

D2.4 Report of the methodology chosen. Ground for and objectives of the proposal

FORCIP+: Forest Roads for Civil Protection





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ABBREVIATIONS

Term	Explanation
CRS	Coordinate Reference System
ETRS89	European Terrestrial Reference System 1989
FCT	Firefighting Traffic Capacity
GIS	Geography Information System
GRS80	Geodic Reference System 1980
OGC	Open Geospatial Consortium
OSM	Open Street Map
SI	Système international d'unités
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service

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EXECUTIVE Summary

The scope of this deliverable is to report about the methodology selected to carry out the field data collection. This methodology comprises of the data model selected, the means and the procedures to perform it.

1. INTRODUCTION

An inventory comprises of a data model which defines the relevant information that should be collected in the field and a methodology to carry it out.

INVENTORY = model data (relevant info) + *methodology*

In this document we address the second part of the formula, in other words, the procedures, rules, initial information and means that lead to reach the final objective.

Some information is addressed in other deliverables of this project, but due to its tight bonds with the current subject it is necessary to include it in this one too.

The methodology selected is based on information from the study of different methodology report (Forcip+ D.2.1) and the model data which as the result of the analysis of forest fire requirements (Forcip+ D.2.2) and set in the model schema report (Forcip+ D.2.3).

The objective is to acquire the knowledge regarding the accessibility to the forest in order to improve the efficiency of ground means in case of forest fires. To meet this goal, it is necessary to perform an inventory of roads, setting their capacity to support the circulation of firefighting tracks and other vehicles involved in these situations, and finally, implement a spatial database which will be use as the basis for applications like the Satellite Navigation System, or a public information system.

Therefore, this document defines the data (data model and road classification), the spatial database and the elements of the field data collection stage, including the initial data, devices to be used, data collection software, and rules of collection.

2. THE DATA

2.1. Scope of the inventory

Roads subject to inventory: All non-temporary forest roads and tracks allowing at least a light firefighting vehicle to drive along it. That means: forest roads, skid trails, firefighting corridors suitable for dedicated vehicles and any other road considered important for firefighting purposes.

Roads not subject to inventory: Public roads (local roads, regional roads, state roads) and temporary forest roads and tracks.

The data obtained in the inventory must be complemented with external sources in the case of public roads. This type of roads goes beyond the scope of this project but it must be considered as essential part of it, since the inventory roads must connect with this network. Therefore non-inventoried roads network must be included in the system (see Forcip+ D.2.5 for further information).

2.2. Data model

The *relational model* separates the logical design from the physical design. With the objective of minimizing data redundancy we follow the database normalization standards. Normalization involves decomposing a table into less redundant tables without losing of information (Codd, E. F, 1970). See Forcip+ D.2.3 document for more detailed information (this document includes a description of the data model, attributes considered, relationships and the data dictionary).

This way the selected data model meets the requirements for an easier update process. It comprises of a basic table (core of the inventory) and additional (optional) related tables in order to complete the information about roads. Besides, special nature objects are considered for collection, specifically those which affect the firefighting and the traffic of the road and will be stored as different information layer.

This information will be stored as Geographic Information System (GIS) layers, ensuring that the spatial reference of all collected data is kept, and future exploitation of the data by other applications is assured. The roads, due to their linear nature will be displayed in GIS linear layers and those objects which have a special nature as GIS point layer.

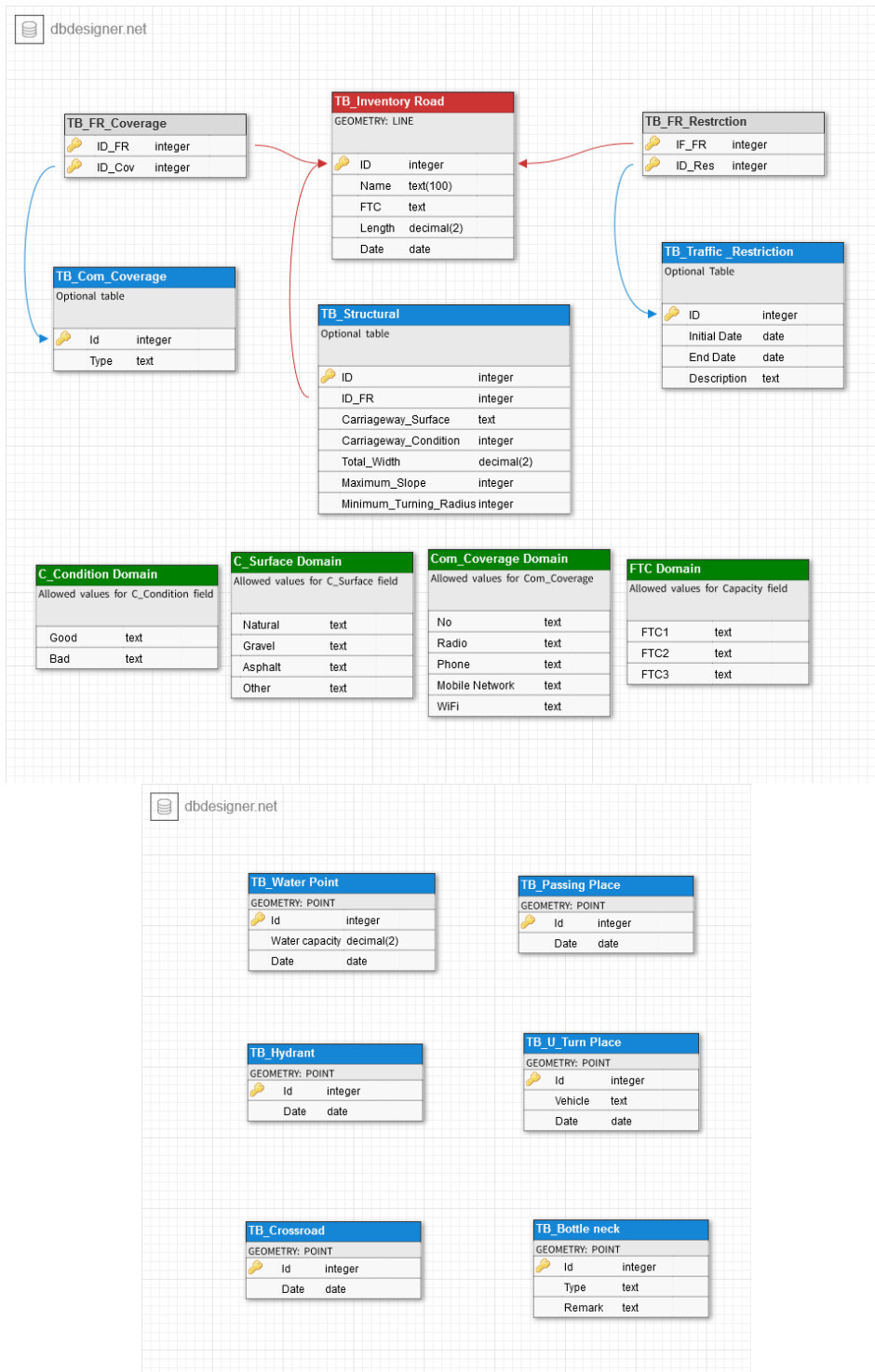


Figure 1: Logical data model

To manage this information (visualize, edit, analyse data, etc.) it is necessary to use GIS software. For this project, **QGIS** seems to be the best option since it is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License and it runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster and database formats (<http://www.qgis.org/en/site/>).

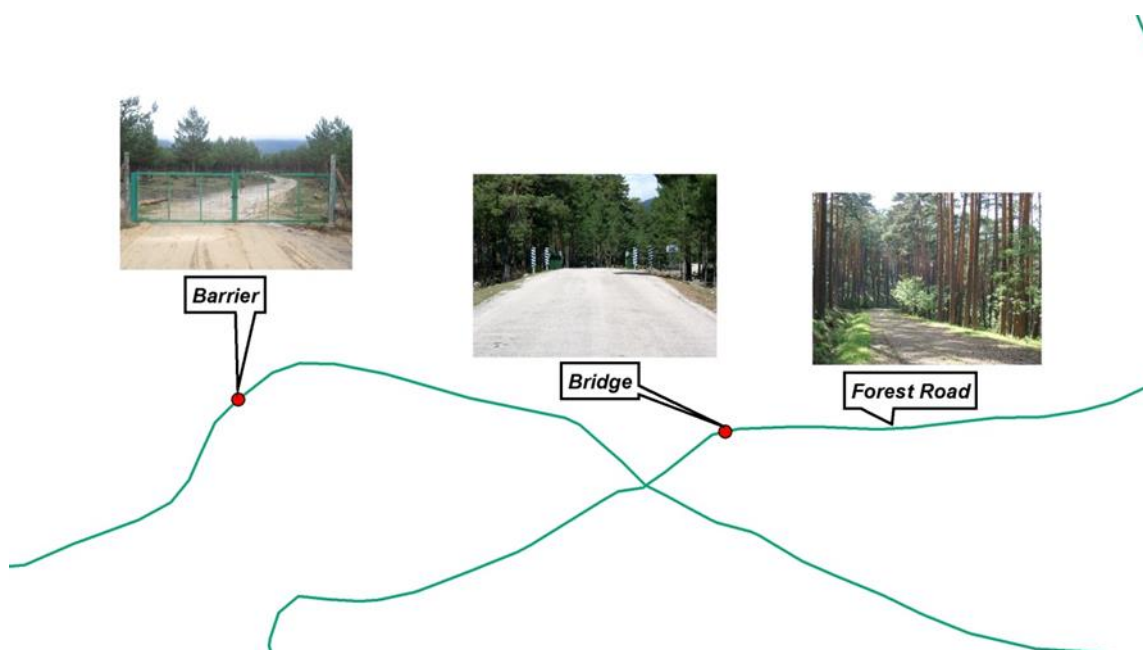


Figure 2: Lines and points in the road network

2.3. Road classification

Setting a common **road classification** for firefighting purposes is a scope of the present project. Taking into consideration that the key factor in this type of emergencies is the possibility of access to forest areas by different ground means that are involved in suppression tasks, it has been decided that the classification must be based on the capacity of roads to support different types of vehicles. This attribute (*Firefighting Traffic Capacity*) has to be the segmentation basis of the road network, this way the firefighting personnel will be provided with accurate and useful information for planning and implementing fire suppression operations.

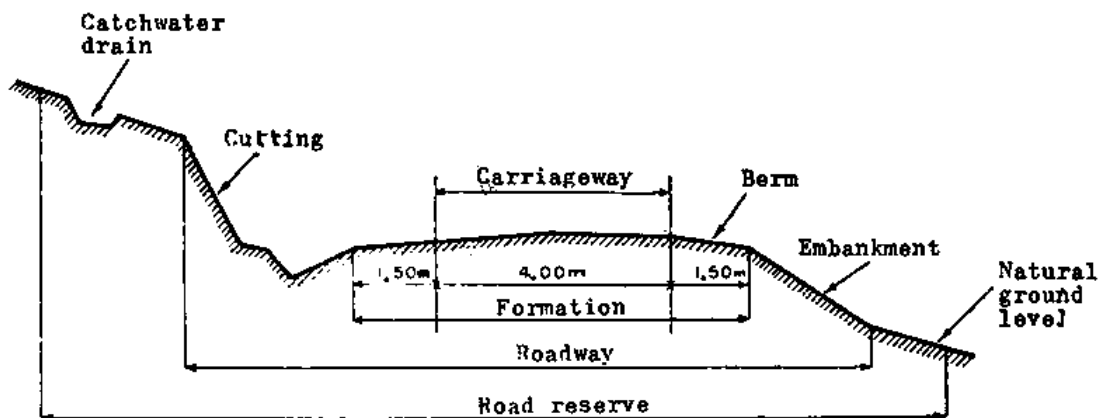
The road network is divided into three levels:

- **FTC1** – high traffic capacity
- **FTC2** – medium traffic capacity
- **FTC3** – low traffic capacity

The following table shows the classification and the definition for each level:

	Structural parameters	Infrastructure associated parameters	
Vehicle capacity		Passing areas	U_Turn Place
FTC1	Forest roads which allow all kinds of firefighting vehicles (gondola included) to drive along them.	When needed	At the road/segment end (dimensioned to all types of vehicles)
FTC2	Forest roads which allow suppression trucks (loaded with water) to drive along them. These include vehicle classes V2 and V3 (see Forcip+ D.2.3).	When needed	At the road/segment end (dimensioned to suppression trucks of 6-7 m length)
FTC3	Other characteristics allowing at least a light firefighting vehicle to drive on it. Only vehicles of V3 class can drive along them.		

NOTE: The presence of bottle necks (limitation of weight, height, width, difficulties to access) will make the road segment drop in the classification until the level of vehicles involved can use it.



2.4. Basic unit of inventory

The basic unit of inventory has been set on the basis of the *FTC attribute*, this way, a change in the value of this attribute will determine the end of the road segment. The solution adopted will allow keeping the accuracy in traffic capacity, a key factor in emergency ground means accessibility.

The rest of the information related with roads can be linked to these features and it will be contained in related tables.

Future use in applications based on this cartography is not compromised since geographic requirements for them can be implemented with GIS work, e.g., new segmentations can be performed keeping the information of each stretch.

2.5. Spatial data specifications

Due to the European dimension of the project and according to the guiding principle of standardization, a series of specifications are considered with regard to the spatial data of the inventory (based on The Inspire directive, <http://inspire.ec.europa.eu/>):

Datum

The datum shall be the datum of the European Terrestrial Reference System 1989 (ETRS89).

Coordinate reference system (CRS)

Spatial data sets shall be made available using at least one of the coordinate reference systems described below:

- Three-dimensional Cartesian coordinates based on the above specified datum and using the parameters of the Geodetic Reference System 1980 (GRS80) ellipsoid.
- Three-dimensional geodetic coordinates (latitude, longitude and ellipsoidal height) based on the above specified and using the parameters of the GRS80 ellipsoid.
- Two-dimensional geodetic coordinates (latitude and longitude) based on the above specified and using the parameters of the GRS80 ellipsoid.
- Plane coordinates using the ETRS89 Lambert Azimuthal Equal Area coordinate reference system.
- Plane coordinates using the ETRS89 Lambert Conformal Conic coordinate reference system.
- Plane coordinates using the ETRS89 Transverse Mercator coordinate reference system.

Unit of measure

All measure values shall be expressed using International System units (SI).

Topology considered

Spatial features in the inventory can be represented through nodes and edges. Topology is defined through a group of rules that define how features share a geographic space.

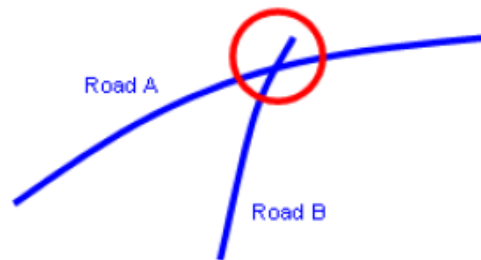
Topology is used to ensure the data quality of the spatial relationships, and among other functionalities, it supports topological relationship queries and navigation, providing the ability to identify adjacent and connected features and navigate along series of connected edges (basis for the Satellite Navigation System planned in task D of this project). The topological consistency must be assessed considering the following errors:

- Missing connections due to undershoots: lacks of connectivity if the real features are connected in the road network.

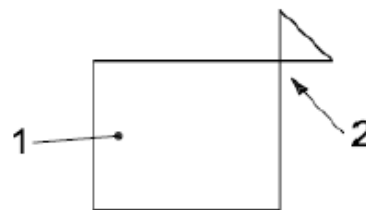


Figure 4: Topological error - undershoot

- Missing connections due to overshoots: lacks of connectivity if the real features are connected in the road network.



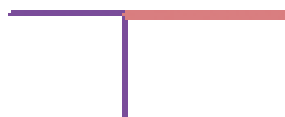
- Self-intersect errors: items in the data that illegally intersect with themselves.



Key

- 1 Enclosed Traffic Area
- 2 Illegal intersection (loop)

- Self-overlap errors: items in the data that illegally self-overlap.



- Other errors can be considered if we take into account the additional infrastructure collected: Points (bottle necks, passing areas, crossroads or U_turn areas) are not covered

by lines. However those infrastructures that are in reality out of the road (water points) can be considered as exception within the topology.



Metadata

The metadata describing a spatial data set will include the following metadata elements required for interoperability:

- *Coordinate Reference System*: description of the coordinate reference system(s) used in the data set.
- *Temporal Reference*: at least one of the following temporal reference metadata sub elements shall be provide: temporal extent, date of publication, date of last revision, date of creation.
- *Encoding*: description of the computer language.
- *Topological consistency*.
- *Character encoding*.
- *Spatial Representation Type*: the method use to spatially represent geographic information.

3. THE SPATIAL DATABASE

The storage of the data collected must be carefully considered since the efficient of future applications depends on it, the data display and the degree of difficulty in data update must be foreseen. Instead of using proprietary formats to store spatial data (e.g. shapefiles) or any other file storage, it is more useful to use a spatial data base.

In particular, the spatial database (SDB) must meet the following requirements:

- It should allow keeping the data centralized. Unique repository.
- Data distribution must be guaranteed.
- Integrity of the data. It must allow for topology integration.
- Easy update of the data.
- Coincidence: simultaneously access to the data.

- Open source.
- Display tools.
- Map server implementation possibility.

PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL (<http://postgis.net/>). It is an open source software, released under the GNU General Public License. Among other characteristics PostGIS has several tools designed to import and export data, it is compatible with QGIS for editing/viewing tools and it can work with open source mapping servers, most conform to OGC mapping standards: WMS, WFS, WCS, etc.

For further information see Forcip+ D.2.6: Selection of the solution.

4. THE FIELD DATA COLLECTION

Performing an inventory requires some previous processes in order to establish the procedure and the tools to be used. Once we settle a data model, the next step consists of the preparation of the field work.

4.1. Base cartography

This stage comprises of all the necessary procedures to get a cartography that is used for the field work:

1. The **selection** of the roads to inventory, according to the scope of the project. In this case they are all the roads that ground emergency means can use to extinguishing a forest fire, regardless of the owner, type, or function of the road. The only requirement is that at least a light firefighting vehicle (off-road vehicle) can drive on it, allowing the surveillance and a first attack with this type of means. The different cartography sources in each region of the project are addressed in an independent document. The final result is a geo-referenced GIS vector data. For further information see Forcip+ D.2.5 delivery.
2. **Imagery**: geo-referenced image data of the Earth's surface from either satellite or airborne sensors is useful information when performing the field work. Surface images along with a GPS/GNSS positioning utility allow the personnel in charge of the task to know their location in real time and the location of the roads. Cartography providers can be found in Forcip+ D.2.5 delivery.

3. **Edition:** when different cartography sources are required in the process of the generation of a new one, it is likely that there will be a need for adjustment in order to assure the connection between them. GIS software provides a series of tools for spatial adjustment, specifically in QGIS:
 - i. **Editing:** setting snapping options (tolerance, vertex, edge, etc.)
 - ii. **Georeferencing Aerial Imagery:** Georeferencer tool.
 - iii. **Coordinate Reference System (CRS):** QGIS provide tools to set, change and export projections.
 - iv. **Data format:** QGIS works with a high number of GIS data formats (both vector and raster); therefore the data can be exported to the proper format according to the end user or application.

4. **Implementation:** the produced cartography will be loaded in android devices with a satellite location system utility (tablet) for positioning and planning.

4.2. Device: tablets specifications

The purpose of the tablet acquisition is to provide a system in order to collect field data, but also that can be used to implement some of the Task D (ICT applications) results. Both objectives do not require special or extra specifications beyond a regular tablet although we should consider some ideas.

Size: Tablets with 10 inch provide a good balance between portability and productivity.

Operating system: Android

Other specifications: processor in mid-ranges table is enough, RAM: at least 1 GB (2 GB is optimal), Storage: 8 to 16 GB internal and SD card reader and a battery life that runs for no less than 7 hours on a single charge.

Optional specifications: water and dust protection.

For further information see Forcip+ D.2.6: Selection of the solution.

4.3. Software

The solution adopted for the field data collection considers the use of an application, as mentioned above, where the base cartography must be loaded into and allow for road characterization through customized forms.

The software selected to collect data in the field is geoODK (<http://geoodk.com/>) since it allows adding cartography off-line (MBtiles), geo-positioning, customized forms and sending the collected data to a central server.

For further information see Forcip+ D.2.6 deliverable.

4.4. Procedure

Finally, the group of rules to carry out the field work has to be established. This work consists of travelling the roads that are subject to inventory by off road vehicle and picking up the information with the tablet (attributes and geo-referenced data).

In order to avoid duplications or mistakes in this phase of the project, a method must be implemented.

Field data collection work should be performed by staff trained in mobile data collection and IT technologies, as well as the specific software to be used in this project and the procedures to achieve it. Optionally the staff in charge of collecting field data can have a thorough understanding of fire fighting vehicles or activities.

The field data collection was divided in three parts:

1. Planning and preparation

This stage comprises of the necessary steps to set the device ready to be used in the field.

The three first steps will be carried out once and they will be available for the rest of the inventory:

- The first step is to set up the server where the collected information will be sent and create the customized forms for the task. It includes the database service (PostgreSQL), a web service (Apache), an application service (Tomcat) and the data collection service (Smap).
- The customized forms will be created in the server and will be ready to be downloaded from the users. Besides, users and permissions will be configured.

- Each user will be able to download the forms and connect with the server through the geoODK collect software. To do it, it will be necessary to enter the user and password credentials.

Daily office work previous to the field data collection work:

- Off-line cartography addition to the device to be used in the field. This can be performed through different ways:
 - Using **Maperative** software is possible to create MBTiles with Open Street Map (OSM) data. The process is very direct and simple and allows introducing the base cartography (road network subject of inventory) as .gpx files.
 - **MOBAC**: though this software MBTiles can be produced. The main advantage is the great number of sources to create them, including aerial imagery. In addition this software permits the addition of custom maps that can be used in the field.
 - There is more software that produces MBTiles: Mapbox, TillMill, etc.
- Planning of the daily task, which area it must be covered each day.

2. Actual field data collection

Depending on the personnel who are performing the data collection two alternatives to carry out the inventory are available:

- Staff with specialized technical expertise in firefighting: the segmentation of the network can be performed in the field, the personnel can decide and select at that moment the different FTC of the road.
- Staff that does not meet the above requirement: the segmentation of the network will be carried out in basis of structural characteristics of the roads. Subsequently, the FTC will be assign in the office taking into account the levels definitions and the information collected in the field. The new segmentation can keep the information collected in the extra (optional) tables provided in the data model.

Anyway, the procedure for collecting data in the ground is the same in both cases. The method consists of collecting georeferenced points (waypoints) when a segment of the road starts. This point will contain the information related to the segment. If a new segment has to be added, the software allows recording a track. Besides, infrastructures or bottle necks will be picked up with the device when they appear.

Three different types of point will be collected:

- **Infrastructure point:** collected for special infrastructure when appearing. It contains information about infrastructure. It can be:
 - Bottle neck: a point will be collected when a bottle neck appears and the specific form will be filled out.
 - Passing areas: when driving along the road and a passing area is found a point will be collected and its form filled out.
 - U_turn areas: same as passing areas
 - Water Points: same as above.
 - Crossroads: same as above.
- **Segment point:** collected for segment information. The attributes of the road will be gathered and in the post-processing stage they will be transferred to the lines of the base cartography.
- **End point:** collected when necessary to delimit the segment. That will occur in the following situations:
 - Dead ends
 - Crossroads with public roads

To sum up, the process will be:

- Collect a segment point
- Fill out the segment specific form
- Keep along the path
- Collect infrastructure points
- When segment basis changes, collect a new segment point to characterize the new one
- If the segment finishes in a dead end or in public road collect end point.
- When finished, submission of the information gathered to the central server. Internet connection required.

The roads will be covered by all-terrain vehicles.

3. Post-processing review

Once the field data has been received in the server the next step is to proceed with data processing.

- This data can be exported through Smap to shapefile format.
- Using QGIS the information from segment point shapefile will be transferred to a line layer.

- In addition the segments of the road network will be delimited with segment points and end points.
- Afterwards, if the second alternative has been selected the FTC level can be assigned to the segments according to their definition and the data collected. Later, a new segmentation can be applied taking into account the FTC attribute.

The final step would be the exportation of the GIS layers to the Spatial Data Base.

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