7 axle [kN]
16	Axle load 8	load of 8 axle [kN]
17	Total wheelbase	distance between first and last axle [m]
18	Wheelbase between axle 1 and axle 2	distance between axle 1 and 2 [m]
19	Wheelbase between axle 2 and axle 3	distance between axle 2 and 3 [m]
20	Wheelbase between axle 3 and axle 4	distance between axle 3 and 4 [m]
21	Wheelbase between axle 4 and axle 5	distance between axle 4 and 5 [m]
22	Wheelbase between axle 5 and axle 6	distance between axle 5 and 6 [m]
23	Wheelbase between axle 6 and axle 7	distance between axle 6 and 7 [m]
24	Wheelbase between axle 7 and axle 8	distance between axle 7 and 8 [m]
25	Temperature	[^{o}C] of concrete
26	Equivalency Factor of a vehicle	Format: Double, 2
27	Frontal picture of a vehicle	Name of a picture in jpg format

- After the measurements on a particular site are finished, the Consultant undertakes to prepare and submit the Site report in 30 days. The Site report shall contain results of the measurements per individual location and presentations with graphs and tables with the following data:

  • Data on locations on which measurements have been performed (road, road section, chainage, span, the type of support structure, quality of the pavement on the bridge, coordinates, images of locations).

  • Accuracy of measurements according to the European WIM specifications (COST 323),

  • Histograms of measurements by axle load,

  • Distribution of Equivalency Factors (EFs).

  • Hourly, daily and fortnight distribution of vehicles,

- Average daily traffic loading,

- The average daily number of vehicles with the gross vehicle weight of 3,5 t, the number of vehicles which have exceeded at least one axle load, the number of vehicles which have exceeded only the gross vehicle weight, the number of overloaded vehicles and their share.

- An average Equivalency Factors per vehicle categories 5 to 8.

- After the completion of the project, when all 20 sites are measured and reported, a Final Report shall be prepared, summarizing Site reports and proposing the overall average Equivalency Factors for individual vehicle groups 5 to 8 according to table 3.

The Consultant must deliver the reports in 2 hard copies as well as in soft copies (disks, CDs, DVDs). The databases and the pictures of vehicles from 5 sites must be delivered on DVDs. Electronic media, used for soft-copies of reports and database, must be clearly marked with regard to contents, version, formats etc. Also, the traffic counting data must be structured and imported to RDB according to the data layers defined in request 11.

[Mandatory Req. 84] HS WIM measurements data property
All of the data obtained with the measurements shall be the property of the Client. The Consultant shall not be allowed to use the measured data for their own purposes or independently submit or provide the data to the interested third parties without Client's prior consent.

5 TASK 5 - RAMS SW MAINTENANCE AND USER SUPPORT

After the initial 12 months of system development the Consultant must provide for period of additional 24 months maintenance of all RAMS SW components. Also user support must be assured and some budget will be provided for upgrades of the system in the future.

[Mandatory Req. 85] Basic Corrective Maintenance of RAMS SW
The basic maintenance includes bug fixing, incident solving, software updates, reporting, end user domain support and service requests handling services.

Basic Corrective Maintenance services do not include maintenance of standard hardware and software of any of the environments, as well as any third party applications, to which the Application is integrated with.

[Mandatory Req. 86] Submitting of maintenance request
The Consultant provides the Service Desk as a single point of entry for communication concerning all services provided. All the requests and inquiries from the Client shall be registered at the Service Desk via Request handling web portal. Basic request handling will be handled mainly via web interface, or as an exception via e-mail or telephone. For follow-up reasons, requests not submitted via web interface will be registered in web portal afterwards by Consultant.

Requests for support service from Client and End Users will be issued towards Consultantvia RAMS Unit. RAMS Unit will investigate and classify all requests and after selection will route appropriate requests to Consultant. Consultant shall receive all requests via RAMS

Unit, direct communication between End User and Consultant can be established by Consultant as an exception if end-user assistance is required for problem solving. Lead-time measure starts from the moment when Consultant receives CSR from RAMS Unit.

For the sake of clarification, the procedures and requirements for handling of requests concerning emergency priority incidents are separate and described in "Emergency Handling".

[Mandatory Req. 87] Incident Solving
Incident Solving Service means eliminating defects and errors, caused by irregularities in Application operation, which is installed on Production and Test Environment of RAMS System. The Service is performed by remote access. The irregularities refer to divergence in Application's functioning, compared to definitions in End User Manual.
Incident Solving service does not include solving of incidents caused by End User mistakes errors that occurred as a result of Force Major, unauthorized and/or malicious System use, errors caused by the System elements which are not under Consultant's responsibility, etc.

The process of providing Incident Solving Service begins with the Incident Solving Request submitted to the Service Desk.

Within the Incident Solving Service, a Service Desk delivers the following services:
- Receipt of Incident Solving Requests;
- Confirming the Incident Solving Requests reception within the Response Time specified as call-back time in Table "Incident Solving Request service lead times";
- Analysis of Incident Solving Requests;
- Classification of a Request itself, and/or checking the classification of the received Incident Solving Request
- Control of assigning an adequate priority to requests according to Table "Severity Levels";
- Collecting of additional information related to incident solving by Application remote access and/or from End User via RAMS Unit;
- Filtering a Incident Solving Request from the system level (overall solution) up to product/application/functionality level;
- Forwarding a Incident Solving Request to the Consultant Support Organization, so that the mentioned Request can be forwarded to the institution, responsible for the product/application/functionality level support;
- Delivery of an Answer to the End User by RAMS Unit via Request handling web portal,
- Closing a Incident Solving Request.

[Mandatory Req. 88] Severity Levels
All requests shall be assigned a severity level "Emergency", "High", "Medium" or "Low". If RAMS Unit has not assigned a request severity level Consultant shall assign an adequate severity.
Except as otherwise stated in the Agreement, RAMS Unit shall be responsible for classifying and assigning the applicable Severity Level to a particular request in accordance with the following conditions:

Severity Level	Description of classification
Emergency	Emergencies are applicable for business critical parts of Application, i.e. the Client's business suffers significantly. The situations which that have or may have an impact to all the End Users. The following situations are classified as severity level emergency: • a complete failure of the System, excluding components of the System that are not subject of contract. • a major disturbance in functionality of the System with the critical level business performance. • business critical Application component is inoperable • End Users are unable to use the program resulting in a critical impact on operations
High	*Situations that **may** result in emergencies. Major problems or disturbances that require immediate action.* The following situations are examples of severity level high: • Application can operate only in restricted fashion • Outage or incorrect business process in the System, with the critical level business performance • frequent (not constant, max. once per day) crashes of the System as defined by the Contract that were ordered from and delivered by Consultant, excluding components of the System that are not subject of the contract. • loss of redundancy on business critical Application component
Medium	*Problems or disturbances affecting a specific area of functionality, but not the whole system. Disturbance with impact given to services.* The following situations are examples of severity level medium: • the System is usable with less significant features (not critical to operations) unavailable • Outage or incorrect business process operating in Application refers to a single item, and not the overall System • lack of documentation • a disturbance degrading performance of the System with minor impact to the whole System
Low	*General consultation and minor problems that have a minor effect on the functionality of the System.* The following situations are examples of severity level low: • disturbances that do not or causes any loss of service • errors in Application user interface or user interface layout that do not prevent normal operation of application • End User documentation faults • operational queries

After receiving the "Emergency" or "High" priority Request, the Consultant will confirm the receipt of the Request within the agreed Response Time via Request handling web portal and/or by phone. In case the received Requests are classified "Medium" or "Low" priority Requests, the Response is performed by automatically generating a Request number via Request handling web portal.

Incident Solving Requests **lead-times**

Severity	Call-back	Remedy	Restoration
Emergency	2 hours	24 hours	48 hours
High	4 hours	2 working days	5 working days
Medium	Automatic	5 working days	1 month
Low	Automatic	Next product version	Next product version

The Answer to the request means the implementation of a remedy (if available for the particular incident) and restoration, which will return the Application to the correct status. The Answer to the submitted requests means that the Consultant is ensured with the full ("read/write") remote access to the production and test environments. In case that the full remote access is not available or, if the incident is caused by the parts of the System, which are not the Consultant maintenance responsibility (e.g. hardware and system program support), Answer Time can be extended by the maximum period of remote access unavailability. Answer Time can be extended for a period when Consultant is waiting for RAMS Unit and/or End User's response, i.e. when additional information is required to be delivered to Consultant to solve a particular incident.

Emergency Handling of the Consultant shall be available each working days from 8 a.m. to 4 p.m. For emergency priority requests reported outside of the listed working hours, the time of the request receipt, will be recorded as the first hour of the next day when the service is available (e.g. working days at 8 a.m.). Consultant shall continue to work on resolving a reported emergency priority incidents during availability of the service for a particular Application component, and the remedy/restoration time shall be measured in accordance with the service availability for the particular Application component.

Under specific circumstances it may be necessary for Consultant to visit the Client's Centre to solve an emergency situation. The Emergency On-site option involves Consultant support organization being on constant stand by to travel to the Client's Centre. A Consultant representative will travel to the site to perform the necessary actions needed on-site to find a remedy and/or a restoration to the emergency situation.

Incident solving service for "High", "Medium" and "Low" priority is available on working days from 8 a.m. to 4 p.m. This period does not include Saturdays, Sundays, national holidays and banking holidays in the Republic of Macedonia. For the incident solving requests, reported outside of the listed working hours, the time of the request receipt, will be recorded as 8 a.m. of the next working day.

If the Answer to the request includes the activity on the Application (i.e. implementation of patch), which impacts the Application or System availability, the Consultant shall, before the planned Answer delivery, ask for the Client's approval of the activity. After obtaining the Client's permit, the Consultant will deliver the Answer to the registered request.

Lead times can be extended for the time when Consultant is awaiting necessary Client's permit of the activity till the moment when Client agrees that Consultant can continue working on incident solving by impacting Application or System availability specified by Client's permit.

[Mandatory Req. 89] Remote support

Consultant performs fault tracing or gather information to solve the requests using remote access. Remote access cannot be established without authorization from the appropriate people in the PESR organization.

While solving requests, if Consultant finds that the situation so requires, Consultant can request permission from PESR to establish remote access between Consultant and the Client's system.

The remote support connection is encrypted all the way from the computer at the desk of the Consultant engineer to the network of PESR. Throughout the procedure PESR has the ability to monitor activities and restrict access to specific areas and times, and only named and PESR approved Consultant personnel are permitted access. Consultant will undertake all necessary steps to ensure that no deliberate harm or damage is caused to the Client's system.

Prerequisite infrastructure and conditions for the logon-procedure shall be strictly regulated in the Procedures Manual.

If the remote access does not function, due to reasons outside Consultant's control the lead times may be prolonged by the time it takes to solve the issue in another way.

[Mandatory Req. 90] Completion of the service - CSR closure

The Incident Solving service shall be considered completed, i.e. the request is closed if:

• End User accepts the request answer and/or request resolution implementation if applicable (defect is solved, repaired or replaced).

If End User rejects the request answer, Consultant shall make a further analysis and deliver a new request answer. A rejection of the new request answer is handled outside the normal request process and a follow-up done on the service review meetings (Management Escalation Procedure). Such exceptions shall be reported separately and shall not be a part of request handling statistics.

• Answer is neither accepted nor rejected by the End User, within ten (10) working days;

• End User, within three (3) working days from the Consultant notification did not provide data to the Consultant, which is necessary to Consultant for the Request solving.

[Mandatory Req. 91] Software Updates and Implementation

For the bug fix requests the Consultant shall deliver Application Software Update Package, which include Application changes, with the aim to implement the Application program code

corrections. The Process of the Application Software Update Package delivery shall be conducted as follows:

• After the development and testing of the Software Update Package is finished the Consultant will deliver the Client:

- "Release Notes" document, release update procedure. "Release Notes" document will contain list of fixes contained within the release with reference to the reported problems and their respective priorities;
- Report from the Consultant internal software update testing Consultant, as well as testing procedures for verifying the release;
- Consultant shall update the Application software of test environment in accordance to update procedure delivered by Consultant;

• After the Application software update on test environment, the Client shall, in accordance with testing procedures for verifying the release delivered by Consultant, conduct the verification of the Application Software Update;

• After the verification was conducted the Client will deliver the Consultant the verification results and a written decision to continue the delivery of Application Software Update to the Production Environment;

After the Client's positive decision, the Consultant shall execute the Application Software Update of the Production Environment. The Client can postpone the delivery of the Application Software Update, if the results of the verification of the Application Software Update, conducted by the Client, significantly deviate from the results in the Report from the Consultants intern Application testing or the Release Notes document, meaning one or more problems haven't been successfully corrected. In such case, the Client and the Consultant will make a plan of corrective actions, and define a new time for Application Software Update delivery.

In case of minor deviations in the results of the Application Software Update verification, from the results in the Report of the Consultant intern Application testing of Release Notes document, the delivery of the Application Software Update will be executed according to previously defined plan, and the Client and the Consultant shall make a plan to address the identified discrepancies.

[Mandatory Req. 92] Service Request Processing

Description of Service request processing is:
- resolving incidents caused by the user error for which no solution has been provided under the application functionalities;
- editing individual, existing templates and reports;
- maintaining individual codebooks and registers at End User's request.

Users of the Service Request Processing service are Client's authorized persons who will be defined in the Procedures Manual. The Client has assumed the obligation to provide support to the application End Users, analyse problems and forward to the Consultant only Application-related Requests described in detail. Service requests submitted by the End Users not defined as Client's authorized persons shall be rejected, and the End Users will be notified to contact Client's authorized persons first.

The Service Request Processing service envisages the engagement of the Consultant in the realization of service requests, in particular when they are of lesser complexity and need for quick realization.

After service requests have been filed, the Consultant shall:
- analyze the reported service request;
- assess the feasibility of the service request. If it is not feasible, it will be rejected and the Consultant shall submit a reply to the Client's authorized person which submitted the service request along with the reason for rejecting the service request;
- if the service request is feasible, collect additional information related to the service request (e.g. case status, case implementation mode etc.) by remotely accessing the Application;
- carry out the service request and deliver a response to the Client's authorized person

The service requests that are actually functionality change requests, requests for the production of new functionalities and requests to implement legislative changes shall be rejected, closed into the request tracking system or rather shall be removed from the service requests processing procedure. Such rejected service requests shall be communicated through a separate procedure to the Client as a change request outside the scope of this service.

Resolving incidents caused by the user error for which there is no solution within the application functionalities does not involve the processing of requests related to the functionalities for which the Consultant has submitted to the Client a proposal for the development and implementation of the said functionality but which has not been accepted by the Client.

The service request processing service is available on working days between 8 a.m. to 4 p.m. The afore-mentioned period does not include national holidays in the Republic of Macedonia. For the service requests reported outside the office hours, the time, recorded as the time when the service request was received, will be 8 a.m. of the first following working day.

The table below shows typical service request types, response time and resolution time.

Service request	Response time	Resolution time
Resolving incidents caused by the user for which no solution has been provided under the application functionalities.	Up to 4 working hours	1 month
• Editing the existing templates and reports • Code book and register maintenance	Up to 4 working hours	1 week

Service Request Processing service will exclude the item regarding the new request implementation (Adaptive Maintenance service) and this item will be expressed separately.

The support for Service request processing is estimated to 480 hours in the period of 24 month.

[Mandatory Req. 93] Change request maintenance

The Consultant must provide Change request maintenance of RAMS SW to assure the System will stay usable in a changed or changing environment and to improve performance, maintainability and some new functionality can be added if needed.

Users of this services are Client's authorized persons who will be defined in the Procedures Manual.

After service requests have been filed, the Consultant shall:
- analyze the change request;
- assess the feasibility of the service request. If it is not feasible, it will be rejected and the Consultant shall submit a reply to the Client's authorized person which submitted the change request along with the reason for rejecting the service request;
- if the change request is feasible, make the proposal of system change, an estimation of time and budget needed for its implementation and delivered this information to the Client's authorized person;
- after the confirmation of change request proposal from the Client's authorized person carry out the change request;
- deliver a new version of SW package according to the SW updates and implementation protocol.

The support for Change request processing is estimated to 960 hours in the period of 24 month.

[Mandatory Req. 94] End User Domain Support

Within End User Domain Support Service, the Consultant shall ensure a consultancy services in order to address End User Domain Support Requests. Consultant must provide support to client:
- for use of all components of RAMS SW (using of RDB, HDM-4 and GIS),
  - support in executing business process in Application,
  - identifying the improper Application use and giving End User instructions, related to the proper use of the Application,
  - assisting End Users with inquiries, related to Application options and functionalities,
  - Clarifying documentation, referring End Users to Documentation on a particular question
- in processes of road data collection, preparation, insertion to RDB, etc.,
- in the process of road reference system maintenance,
- preparation of plan of road maintenance,
- preparation of annual report and other reports,
- other works requested with the RAMS by the Client.

The support is estimated to 960 hours in the period of 24 month. The support is expected to be done mostly on-site.

End User Domain Support Service is available on working days, from 8 a.m. to 4 p.m. This period does not include Saturdays, Sundays, national holidays in the Republic of Macedonia.

Response Time for End User Domain Support Requests is 8 working hours. Answer Time is 2 working days measured from the time of receipt of the Request.

[Mandatory Req. 95] Service Performance Management and Reporting

Service Performance Management ensures an active contact between Client Client, RAMS Unit and Consultant. A Service Delivery Manager is assigned to support Client and RAMS Unit with this.

Deliverables from Service Performance Management are:

- Request monitoring
- Reports upon maintenance request
- Reports upon service request processing
- Reports upon change request maintenance
- Reports upon end user support
- Escalation management

[Mandatory Req. 96] Prerequisites for Services Performance

In order to perform Services the following prerequisites shall be met:

- Within the frame of the Client's safety regulations, enable the Consultant authorized personnel remote access to the Application (read/write access to the production, test environment). The Consultant authorized personnel will use the remote access to review the Application proper operation, for incident solving, which can be solved this way, and to implement new Application releases. In case that the full remote access ("read/write") to Application does not function, due to reasons out of Consultant control, the Response Times are prolonged by the time necessary to solve Request in a different mode;
- Ensuring a working environment for at least 2 Consultant's person in the same time in the Client's premises for those Requests that cannot be solved via a remote access. This will enable a safe and controlled Application access. The Client shall ensure that the authorized PESR representative is present in order to support the Consultant, during the time the Consultant executes Services in Client's Centre premises;
- Client has the ensured support and maintenance of production and test environments, hardware and system software, other environments, and all the other equipment, devices and communication media that may be connected to the Application, in order to achieve Application smooth operation;
- Client shall not undertake any activity on the System that may influence regular working order of the Application (e.g. standard software upgrades, firmware updates/upgrades, System hardware/software moves, adds, changes, etc.) without Consultant's prior analysis of the Client's activities and Consultant's written consent of the said Client's activities;
- Consultant's timely announcement to Client of works on components, which may have impact on the Application performance (at least 3 working days earlier for medium and low priority incidents, the same working day for high priority incidents and the same day i.e. the same day during emergency handling service availability for emergency handling priority incidents). Providing the necessary documentation to the Consultant, on the basis of which the Consultant will be able to diagnose the possible

consequential problems in Application operation and approve the necessary work in writing, and, optionally, suggest additional corrective and prevention measures;

- Client shall undertake all the corrective measures, consultation and help towards the End Users, which can reasonably be performed without the help of the Consultant;
- Preventive maintenance in terms of regular System functionality, in order to ensure System optimal operation, in terms of reliability, safety to data access, data protection, making regular data transcript to external media (backup), physical and technical System protection;
- Client shall ensure a sufficient number of qualified persons that will act as single point of contact towards the End Users, that will provide a continuous support to the End Users during the period of solving of a reported incidents, and which will be in charge for forwarding the End User reported incidents to the Consultant and communicating the status of a reported incidents back to End Users;
- Elimination of intentionally caused damage on Application, which includes damages caused by computer viruses, the attempt to change the System without the Consultant written consent and similar.
- End User administration (user account administration, change of user account settings, role changing), authorization of the existing and new End Users, creating, unblocking of End User accounts, changing passwords for End User Application Access

D. Reporting

The Consultant will report to PESR. The deliverables will include:

- Inception Report to the Client, copied to the WB, containing the detailed work plan, confirmation of staffing, within 3 (three) weeks of contract signing, to meet all the project objectives and set out all review steps;

- Progress Reports every month to the Client, copied to the WB;

- Deliverables for Task 1 – RAMS SW:
  - RAMS Portal:
    a. functional and technical description of proposed solution
    b. test protocols and acceptance test by side of PESR
    c. installation of RAMS portal SW in test and production environment
    d. delivery of source code and technical documentation
    e. prepared metadata catalogue for all RDB and GIS data
    f. user manual for portal administrators
    g. user training for RAMS portal management
    h. initial user support - 4 months

  - RDB database and application:
    i. functional and technical description of proposed solution
    j. test protocols and acceptance test by side of PESR
    k. delivery and installation of RDB SW (database, C/S application, WEB application) in test and production environment
    l. delivery and installation of Data handling module and Workflow module
    m. delivery of source code and technical documentation for all RDB modules

      n. existing road data imported to RDB
      o. user training for RDB administrators
      p. user manual for RDB users
      q. user training for RDB users
      r. road network evaluation with HDM-4 to support programming of road works based on the collected road network data
      s. initial user support - 4 months

- GIS:
  - t. functional and technical description of proposed solution
  - u. test protocols and acceptance test by side of PESR
  - v. delivery and installation of WEB GIS with connection to RDB database in test and production environment
  - w. delivery of source code and technical documentation for GIS
  - x. collected and deployed cartographic and other data from other sources
  - y. prepared spatial data presentation for existing road data stored in RDB and for results of data handling module and HDM analyses
  - z. user training for WEB GIS administrators
  - aa. user manual for WEB GIS
  - bb. user training for WEB GIS users
  - cc. initial user support - 4 months

- Deliverables for Task 2 – Road reference system:
  - a. verified list of nodes, road sections and roads
  - b. methodology for reference system GIS presentation
  - c. geodatabase of road nodes and centerlines of road sections; attributing with road section identificator and mileage
  - d. import of prepared data to RDB and GIS database
  - e. prepared IT environment at PERS for reference system data maintenance (Desktop GIS with additional procedures)
  - f. user manual for reference system maintenance
  - g. user training for reference system maintenance
  - h. initial user support - 6 months

- Deliverables for Task 3 – Ground Penetrating Radar Measurements:
  - a. time plan of road measurements for all locations
  - b. database of raw measured data
  - c. relational database of homogeneous sections of equal pavement structure
  - d. database of pictures of measurement locations equipped wilt location data
  - e. user interface for viewing and displaying the obtained data
  - f. a final report on the measurement and analysis

- Deliverables for Task 4 – Weighing of Commercial Vehicles in Motion:
  - a. time plan of road measurements for all locations
  - b. database of raw measured data for each individual vehicle
  - c. the Site reports containing the results of the measurements per individual location
  - d. a Final report, summarizing Site reports and proposing the overall average Equivalency Factors for individual vehicle groups
  - e. relational database of collected and analyzed traffic data

f. database of pictures of vehicles from 5 sites

- Key Project Task Completion Summary Reports to the Client, copied to the WB, on completion of each project task;

- Draft Final Report on project implementation to the Client, copied to the WB, 11 (eleven) months after contract signing. The Consultant is also expected to present a results of the project to the Client;

- Final Report on project implementation to the Client, copied to the WB, not more than 4 (four) weeks after the receipt of the Client's comments on the Draft Final Report.

- Deliverables for Task 5 – RAMS SW maintenance and user support:
    a. Reports upon maintenance request
    b. Reports upon service request processing
    c. Reports upon change request maintenance
    d. Reports upon end user support
    e. Escalation management

The Consultant will submit two hard copies of each report in English language and soft copies to PESR. The Consultant will provide electronic copies of all working notes and technical materials developed during the project in their original electronic format (e.g. word processor, spreadsheet and database).

E. Duration

The duration of the assignment is twelve (12) months from the start of project - contract signature. The assignment is estimated to commence in April, 2016 and end by April, 2017.

The Consultant shall complete the works and the assignments according to the next timetable:

	Project/tasks	Delivery Date (months from start of project)
1	RAMS SW	
	delivery and installation of RAMS portal SW	3
	implementation of single sign on and integration with PESR infrastructure	4
	preparation of metadata catalogue	5
	user training	6
	delivery and installation of RDB SW (database, C/S application, WEB application)	4
	delivery and installation of WEB GIS with connection to RDB database	4
	delivery and installation of Data handling module	6
	delivery and installation of workflow module (Road works, Data maintenance)	6

	Existing road data transformation and importing to RDB	5
	Acquisition of cartographic and other data from other sources (ortophoto, topographic maps, registers, land and buildings cadastre, environmental data, etc.)	3
	Preparation of spatial data presentation for existing data stored in RDB	5
	User training for RDB	6
	User training for WEB GIS	6
	User training for system administration	6
	User training for Data handling module and workflow	7
	Preparation of spatial data presentation for results of data handling module and HDM analyses	8
	Installation of all IT systems on PESR production infrastructure	8
	HDM-4 evaluation of the road network to support programming of road works	11
	Initial user support prior to end of development and implementation phase- 4 months	12
2	REFERENCE SYSTEM	
	Methodology for reference system GIS presentation	1
	Verification of existing attributive reference system data	1
	Digitalization of road centrelines and attributing with road section identification and mileage	3
	Import of prepared data to RDB and GIS database	4
	Preparation of IT environment at PERS for reference system data maintenance (Desktop GIS with additional procedures)	5
	User training for reference system maintenance	6
3	GROUND PENETRATING RADAR MEASUREMENTS	
	Preparation activities	2
	Data acquisition for all state roads	4
	Data analyses and data base preparation	6
	Final report	7
4	WEIGHING OF COMMERCIAL VEHICLES IN MOTION	
	Preparation activities	2
	Installation, data collection, data analyses and reporting for WIM measurements for 20 locations	8
	Data analyses and data base preparation	9
	Final report	10
5	RAMS SW MAINTENANCE AND USER SUPPORT	from 13 to 36
	PROJECT MANAGEMENT	
	Inception Report	1
	Progress Reports	every month
	Draft Project Report	11
	Final Project Report	12
	Regular report on RAMS SW maintenance and support	every 3 months

F. Deliverables and Payments

Deliverables correspond to the following payment schedule:

Milestone	Tasks and Deliverables	Delivery Schedule	Payments
1	All tasks and corresponding deliverables for the first 3 months according to the timetable in chapter **Duration** above	3 months after signing contract	20% of Total contract price for development and implementation after submission of all deliverables accepted by the Client
2	All tasks and corresponding deliverables for the months 4, 5 and 6 according to the timetable in chapter **Duration** above	6 months after signing contract	30% of Total contract price for development and implementation after submission of all deliverables accepted by the Client
3	All tasks and corresponding deliverables for the months 7, 8 and 9 according to the timetable in chapter **Duration** above	9 months after signing contract	25% of Total contract price for development and implementation after submission of all deliverables accepted by the Client
4	All tasks and corresponding deliverables for the months 10, 11 and 12 according to the timetable in chapter **Duration** above	12 months after signing contract	25% of Total contract price for development and implementation after submission of all deliverables accepted by the Client

5,6,7,8, 9,10,11,12	RAMS SW maintenance and user support	• 15 months • 18 months • 21 months • 24 months • 27 months • 30 months • 33 months • 36 months after signing contract	12,5% of Total contract price for RAMS SW maintenance and user support at each milestone

G. Qualifications

Company

The project will be conducted by a Consulting company (Consultant). The following qualifications are required for the Consultant:

(1) The Consultant must have a proven reference for at least 1 implementation and maintenance of comparable system of RDB including GIS that is in regular use for the roads covering the whole country or a state of a country, including motorways.

(2) The Consultant must have a proven reference for at least 1 implementations of WEB GIS system in the field of Road Management for the state level road network that is in regular use in the last 5 years, where data are managed on the base of dynamic segmentation (section identifiers and chainage)

(3) The Consultant must have a proven reference for at least 1 finished project where road reference system in form of road centrelines was established and/or maintained

(4) The Consultant must have a proven reference for at least 1 finished project for Quality control and Quality assurance for entering the spatial data into national registers in the last 5 years

(5) The Consultant must have 1 completed project for the determination of road pavement structure and 1 completed project for weighing of commercial vehicles in free traffic flow with the same system as planned.

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The Consultant must submit a reference proof from contractual partners (Clients), showing the contract value (without VAT), the quantity, contract number and confirmation of the Client that contractual obligations were carried out properly, qualitatively and within the agreed deadlines.

The Consultant must have as a minimum the following experts:

a) Team Leader
   o overall working experience min 10 years;
   o experience in PM of IT system development, implementation or maintenance; in last 10 years must be the PM of at least 3 corresponding projects with the value of 100.000 EUR for each project
   o experience in RAMS, RDB, HDM-4, GIS and road reference system projects in last 10 years;
   o full time employed by the Consultant

b) Expert for RDB
   o overall working experience min 10 years;
   o experience with design, development, implementation and administration of RDB system and software development; in last 10 years the expert must participated in at least 2 projects in the implementation and maintenance of RDB;

c) Expert for HDM-4
   o overall working experience min 10 years;
   o experience with the use of the HDM-4 model for planning and programming of road works;
   o experience with the interface between RDB and HDM-4;

d) Expert for GIS
   o overall working experience min 10 years;
   o must have a GIS certificate: ESRI certified Enterprise Associate (Enterprise Geodatabase Management Associate) or equivalent;
   o experience with GIS projects; in last 10 years the expert must participated in at least 2 projects in the field of GIS using standards and services based on Open Geospatial Consortium (WFS/WMS/WMTS);

e) Expert for GPR measurements:
   o overall experience min 10 years;
   o 5 years of experience with GPR data interpretation;
   o experience in preparing and managing projects related to GPR measurements; in the last 10 years the expert must be a project management for at least 2 projects in the field of GPR measurements with value more than 100.000 EUR
   o with references for at least 2 projects in the field of GPR data interpretation with value more than 100.000 EUR

f) Expert for WIM measurement:
   o overall experience min 10 years;
   o 5 years of experience with WIM Traffic analyses;
   o experience in preparing and managing projects related to weigh in free traffic flow measurements; in last 10 years the expert must be a project management for at least 2 projects in the field of WIM measurement with value more than 100.000 EUR

- knowledge of heavy vehicle characteristics and of the impact of heavy vehicles on pavement deterioration;
- with references for at least 2 projects in the field of WIM data analysis;

It is highly desirable that experts on:

- Solution architect for SW Development (certified),
- Database administration (certified) and
- Road reference systems

be part of the team working on the development of the RAMS.

Team Leader and all experts must have:

- finished university degree of education (bachelor's degree or higher),
- English language skills.

H. Bidder Proposals

- Bidder should clearly include full list of references for the proposed work.

- Bidder should clearly include proposed approach, methodology and work-plan.

- Bidder should clearly include the exact functional and technical description of proposed solution for each requirement defined in tender documentation (the numeration of request must be the same as in tender documentation); from description of each request it must be clearly visible how request will be supported through the project.

I. Duties of the Client

The Consultant shall work directly with the PESR RAMS Unit and PESR IT group. Through the RAMS Unit and IT group, PESR shall make available to the Consultant existing information relating to the assignment, in particular:

- existing digital data of the state road network;

- relevant study reports;

The Client will provide:

- IT infrastructure needed for installation of RAMS SW;
- office space for the consultants at the PESR premises; ideally the consultants should work together with the RASM team;
- venues for the trainings.

J. Bid quotation

	Task	Unit	Cost/piece	Pieces	Cost
1	RAMS Portal				
	delivery of RAMS portal SW	piece		1	
	implementation (installation, integration of single sign on)	piece		1	
	preparation of metadata catalogue	piece		1	
	user training	piece		1	
2	Road data bank and GIS				
	delivery of RDB SW (database, C/S application, WEB application)	piece		1	
	delivery of WEB GIS with connection to RDB database	piece		1	
	delivery of Data handling module	piece		1	
	delivery of workflow module (Road works, Data maintenance)	piece		1	
	Existing road data transformation and importing to RDB	piece		1	
	Acquisition of cartographics and other data from other sources (ortophoto, topographic maps, registers, land and buildings cadastre, environmental data, etc.)	piece		1	
	GIS configuration - preparation of spatial data presentation for existing data stored in RDB and for results of data handling module and HDM analyses	piece		1	
	User trainings for RDB, GIS and system administration	piece		1	
	Installation of all IT systems on PESR test and production infrastructure	piece		1	
	Initial user support - 4 months	piece		1	
3	Reference system				
	Methodology for reference system GIS presentation	piece		1	
	Verification of existing attributive reference system data	piece		1	
	Digitalization of road centrelines and attributing with road section identificator and mileage	piece		1	
	Import of prepared data to RDB and GIS database	piece		1	
	Preparation of IT environment at PERS for reference system data maintenance (Desktop GIS with additional procedures)	piece		1	
	User training for reference system maintenance			1	
4	GROUND PENETRATING RADAR MEASUREMENTS				
	Preparation activities	piece		1	

	Data acquisition for all state roads	piece			1	
	Data analyses and data base preparation	piece			1	
	Final report	piece			1	
5	WEIGHING OF COMMERCIAL VEHICLES IN MOTION					
	Preparation activities	piece			1	
	Installation, data collection, data analyses and reporting for WIM measurements for 20 locations	piece			1	
	Data analyses and data base preparation	piece			1	
	Final report	piece			1	
	Total for development and implementation					
6	RAMS SW MAINTENANCE AND USER SUPPORT					
	Basic Corrective Maintenance of RAMS SW	months			24	
	Service Request Processing	hours			480	
	Change request maintenance	hours			960	
	End User Domain Support	hours			960	
	Total for Maintenance and support					

	TOTAL for Contract	