Masters Program in **Geospatial Technologies**

INTEGRATION OF FOREST FIRE MANAGEMNT WITH SDI

User requirements

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ABSTRACT

Forest fires management is not only an emergency task, the preventive task could be even more important, being better avoid the possibility of a forest fire ignition before it start or reduce its hazard, that latter try to extinct it. To implement a useful forest fire management into a SDI is crucial to know the user requirements, which is the spatial information they manage, which are the GIS applications they manage in their work, which are the alerts send a receive in the forest fires context. A Survey has been done to have a better compression of the reality and user requirements. A review of Spanish and European works in forest fires and emergency management has been done to identify which are the actual challenges in emergency management.

INTEGRACIÓN DE LA GESTIÓN DE LOS INCENDIOS FORESTALES EN AL IDE

Perspectiva de las necesidades de los usuarios

RESUMEN

La gestión de incendios forestales no es tan solo una emergencia, las labores preventivas pueden ser incluso mas importantes, siendo mejor prevenir un incendio forestal que extinguirlo. Para implementar un sistema de gestión de incendios forestales integrado en una IDE es crucial saber las necesidades de los usuarios. Cual es la información espacial que suelen manejar, que aplicaciones GIS utilizan en su trabajo, cuales son las alertas trasmitidas y recibidas en el contexto de los incendios forestales. Se ha realizado un cuestionario para tener una mejor compresión de la realidad y de las necesidades de los usuarios. Se ha realizado una revisión de las experiencias Españolas y Europeas en incendios forestales y gestión de emergencias para identificar cuales son los desafíos actuales en la gestión de emergencias.

KEYWORDS

Forest fires

Emergency management

User requirements

SDI

PALABRAS CLAVE

Incendios forestales

Gestión de emergencias

Necesidades de los usuarios

IDE

ACRONYMS

ER - Environmental rangers

ET - Extinction technician

GIS – Geographic Information Scene, also works like Geographic information Software or application.

H - Helicopter transport squads

OGC- Open Geospatial Consortium

PPG - Public participation GIS

PT - Prevention technician

RL - Rural emergency squads

SDI - Spatial Data Infrastructure

SLD - Styled Library Description

SMS - Short Message Service.

VGI - Volunteer Geographic Information

WMS - Web Map Service

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1 INTRODUCTION

When a forests fire starts, actions are more important than analysis. It is time to decide. The important task related with geospatial information is to have every thing ready, information about the terrain the vegetation, wind, temperature, humidity and so on to have a fast overview about the emergency situation (Rocha et al. 2005). In an emergency situation the analysis time is minimal. It is time to deliver information in an effective way, keep it simple. Give optimum information to each user at right time to ensure an effective understanding of the spatial information.

Professionalism (Vélez Muñoz 2004) in the wildfire fighting and prevention sectors is a reality. People involved in covering a huge area, therefore is impossible to have a good knowledge of the terrain because the intervention could be in any place within a province or even in the Autonomous Community. The professionals must have a spatial help regarding the terrain conditions, for instance the forest road conditions, how far away the fire is, if they can access an attack position directly from the forest road or they have to walk, existence of water points and if this water points are full. Success in an emergency context depends on a good estimation of the current situation (Scholten et al. 2008) It is crucial in a forest fires, to have knowledge of the terrain conditions and meteorology conditions.

Spatial information is changing constantly, as new data is recovery. Forest fires require such update data sets ready to be use. Moreover data maintenance is necessary to ensure delivering of up-to-date information (Díaz et al. 2010) when and where a fire is detected and the emergency protocol is started. The Spatial Data Infrastructure (SDI) is a new way to access the information with a guarantee to deliver to the most recently information officially or unofficially published, the SDI has become "*a critical aspect of decision-making in disaster management" (Scholten et al. 2008)*

Alan Leidner is the chief of Citywide GIS, New York City Department. He has experience from the 9 11 terrorist attack on the World Trade Center and says in the introduction to Confronting Catastrophe, a GIS handbook (Greene 2002) : “No other technology allows for the visualization of an emergency or disaster situation as effectively as GIS. By placing the accurate physical geography of disaster event on a computer monitor, and then align other relevant features, events, conditions or threats with that geography, GIS lets police, fire, medical and managerial personnel make decisions based on the data they can see and judge for themselves. This visualized information can be of critical relevance to a disaster manager: the size and direction of wildfire perimeters, the location of broken levees or of hazardous chemical spill release points, or the whereabouts of surviving victims inside a bombed building. GIS can be a matter of life and death.”

This thesis focused in spatial information forest fire professional requirements. How spatial information is managed and how is delivered this information. The objectives of the thesis are:

- Geographic information Science and Software (GIS) knowledge and familiarity with the GIS applications.
- Relevant spatial information according to the different tasks in a forest fire.
- How is nowadays communication and delivery of the spatial information in forest fire context.

This thesis is structure in two blocks. First one is a discussion about the actual situation of the forest information systems for emergency response and forest fires. This chapter is base on Spanish expediencies for forest fires management and European initiatives for a common inter-operable emergency system. Also is important know information infrastructure challenges in an emergency context to make the spatial information useful.

The second block of the thesis is about the survey design and the analysis of survey result. With the analysis of this survey results, the user's needs will be discovered. This survey will contribute to define how, where and to whom to deliver the spatial information and which spatial information is needed.

2 BACKGROUND

This chapter describe relation among forest fires and spatial information. The development of the SDI has contributed to improve access to the spatial data (Bejar et al. 2005). The regional governments and some European initiatives has tried to solve the spatial issues in emergency and forest fire management context. Here is show an overview on these initiatives to have a benefit of its experiences.

2.1 SDI and forest fires

Most of the implementations of the forest fire emergency system, are based on desktop GIS interface. This desktop application allow you to access to some tools like fire simulation, and geographical datasets. This way or working is good if you have all the information available in your computer. With the development of the SDI infrastructure there is available more information in Internet than a simple desktop computer can store. Information stored in a local machine can be out-of-date whereas information in a SDI is usually up-to-date. The SIGDIF (de Sarriá Sopeña et al. 2007) has gone further implementing a system based on modules, accessible across a web portal. The SIGDIF initiative is an SDI but it is not open. No one out of the Andalucía government can have access to any of their modules, also to the geographical information related with the forest fires. They are their own providers of the geographical information and the consumers of it.

The architecture of forest fire emergency system, should ensure the access to the data (geographical data from sensors, vegetation information, topographical data),coming from different providers, according with user requirements and data availability for each location.

There is a huge quantity of environmental information related with the space. The environmental information use to be distributed in different providers, regional and state institutions. INSPIRE initiative recommend to publish the spatial data following the standards and INSPIRE specifications to improve the compatibility between different official data providers (Drafting Teams "Data Specifications", "Network

Services", "Metadata", 2007). INSPIRE initiative wants to ensure data connections with different data providers. Following INSPIRE recommendations is possible to enable a small SDI to be integrated into bigger SDI following the same recommendations and standards (Bejar et al. 2005)

With the development of a simple SDI, the solution for manage the spatial information during a wildfire is not done. If you have not an efficient access to the information, you can lose a very important time searching for the right information related with a concrete wildfire in a specific location. Scholten (Scholten et al. 2008), have proposed a context aware SDI where the information is served according to the real situation and location. With this approach is possible to save a lot of time searching for the relevant information.

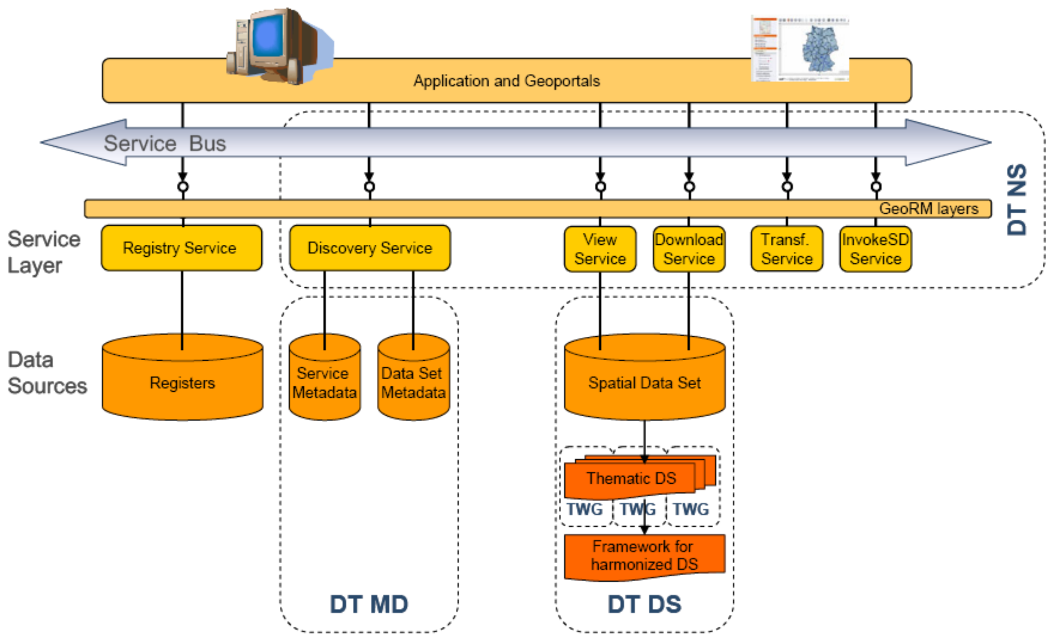

Figure 1: INSPIRE thecnical architecture overview (Drafting Teams "Data Specifications", "Network Services", "Metadata", 2007)

2.2 Share the information and processes

Sspatial information is created by the surveyors, it is uploaded and maintained by the data providers to be finally displayed, downloaded and used by final users (Granell et al. 2009). Chapter 2.1 is explains how SDI can provide the tools to simplify this process.

The standards ensure the compatibility between different systems. Data discovery is based on metadata, which describes the information documentation (topic, provider, extensions,....). The metadata is store in a standard XML format (ISO 19115/19139), because is a standard it can be distributed and access anywhere on the network (Granell et al. 2009).

The SDI developed in Spain (www.idee.es) by the state government and the ones develop by the regional government accomplishes the sharing philosophy. National SDI provide accessibility to the spatial information using standards, mainly with Web map Services (WMS) (OGC n.d.) and some Web Feature Services (WFS) (OGC n.d.) . The WMS provide just a picture, a background image or layer with no possibilities to implement any operation. With Web processing services (WPS) (OGC n.d.) is possible to process heterogeneous data source (Díaz et al. 2009) Is possible to access to a data provider with a WFS service and use these layers as an input for a WPS to perform, for instance a forest fire analysis getting the spatial evolution of the forest fire.

Sharing spatial information requires the use of standards to harmonize *"the discovery and exploration crossing jurisdictional boundaries" (Granell et al. 2009)*. A forest fires can spread along a territory crossing boundaries and affecting to different governments. An efficiently access to cross-border data related with forest is necessary to improve the fight against forest fires. Only the use of standards can guarantee the interoperability of the different data providers (Bejar et al. 2005).

2.3 Previous experiences in forest fires management systems

This points review some approaches to develop and emergency SDI. The previous experiences are focus in building a corporative SDI. European initiatives in emergency management are focus on solve interoperability problems of emergency and forest fires.

2.3.1 Spanish experiences

The forest fires in Spain as was comment in the chapter 1 , has become a professional task. A forest fires can affect to a big area and many times are going on more than two fires at the same time. In this context a huge number of people is working at the same time in different locations. These fires must be located to deliver the firefighters squads. Movement monitoring of all the people involved on it is required, as well as the evolution of the fire.

"La Junta de Andalucia" has developed a system, SIGDIF (de Sarriá Sopeña et al. 2007), to manage the forest fires emergencies. SIGDIF is based on some subsystems dedicate to some specific task, SIGDIFstructure is show in figure 2. SIGDIF has one subsystem to simulate the forests fires based on FARSITE. SIGDIF has access to different layers coming from the data base from the "Junta de Andalucia". Layers can be use for FARSITE to simulate forest fires evolution. SIGDIF has system to manage the human resources involve in forest fire.

The problem of SIGDIF systems is how to deliver the information to people locate in the forest. The GPRS coverage has a lot of gaps. Another one is it design for decision makers in a forest fires, leaving out the people below this line of command.

Another example of forest fires is SIGIF from the "Generalitat Valenciana" (Vicente López & Poyatos Hernandez 2007) This system is focus in the prevention and surveillance of the forest fires. The system allows a decentralized access to spatial and meteorological data. SGIF can carry on fire simulation and location of forest fires. SIGIF somehow accomplish the Open Geospatial Consortium (OGC) standards to integrate forest fires data into a SDI. The figure 3 show the structure of SIGIF.

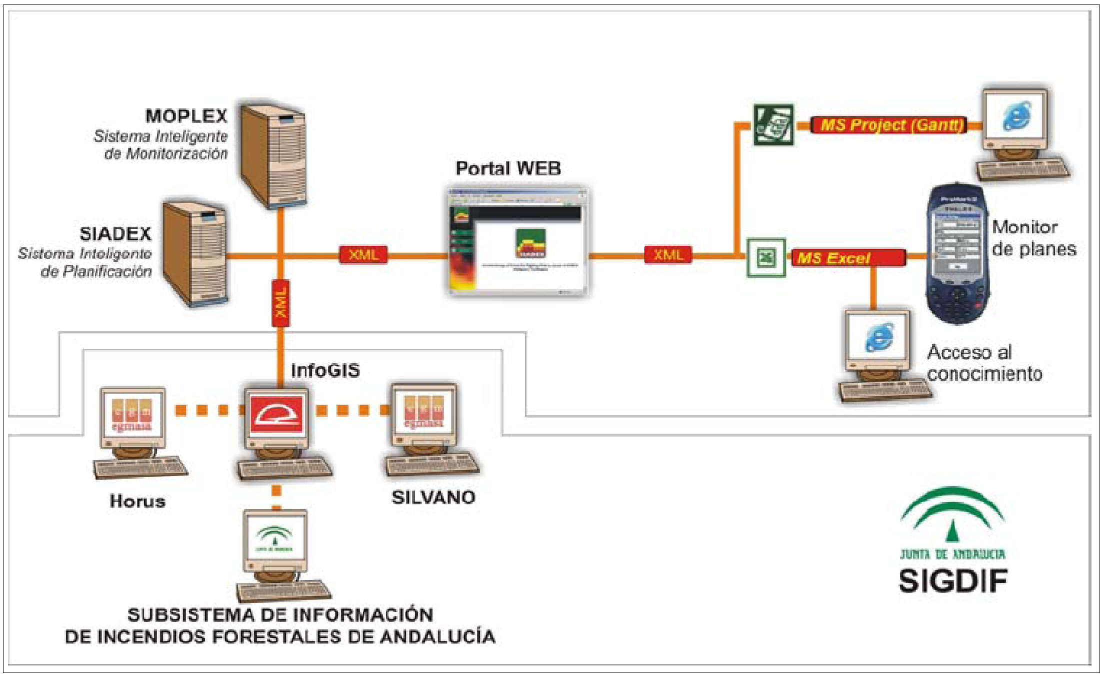

Figure 2: Structure of SIGDIF. (de Sarriá Sopeña et al. 2007).

SIGDIF and SIGIF systems simplify all the complexity of the forest fires management. Their structure centralize all the relevant spatial information for forest fires. SIGDIF and SIGIF systems have a lack of ability to deliver information to final user when user is in the middle of the forest fighting against the fire. Forest fires technicians, those that has a good access to an Internet connection, from their office or a mobile unit, are the ones that can appreciate the goodness of those systems. Whereas others only can appreciate that in case of prevention or surveillance. These systems are usefulness in extinction where the decisions and the accessibility to the information should be fast and efficient.

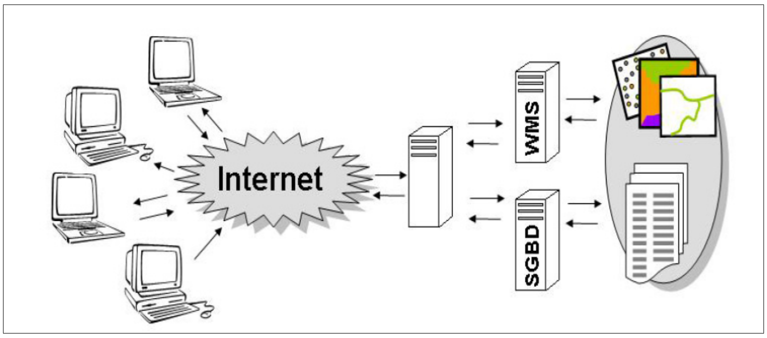

Figure 3: Structure of SIGIF. (Vicente López & Poyatos Hernandez 2007).

The challenge in a system for forest management base in the distribution of the spatial information is the interoperability of the different systems. Inside this issue is the data interoperability. SIGIF is doing an effort to use OGC standards, but the information is still corporative, not accessible outside. The fire data will be difficult to integrate with other systems to be use in other autonomous communities and vice versa.

2.3.2 Orchestra project

The European Union has worked in the orchestra project. It's main goal is to improve risk management. The key goals related with the spatial information are the as follow (Annoni et al. 2005):

- To design an open service-oriented architecture for risk management that links spatial and non-spatial information services. In this context Orchestra will provide input to INSPIRE and GMES.
- To develop the service infrastructure for deploying risk management services.
- To provide software standards for risk management applications. In particular, the facto standard of OGC and the standards of ISO and CEN are envisaged to be influenced.

the design of user requirements in the Orchestra architecture is part of the process and ontology is in the background of the data sharing, accessibility and usability. The OGC standards like WMS, WFS.., enable spatial information sharing, but doesn't ensure the understanding of the same concept coming with a different name. Annoni (Annoni et al. 2005) propose ontology to solve the problem. Ontology will not be necessary if all the database are using the same semantic, the same database structure and design, this ideal situation of uniformity, differs from spatial information reality.

The orchestra project is focus in technology problems, as was mention before and not in the final user requirements. In forest fires the people direct involve in fire extinction or preventions, develop the 90% of his job in the countryside. If th technology doesn't cover the user requirements, it will be not use, even if technology problems are solved. The technological point of view of this project doesn't take into account user requirements regarding to what spatial information is need in each situation for each user.

2.3.3 MEDSI project

MEDSI is an EU sponsored project, intends to overcome the interoperability issues (Rocha et al. 2005) Figure 4 shows the organizational view of MEDSI. MEDSI is design to sharing spatial information for crisis management. MEDIS has some utilities like the possibility to visualize the geographic information displayed by other agents and save a personalized view. Symbology is other issue for MEDIS, not all the organizations are using the same symbology, moreover if them depend on different governments or states. Symbology should adapt to the user requirements to have better understand of the spatial information. MEDIS try to solve the problem with the Styled Library Description (SLD). The problem is that to personalize the symbology for each agent is needed a previous agreement with the semantic of each spatial database. MEDIS committed to use the standards propose by OGC to ensure a real interoperability between the actors in an emergency (Rocha et al. 2005) see figure 5.

MEDSI go on a step more close to the user requirements than ORCHESTRA, trying to facilitate the understanding of the spatial information in an emergency context. Therefore doesn't check the user requirements regarding to the spatial information like the ORCHESTRA project.

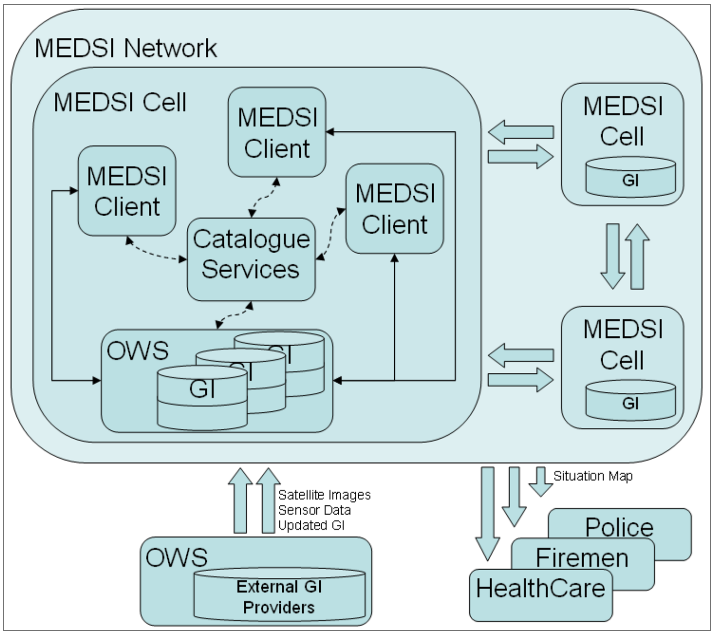

Figure 4: Organizational view of MEDSI (Rocha et al. 2005)

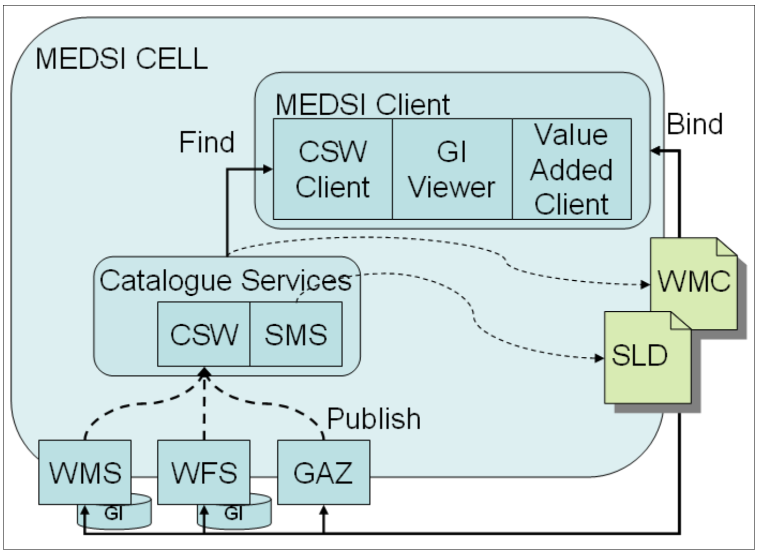

Figure 5: OGC Web Services at use in MEDSI (Rocha et al. 2005)

3 GIS CHALLENGES IN FOREST FIRES MANAGEMENT

The spatial information for being use in an emergency environment like a forest fires have some challenges that haven't been got until know. This challenges are focus in ensure a real and useful spatial communications, interoperability challenges, cell phone signal coverage and social participation. This GIS challenges are described focusing in the forest fire user requirements.

3.1 Interoperability challenges

The interoperability of spatial information“*aims to ensure a process that will allow for the use of data information and services across organizational boundaries”* (Abdalla et al. 2007) This definition is focus in the base of the problem. This problem is the standalone applications and databases which are design to work inside only one organizations.

In an emergency response *“GIS can provide the information to the users, the right information at the right time and at the right place that is easy to access and use”(Kevany 2008).* In an emergency there isn’t too much time to think. When faster is provided the information faster will be solve the problem. As we have seen in the chapter 2, nowadays the information can be access across a SDI, but is still a challenge discover and filter the information, give an alert according to the necessities, interchange the information with a different government or regions, and have access to the same data at the same time by users from different decision-maker levels (Abdalla et al. 2007). Decision-maker has to decide the next movement with the information it can access at the moment. Other information not discovered or not updated before or during the forest fire does not exist.

Access to the information coming from different regions or institutions is crucial for forest fires management. A forest fire can cross a regional border (Ministerio de Medio Ambiente 2006) whereas the spatial information has a challenge to be understand by other emergency staff working with a different spatial emergency system (Estirado Gómez & Pedro Molina 2005). Fires can cross political borders with any problems, spatial information not.

“The availability of the data doesn’t mean that the usability of the data is guaranteed”(Kevany 2008) The spatial data from different sources must speak the same language, or at least understand each other to be use as one. SDI has solved the problem of interoperability but not yet the semantic problem between data (Xu & Zlatanova 2007) Data usefulness to be use like an impute for another forest fires management system if don’t understand the meaning of it. Pundt (Pundt 2008) proposed to build an ontology like a guarantee of intercommunication between different emergency systems. By definition “Ontologies are used to capture knowledge about some domain of interest. An ontology describes the concepts in the domain and also the relationships that hold between those concepts”(Matthew Horridge et al. 2007). The words relationships and concepts are the clue of the understanding between two or more systems. There has been some approaches to for reaching semantic interoperability, and search engines based on ontologies (Scholten et al. 2008)hose approaches has been done to solve a problem of common understanding of the data concepts.

3.2 Collaborative tools for data acquisition and maintenance

The collaborative GIS has two scales, the physical scale and the social scale, the public sector provide information in collaboration (national SDI) until some physical scale. The citizens and public workers in municipalities or relative small regions like the firefighters have more interest about what is happening in the surroundings and the information close to them, at local scale.

The regional government of the Valencian Community is giving subvention to develop local plans for preventing wildfires (Conselleria de Medi Ambient, Aigua, Urbanisme i Habitatge. Generalitat Valenciana 2009). This plans are created at local scale. Thisi plans requires a survey of vegetation, water points, recreational areas, risk areas, and very valuable. This information is not translated to the regional SDI, therefore forest fire management systems haven’t got access to this information.

An open emergency management systemt could help municipalities to upload the spatial information to the system and update it. This is crucial in case of forest fire or preventive tasks. An example could be The city of Vancouver. The city is well coordinated with NGOs represented in the City Emergency Operation center, allowing its direct involvement in the decision-making process as well as the facilitation to their data access in an emergency environment (Abdalla et al. 2007).

Public participation GIS (PPG) or Volunteer Geogrpahic information (VGI), can help to improve the locale scale data quantity and up-to-date it. This information perhaps doesn't have to be highly accurate or complex (Longley et al. 2005). Therefore is the only way to have some information at this level of resolution. The effort in time and money to develop an official data at this scale for non automatic data collection or remote sensing, is impossible to maintain by the public sector (Davis et al. 2009) "*There is a call for a more interaction, to support cooperation, discussion and community building*" (Davis et al. 2009). The Internet social networks, has show the potential to communicate news and events between people (White et al. 2009). Social networks could help to bouild a social SDI.

In a forest fire emergency; getting the information faster than the spread of the fire is a key issue. The availability of the information in the first stages of fire event is very important. Having some information despite that information is not officially reviewed, gives to the forest fire decision maker an advantage. The VIG can help to improve the quantity and the scale of data acquisition or up-to-date. The maintenance and quality filtering of these data is need to ensure a minimum usability for forest fires emergencies (Davis et al. 2009). The public employees can check the quality of the most important contributions of the volunteers regarding to the forest fires emergency, like for instance a bad sate of a forest road for truck driving, or water tank level.

The mobile GIS will be an important issue for the collaborative and public participation GIS. The mobile GIS is not the only way to provide spatial data to the emergency data base. The data can be survey using paper maps or hand GPS and then georeferenced and upload to the database using a web portal.

The public information for emergencies events is an ambiguous topic in a forest fires. Curios people moving trough the forest during a wildfire is not helpful. However there are cottages, farms agricultural lands. The owners have the right to know if his property has been affected by the fire. A forest fires SDI open and friendly accessible can be use to inform the press (Kevany 2008) with the affected area by the fire and other relevant information.

3.3 Visualization of geographical information for forest fires

The forest firefighters are using paper maps in an emergency to move in the terrain and to locate a fire and its limits. The accuracy of this method depends on the experience and the training of the staff. The fast change in the forest fires behavior or emergency situation doesn't allow to deliver up-to-date paper maps (Kevany 2008). Digital spatial information can contribute with the benefits of update, information to the user requirements and be more compatible with the environmental changing conditions during the emergency (Scholten et al. 2008).

The user interface must be different depending on the device use to visualize the spatial information. A flat screen of 22" on a desktop computer is different than a pocket PC with a screen of 5" or a cell phone with a smaller screen. User applications also requires some specific tools depending of his tasks. A director of the extinction has different requirements than a firefighter or emergency truck driver. Different actors needs different user interfaces (Scholten et al. 2008).

According to some suggestions from the chief of firefighters forest section of Castellon (Consorci provincial de Bombers de Castelló) Fernando Kinderan; "too much spatial information displayed at the same time is not helpful and could distract your attention out of the important issues". The visualization of the spatial information should be as simple as possible in order to do not contribute to information misunderstood.

Predefined icons for visualize the emergency information is an important issue. The use of different icons depending on the provider requires an extra effortt to interpret a map. (The Homeland Security Working Group n.d.), has proposed a standard icon collection for emergency. The use of a common symbology needs the agreement between organizations. Rocha (Rocha et al. 2005) have proposed a SDL service to adapt the symbology to each organization.

3.4 Problems of signal coverage for network communication

The information delivered in an emergency is performed via telephone (Scholten et al. 2008). Despite that in a wildfire some of the information is delivered personally. One communication problem in forest fire is the limitation in the mobile phone signal coverage or another wireless technology. This is a problem to update the data or download it when is needed. To solve these problems there are two options:

- Deploy antennas for the emergency event.
- To develop systems to transmit and receive the data when the device has coverage and work off-line whereas there is no coverage.

Both solutions are compatible. The deployment of new antennas don't guarantee the 100% of coverage in the emergency location, moreover if it is a forest fire in a mountainous terrain. The possibility of off-line work should be develop. The off-line work is an alternative when the device has no coverage. This alternative require an automatic download and upload the data when the coverage is guaranteed, without the user intervention. The squads working in a specific area could have data preloaded in the device. When the first alert is transmitted basic information download could start.

4 SURVEY EVALUATION APPROACH FOR FOREST FIRES SPATIAL INFORMATION USERS REQUIREMENTS

The methodology described by (Cea D'Ancona 2004) has been taken as a guide to develop this section. This survey has been design to know the spatial information and management requirements on forest fires. Chapter 4.1 defines the survey goals. The questions have to be design according some criteria, described at chapter 4.2, that mus follow the goals of the survey. Finally the survey questionnaire form is build following the survey criteria, chapter 4.3. Once build the questions the survey must be carry on. The way this is done is described in the chapter 4.4.

4.1 Survey goals

The aim of the survey conducted is to discover the needs about the spatial technologies inside the forest fires community. It is important to know how people is managing and using the spatial information. If they are using the technology by their own (self-knowledge), if they have some knowledge or even a different ways of using the spatial information depending on the professional background.

The communication of the information is very important in forest areas. In the forest and mountains most of the time is not possible to have access to Internet or even cell phone coverage. Improving information delivering in this context is a challenge. The survey can help to know how is the communication issue.

The goals for the survey are the next ones:

- GIS knowledge of people involved in forest fires on understanding its importance.
- Geographical Information need in the different organizational levels involved in the forest fire management.
- How spatial information is managed regarding to forest fires.
- How ensure a real and useful communication between the firefighters and

decision makers.

- Useful geographical alerts in forest fires

This goals will help to fix the challenges into a reality inside the ISD issue. The survey will contribute to know the actual situation about spatial information in a forest fires management context. The survey will help to know how the information is delivered, which is the essential information and which is secondary.

4.2 Survey criteria

This point describes which are the criteria to make the survey questions. The answers of the questions must reach the survey goals enumerate in chapter 4.1. The criteria are the next one:

- Knowledge level of spatial information concept

This concept is addressed to know if the user is able to discriminate which information has a direct relation with the terrain, geography and which doesn't. This criterion is measured with a simple question to discriminate what is spatial information from what isn't.

- Ability to understand a map

This evaluation criterion has a strong relation with the previous one. Here is more focus in the ability to understand the information given in a map or which spatial information visualization way is more comprehensible. This criterion is measured with respondents skills to interpret a map.

- GIS applications use in their work

This criterion is focused on the applications used for data visualization. GIS tools familiarity is very important to know if the spatial data can be managed properly. GIS applications use is measured with direct questions about the knowledge of professional GIS tools and non professional.

- Format of geographical information

This criterion is focused on the way the user work with the spatial information use along his/her job related with forest fires. How is managed this spatial information in a wildfire, during the surveillance or silvicultural works to prevent the forest fires. This is measured with a direct question, which map formats a respondent manage in their work?.

- Useful spatial information and available technology to have access to it

This criterion has a strong relation with the previous one. It is important to know which information is been use and the information is not possible to use because is unavailable or maybe the user don't have an appropriate technological knowledge to manage it or doesn't now the existence of the data. This is measured asking which information a respondent think is interesting and, how often access to the national and regional SDI.

- Use of technology devices for communication in forest fires context

Not all the users have access to a desktop computer, laptop or pocket-PC. Some users only have access to a cell phone to communicate with the operational center or with the colleges. Depending on the device and display size, spatial information should be delivered in an effective way to ensure a properly visualization.

There are some ways to communicate the information. Know how the people communicate each other, could help to design a communication network. This is going to be measured asking which devices are being use. The technology suggested for the survey are the next ones:

  - Email

  - Cell phone
  - Radio
  - PDA or smart-phone

Time available to communicate and to interpret the message given, determine how many time the user spent talking, writing to colleges to transmit the information. Time is going to be measured in percentage of the total working time using a communication thecnology.

- Time available to look at the spatial information

Different actors has a different task. Depending on the task being developed the time available to visualize the spatial information could be more or less. It is not the same working in a preventive task when the user has a lot of time to visualize an analyze spatial information than a firefighter working in a fire front-line with almost no time to look at a map displayed in cellphone screen. This criterion is going to be measured as a percentage of available time to look at spatial information.

- Frequently alerts in a forest fire

Which is the information transmitted in a forest fire? Which is the relevant information regarding to the forest fire that has to be communicated to other colleges? Are the alerts transmitted related with the space?. These questions are important to determine which information is critical regarding to the forest fires and to know if the spatial technologies can help to improve the communication between actors. The criterion is going to be measured as an open question.

- Size of the surveying

There was not a fix size of the survey. Potential respondents were those involved in the forest fires management context. The questionnaire was available on Internet, and an email was sent to the people having jobs related with forest fires and professional collectives, as forestry engineers or firefighters.

4.3 Survey creation

The questioner has been written down in Spanish. In this point is going to be described how surveys questions has been designed to reach the goals described in the chapter 4.1. Questions design are following the criteria describe in the chapter 4.2 to measure the answers. Potential population of the survey is all the people having a work related with the forest fires fighting or prevention. Below are described the goals and related questions in the survey.

The preliminary questions are design to define the universe of the survey. First questions divides the respondents into 6 age groups:

- Less than 20 years
- Between 20 and 30 years
- Between 30 and 40 years
- Between 40 and 50 years
- Between 50 and 60 years
- Over 60 years

Second question ask about respondents gender. Third question ask about respondents job. The jobs described in the questioner are the ones with a relation with a forest fire issue. Third question also have the other option if respondents have a different job than the predefined ones. Predefined jobs in question 3 are:

- Rural emergency squads or similar activated few months per year
- Rural emergency squads or similar activated whole the year
- Firefighters
- Helicopter transport squads
- Prevention technician
- Extinction technician

- Volunteers

The next survey question are described according to the goal are reaching.

- **GIS knowledge of the people involved in forest fires and understanding of its importance**

Survey question 4. The respondent can discriminate in question 4 among spatial concepts, non spatial concepts (festivity calendar) and concepts with non clear relation with the space (traffic information). The question ask is the next one:

¿Which of the next options do you think have a relation with the space and the territory?

Mark as many cells as are need to answer properly

	Town planning, roads and means of communications
	Vegetation
	Weather forecast and climatology
	Traffic information
	Festivity calendar
	Mountains altitude

Survey question 5. This questions is design to know the if the respondents are able to understand a topographic map, figure 6. The question ask is the next one:

¿Which is for you the geographical feature mark with a red line?

	A Valley or a ravine
	A peak
	Flat area
	A ridge

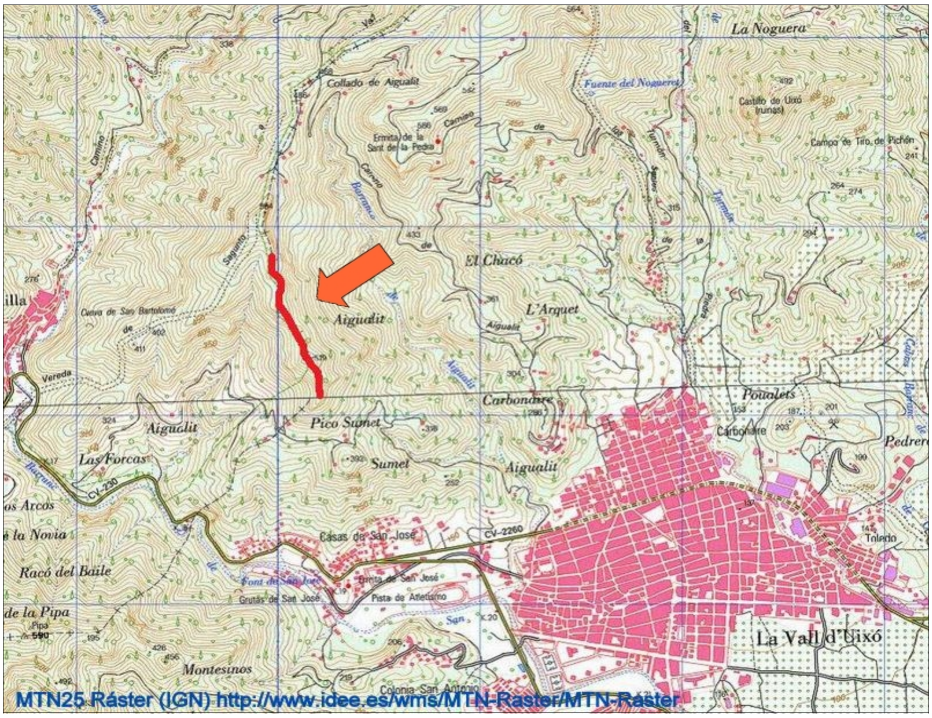

Figure 6: Topograhic map MTN25 Raster. Source, www.idee.es/wms/MTN-Raster/MTN-Raster

Survey question 6 is similar to the question 5 but in this case the respondent is looking at 3D terrain model, figure 7. The aim of question 5 and 6 is to ascertain which representation of the terrain has less problems to be interpreted by the respondents. The question ask is the next one:

¿Which is for you the geographical feature mark with a red line?

	A Valley or a ravine
	A peak
	Flat area
	A ridge

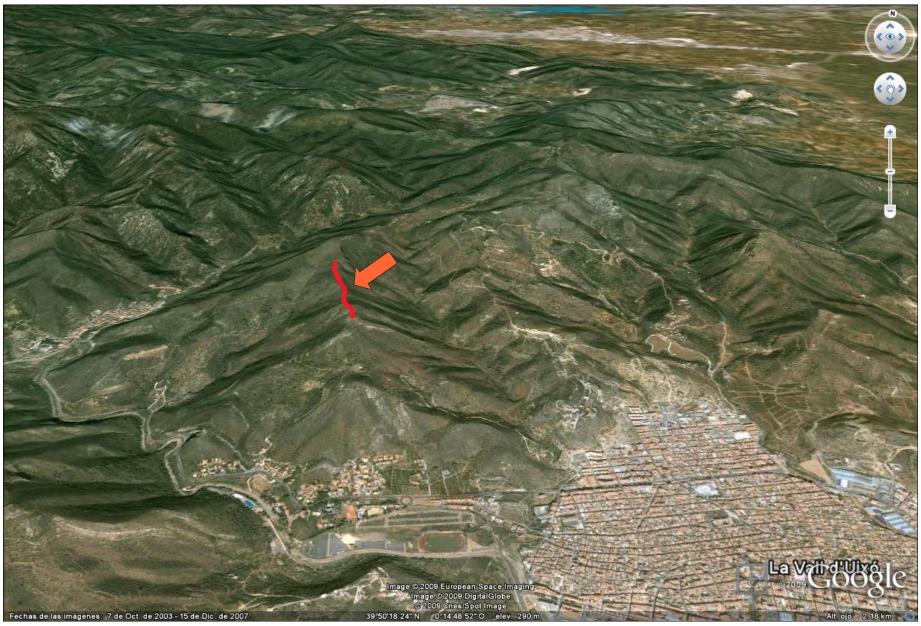

Figure 7: 3D Google Earth view of the same area of figure 6.

Survey question 7. This question is focus in interpretation of a common simple map without the help of a legend, figure 8.

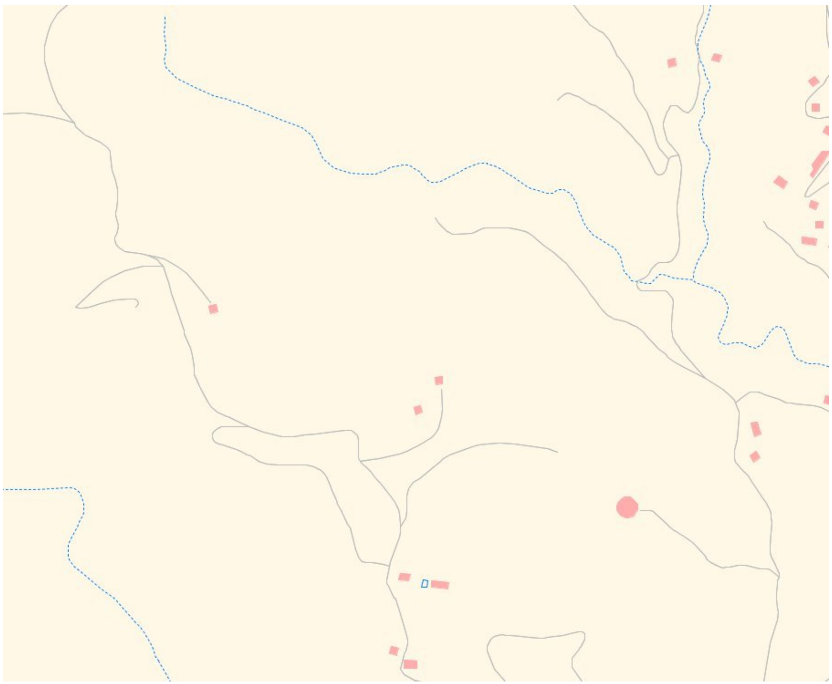

Figure 8: Base map of Spanish SDI. Source http://www.idee.es/wms/IDEE-Base/IDEE-Base

The question ask to the respondent is the next one:

¿Which is for you the meaning of the next lines and polygons?

Mark with an X your election

	It is a road	It is a river or water course	It is a building	Doesn't have any meaning for me
Blue lines				
Grey lines				
Pink lines				

- **Geographical Information need in the different organizational levels involved in the wildfire management**

Survey question 13 ask about which spatial information the user will include into a personalized map. The question is the next one:

Evaluate the following information regarding to your work related to forest fires, for its inclusion on a map. Imagine that the map will be prepared for personal use.

Put an X where appropriate

	I don't have an interest	Interesting but not for forest fires or prevention	Interesting	Very interesting	Essential
Topography					
Vegetation/fuel models					
Roads					
Water point					
Weather and climatology data					

Survey question 14 is similar to the question 13. Question 14 ask for evaluate whic information is interesting and which not. Answers could be different because in this case the respondent is not thinking in this information like one to be display in a map. It is just one information could be interesting. The survey question is next one:

Evaluate the following information according to its interest or importance in a forest fire. Put an X where appropriate.

	I don't have an interest	Secondary	Valuable	Very valuable	Essential
Location of the fire front					
Future location of the fire front					
Vegetation in the fire and surroundings					
Roads state					
Estate of the water points					
Location of the inhabited points					
Location of the firefighter units					
Location of the surveillance units					
Forest fires types(surface, canopy, high density or low density)					
Actual climatological conditions					
Weather forecast					

- **How is managed the geographical information regarding to the wildfires**

Survey question 8 aims to know the familiarity of the respondents with GIS non professional tools. The survey question is next one:

¿How often do you use applications like google earth, google maps, or viamichelin,...?

	Every day
	Once a week
	Once a moth
	Once a year
	Never

Survey question 9 is the same as 8 but asking about the user familiarity with professional GIS tools. The survey question is the next one:

¿How often do you use GIS software like GVSIG, ArcGIS, Miramon or others?

	Every day
	Once a week
	Once a moth
	Once a year
	Never

Survey question 10 is design to measure the use of WMS services in forest fires context. WMS services of environmental issues are available across the regional SDI. The survey question is the next one:

¿How often do you use web map services, using map visualizers or WMS* links from your region or state ?

*The WMS links allow to download georeferenced images to be visualize en some GIS applications, and is possible to overlay layers from different sources.

	Every day
	Once a week
	Once a moth
	Once a year
	Never

Survey question 11 is design to know which kind of maps the respondents use. The different answer options have an increasing knowledge of GIS tools. The survey question is the next one:

In your work related with the forest fires ¿Which maps do you use?

Select one or more options.

	Topographic maps
	Self-done maps or sketch maps
	Available maps on a web or WMS service
	I don't use maps

- **How ensure a real and useful communication between the firefighters and decision makers.**

Survey question 12 is design to measure how many time a respondent have to look at a map. When less time have a respondent to look at a map, less time have to analyze it. The survey question is the next one:

¿How many time do you have in your work related with forest fires to look at the maps?

	Less than 5 minutes
	Between 5 y 30 minutes
	I work constantly with maps
	I don't have time
	I have time but I don't use maps

Survey question 15 is design to know which are the devices use in forest fire context to communicate each other. The survey question is the next one: In your work related with forest fires ¿Which media communication devices do you use and how long? Put an X where appropriate.

	I don't use it	10% of the time	25% of the time	50% of the time	More than 50% of the time
E-mail					
Pocket-PC or smartphone with Internet access					
Cell phone					
SMS					
Radio					

- **Useful geographical alerts in forest fires**

Survey question 16 ask about which are the alerts the respondent receive. This question contribute to have a list of the important issues communicated in a forest context. The survey question is the next one:

Could you write downs, ¿What alerts or advices you receive related with forest fires or preventive works or surveillance?

Survey question 17 ask about which are the alerts a respondent communicate. This question contribute to have a list of the important issues

communicated in a forest context. The survey question is the next one:
Could you write downs, ¿What alerts or advices you communicate related with forest fires or preventive works or surveillance?

4.4 Survey procedure

Most of the measurable variables are found out indirectly using a questionnaire. A questionnaire should be clear, respondent don't has to be confuse with ambiguous questions, the choice in the answers should be comprehensible and the respondent should be comfortable with the length and the privacy of the questionnaire (Rea & Parker 2005). This survey is going to be web-based, the length of this survey is targeted in less than 15 minutes.

The survey was done using Google docs form (http://docs.google.com) and was uploaded in this webpage http://www4.uji.es/~al120248/encuesta/. All the records were stored in the Google docs spreadsheet for its posterior analysis

5 SURVEY RESULTS AND ANALYSIS

The questionnaire was open in Internet from the first of November to the 23 th of December. In this period a total of 124 people have filled the questionnaire The first person filled the questionnaire the first of November and the last one filled in the 9 th of December.

5.1 Users

Most of the respondents are male. Figure 9 and table 1 show the gender distribution of the survey. Most of the people is between 30 and 40 years old, table 2 shows the age distribution.

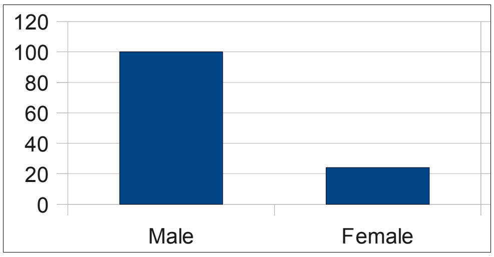

Figure 9: Sex of the respondents to the questionnaire. Values are in percentage

Sex of the respondents	Number	%
Male	100	80.65
Female	24	19.35

Table 1: Sex of the respondents to the questionnaire

Age range of the respondents	Number	%
Between ٢٠ and ٣٠	٣٣	٢٦.٦١
Between ٣٠ and ٤٠	٦٢	٥٠
Between ٤٠ and ٥٠	٢٣	١٨.٥٥
Between ٥٠ and ٦٠	٦	٤.٨٤
More than ٦٠	٠	٠
Total	١٢٤	١٠٠

Table 2: Age of the respondents to the questionnaire

The respondents can specify a different job than the predefined ones in the survey. The table 3 shows the work groups for the analysis. The technicians group is the bigger among the respondents.

Work of the respondents	Number	%
Firefighters	1	0,81
Rural emergency squads (long duration)	2	1,61
Rural emergency squads (short duration)	7	5,65
Environmental rangers	13	10,48
Helicopter transport squads	19	15,32
Prevention technician	40	32,26
Extinction technician	42	33,87
Total	**124**	**100**

Table 3: Work of the respondents to the questionnaire

5.2 Results and Analysis

The analysis of the survey is going to be developed question by question, for a better compression of the answers. Respondents are going to be divided in job groups for the analysis. The job groups for the analysis and its abbreviation for the analysis are show in table 4. Only one firefighter has done the survey, therefore the fire fighter has been included in the extinction technician group. The two groups of rural squads has been joined in on single group because the short number of respondents. The Environmental rangers is a new non predefined group it has been created after question 3 results analyses.

Works related with forest fires	Code for the analysis
Firefighters	ET
Rural emergency squads (long duration)	RL
Rural emergency squads (short duration)	RL
Helicopter transport squads	H
Extinction technician	ET
Prevention technician	PT
Environmental rangers	ER

Table 4: Surveys works reclassification for the analysis

Net graph likes figure 10 explains the answers divided in job groups. The shape of this graph is like a spider net. The net center is the 0% values and the last ring represent 100% value. Values for the groups are connected with a line. When more narrow is the area more similar are the respondents answers. With this graph is easy to notice the answers distribution and if there is a clear predilection for one of the answers (Chambers 1983).

- **Analysis of the question 4** ¿Which of the next options do you think have a relation with the space and the territory?

Spatial information concepts is similar between all the groups as we can see in the figure 10 and table 5. Festivity calendar and traffic information are the two ones which respondents don't think have a relation with space. The other 4 concepts have a direct relation with its work.

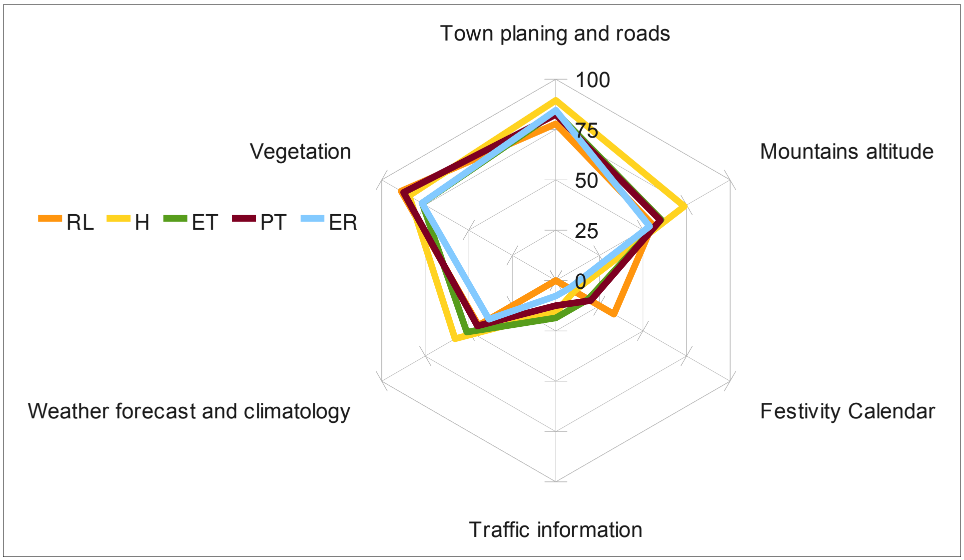

Figure 10: Percentage value of the concepts that the respondents think have a relation with the space.

Roads, vegetation and mountain altitude have the biggest percentage of election. Those concepts use to be represented in the topographic maps. Weather forecast, climatology and mountains altitude, has a direct relations with the space but this relation is not appreciated as strong as vegetation, town planning and roads by most of the respondents.

Opinion concepts realted with the space (%)	Global	RL	H	ET	PT	ER
Town planing, roads and means of communication	83.87	77.78	89.47	83.72	82.5	84.62
Vegetation	82.26	88.89	84.21	76.74	87.5	76.92
Weather forecast and climatology	48.39	44.44	57.89	51.16	45	38.46
Traffic information	13.71	0	15.79	18.6	12.5	7.69
Festivity Calendar	17.74	33.33	10.53	18.6	20	7.69
Mountains altitude	61.29	55.56	73.68	60.47	60	53.85

Table 5: Percentage of the concepts that the respondents think have a relation with the space.

- **Analysis of the question 5 and 6** ¿Which is for you the geographical feature mark with a red line?

This question request to the respondent to identify the geographical feature of the figure 6 and 7. Most of the respondents identify correctly which is the geographical feature represented in the view. Eleven people has confused the geographic feature, look at table 6. Nine people chose a valley as a right answer. Only one that chose a flat area, looking at the topographic map, chose the right one looking at the 3D view. Only 3 didn't choose the right answer when looked at the 3D view, look at table 7. Only 2 persons chose the correct answer looking at the topographic map and the wrong answer looking at the 3D view.

Feature in the topographic map	Total
A valley or a ravine	٩
A peak	٠
Flat Area	٢
A ridge	١١٣

Table 6: Geographical feature the respondents think is represented in the topographic map.

Feature in the ٣D map	Total
A valley or a ravine	٠
A peak	٢
Flat Area	١
A ridge	١٢١

Table 7: Geographical feature the respondents think is represented in the 3D view.

A 3D view of a region was interpreted with less error than the same region in a topographic map. This misinterpret of the geographical feature could represent the difference in the task success assign to the firefighters or any other fire professional. Despite that the 91% elections looking at the topographic map were right.

- **Analysis of the question 7.** ¿Which is for you the meaning of the red and blue line and the pink polygons?

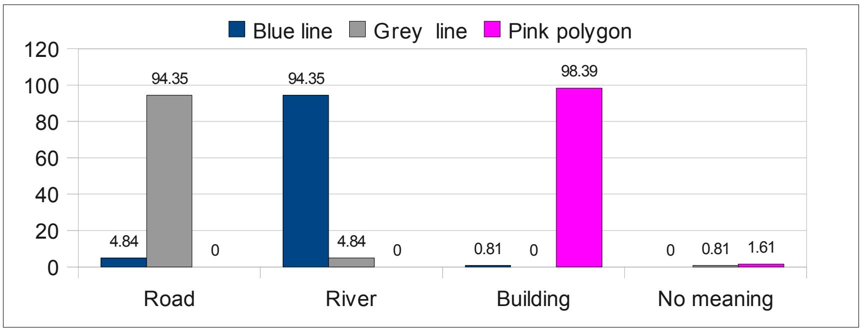

Figure 11: Which is the meaning of the color's shape for the respondents. Values are in percentage

The respondents after looked at figure 8 chose the answers show in the figure 11. More than 90 % of the respondents chose the correct answer about the meaning of the shapes. That give us the clue to use the usual colors and shapes to represent the different features. Even if there isn't a legend to interpret the features the user can interpret correctly the meaning of the features, when those features are represented in a standard or common way.

- **Analysis of the question 13.** Evaluate the following information regarding your work related to forest fires, for inclusion on a map.

Figure 12 and table 8 shows that weather information is more important for people involve directly in forest fires extinction (environmental rangers, extinction technicians and helitransport squads) than for the prevention technicians. Rural squads are the ones with less interest for the environmental data, despite they are working in the extinction's first line. It is curios that less than 50% of the respondents chose the weather data as essential, despite the weather is important for the behavior of the forest fire (Benson et al. 2009).

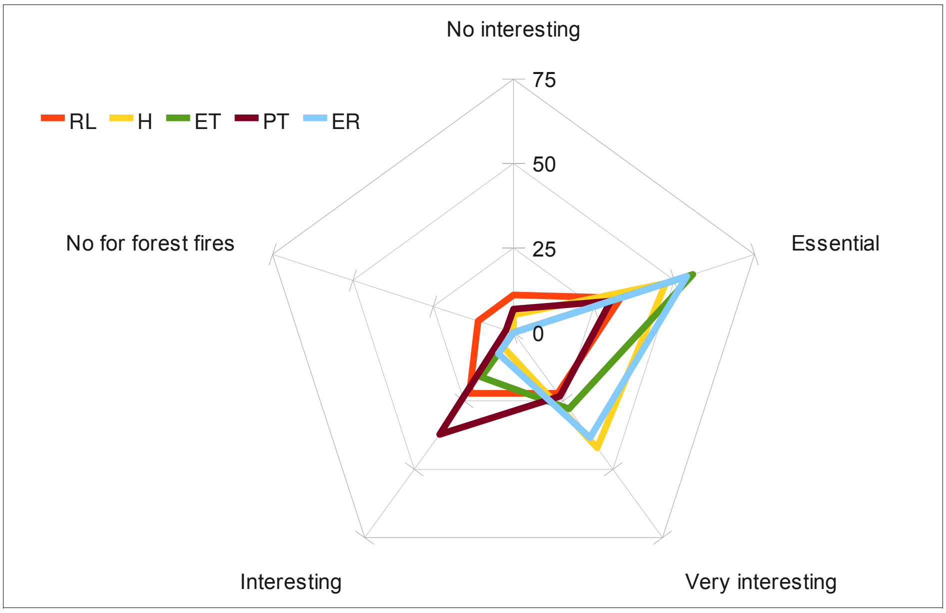

Figure 12: Value of the weather data for the respondents. Values are in percentage.

Value of weather (%)	Global	RL	H	ET	PT	ER
No interesting	3.94	11.11	5.26	0	6.98	0
No for forest fires	1.57	11.11	0	0	2.33	0
Interesting	21.26	22.22	5.26	16.28	37.21	7.69
Very interesting	29.13	22.22	42.11	27.91	23.26	38.46
Essential	44.09	33.33	47.37	55.81	30.23	53.85

Table 8: Value of the weather data for the respondents. Values are in percentage.

Figure 13 and table 9 explains the vegetation importance for forest fires. The groups think this information is essential or very essential. Is not the same a bush vegetation fire than a fire in a forest with a canopy cover of 75%. It is curious that the helitransport squads give more value to weather data than to the vegetation data. This could be because the weather conditions are important for the helicopter fly (Martínez Ruiz 2000). Vegetation is a background information for task planning in prevention (Velez Muñoz 2000b) and extinction (Velez Muñoz 2000a).

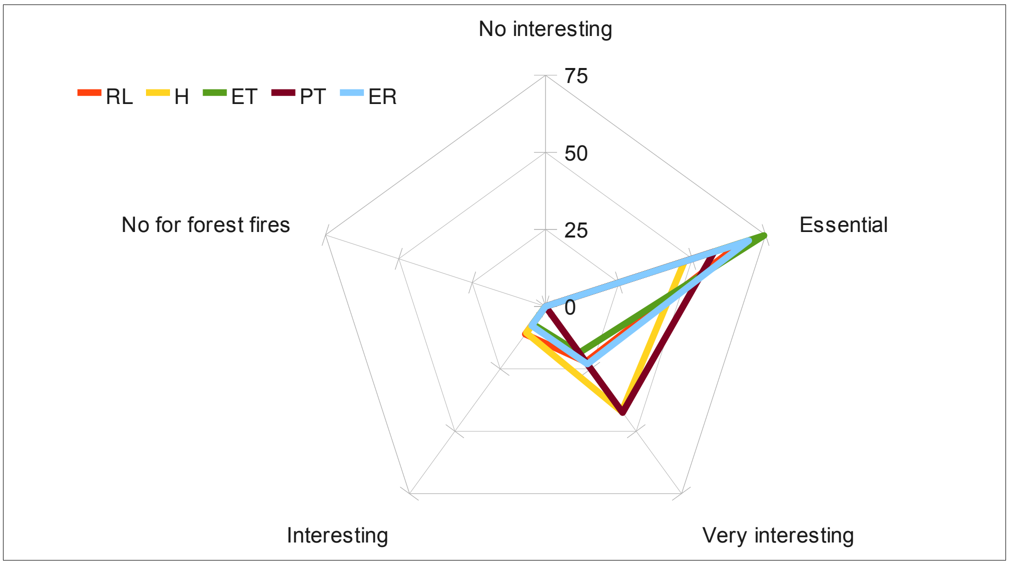

Figure 13: Value of vegetation and combustible data for the respondents. Values are in percentage

Value of vegetation/CM (%)	Global	RL	H	ET	PT	ER
No interesting	0	0	0	0	0	0
No for forest fires	0	0	0	0	0	0
Interesting	5.65	11.11	10.53	6.98	0	7.69
Very interesting	30.65	22.22	42.11	18.6	42.5	23.08
Essential	63.71	66.67	47.37	74.42	57.5	69.23

Table 9: Value of vegetation and combustible data for the respondents. Values are in percentage

Figure 14 and table 10 show the answer for the topography importance for the respondents. This information is essential for all the groups. It is different work in a flat area than in a peak, crest or ravine. It is curious that the helitransport squads have the lowest essential value, this could be because they get the fire location by air.

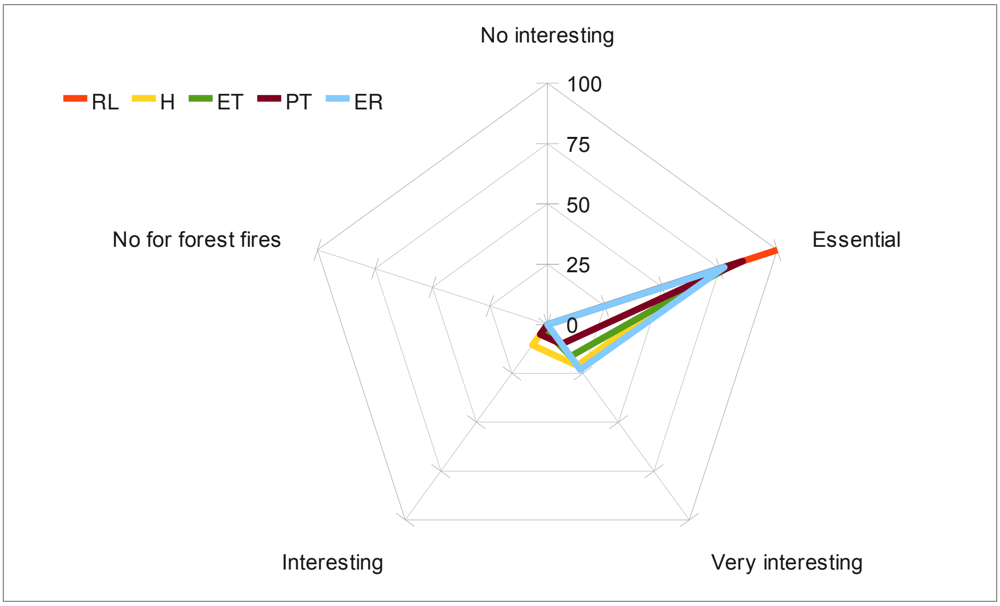

Figure 14: Value of topography data for the respondents. Values are in percentage.

Value of topography	Global	RL	H	ET	PT	ER
No interesting	0	0	0	0	0	0
No for forest fires	0	0	0	0	0	0
Interesting	4.03	0	10.53	2.33	5	0
Very interesting	14.52	0	21.05	16.28	10	23.08
Essential	81.45	100	68.42	81.4	85	76.92

Table 10: Value of topography data for the respondents. Values are in percentage.

Figure 15 and table 11 show the value of water points for the respondents. The answers are very similar to the topographic information. Indeed this information facilitates the location of the water points and the route to fill the vehicles tanks.

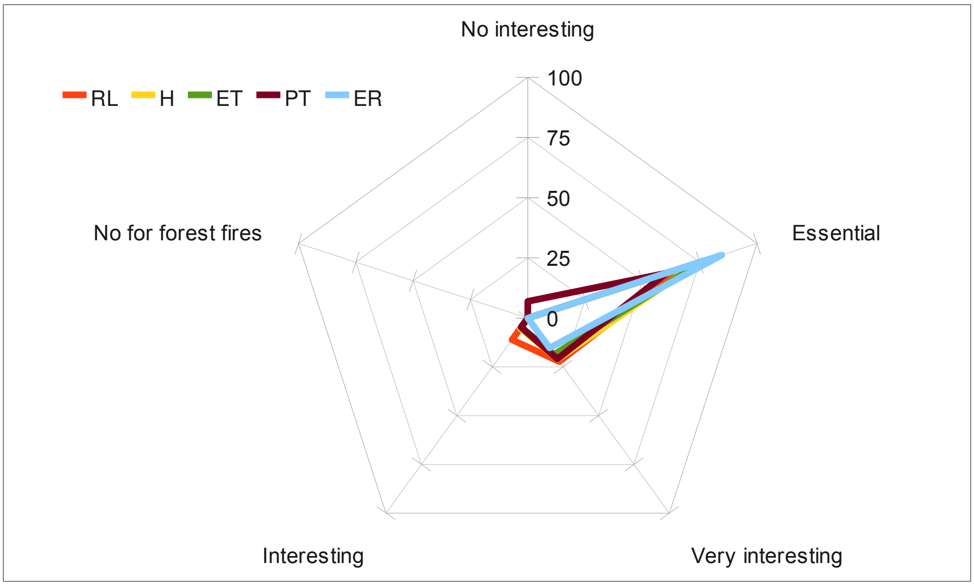

Figure 15: Value of water points data for the respondents. Values are in percentage.

Value of water points (%)	**Global**	**RL**	**H**	**ET**	**PT**	**ER**
No interesting	2.36	0	0	0	6.98	0
No for forest fires	0	0	0	0	0	0
Interesting	4.72	11.11	5.26	4.65	4.65	0
Very interesting	19.69	22.22	21.05	18.6	20.93	15.38
Essential	70.87	66.67	73.68	76.74	60.47	84.62

Table 11: Value of water points data for the respondents. Values are in percentage.

Figure 16 and table 12 show the road value for the respondents. Extinction technicians and environmental rangers give more importance to this information. They have to move along a big area and give orders to the others groups about how to get the fire location, whereas the other groups are being guide to the fire place.

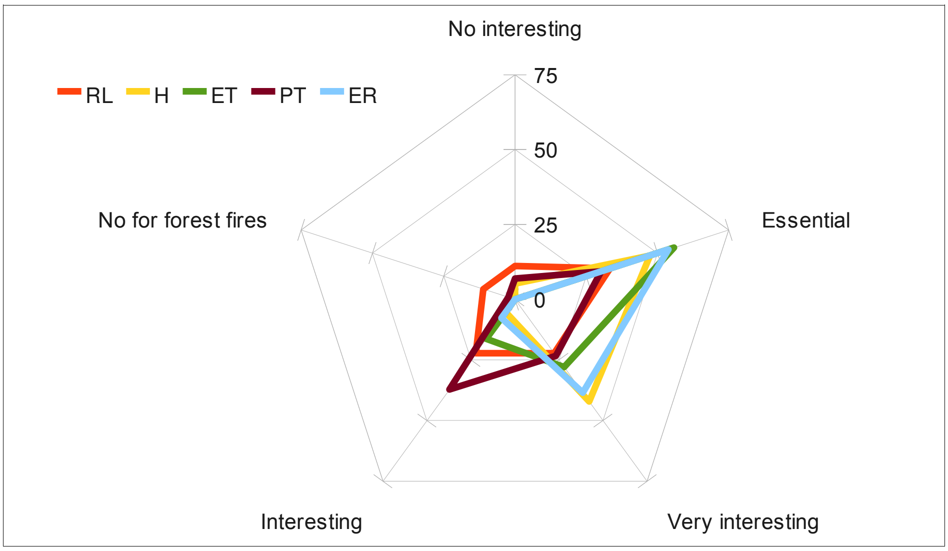

Figure 16: Value of roads and means of communication for the respondents. Values are in percentage.

Roads, means of communication (%)	Global	RL	H	ET	PT	ER
No interesting	3.94	11.11	5.26	0	6.98	0
No for forest fires	1.57	11.11	0	0	2.33	0
Interesting	21.26	22.22	5.26	16.28	37.21	7.69
Very interesting	29.13	22.22	42.11	27.91	23.26	38.46
Essential	44.09	33.33	47.37	55.81	30.23	53.85

Table 12: Value of roads and means of communication for the respondents. Values are in percentage.

Table 13 shows which information is essential for more than 50% of the respondents of the different groups. Helitransport squads is the group with less information considerer is essential. Extinction technicians think it is essential all the information suggested in the question 13. Results shows that every group have different information requirements.

	RL	H	ET	PT	ER
Weather					
Vegetation			74.42%		
Topography					
Water points					
Roads, means of communication					

Tabla 13: Percentage of respondents that thinks the information is essential. White means less than 50%. Yellow means values between 50% and 75%. Orange means more than 75% of the respondents think is a essential information.

- **Analysis of the question 14**. Evaluate the following information according to its interest or importance in a forest fire.

Figure 17 and table 25 show the value of forest fire location for the respondents. This information is essential for most of the groups. The 20 % of prevention technicians think this is not an interesting informationl. Further information about the composition of this group could contribute a better analysis; for instance is not the same develop a surveillance work than a silvicultural work or extinction work.

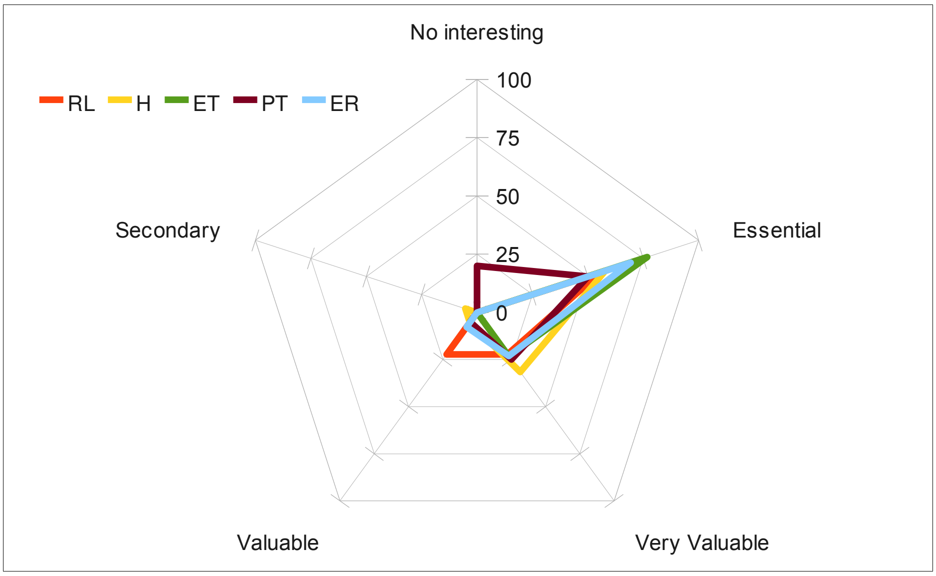

Figure 17: Value of forest fire location for the respondents. Values are in percentage.

Value of fire front location (%)	Global	RL	H	ET	PT	ER
No interesting	6.45	0	0	0	20	0
Secondary	0.81	0	5.26	0	0	0
Valuable	4.84	22.22	5.26	0	5	7.69
Very Valuable	25	22.22	31.58	23.26	25	23.08
Essential	62.9	55.56	57.89	76.74	50	69.23

Table 14: Value of forest fire location for the respondents. Values are in percentage.

Figure 18 and table 15 show the value of future fire location for the respondents. Most of the respondents think this is very interesting or valuable information wheres in the forest fire front location they consider it is an essential information. Future fire front location give some additional information about the behavior of the forest fires.

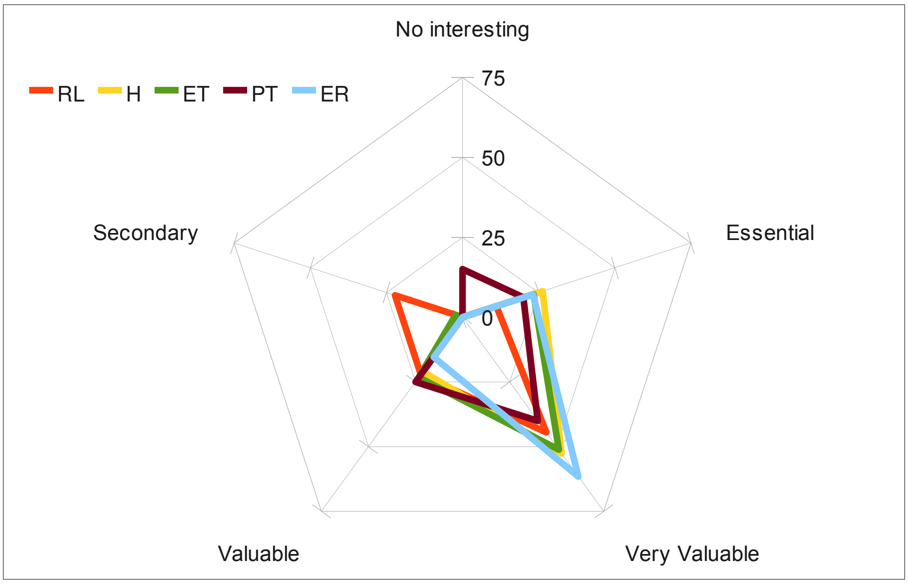

Figure 18: Value of forest future fire location for the respondents. Values are in percentage.

Value of future fire location (%)	Global	RL	H	ET	PT	ER
No interesting	4.84	0	0	0	15	0
Secondary	2.42	22.22	0	2.33	0	0
Valuable	22.58	22.22	21.05	23.26	25	15.38
Very Valuable	48.39	44.44	52.63	51.16	40	61.54
Essential	21.77	11.11	26.32	23.26	20	23.08

Table 15: Value of forest future fire location for the respondents. Values are in percentage.

Figure 19 and table 16 show the value of forest fires types (surface, canopy, high density or low density) for the respondents. The Extinction groups and helitransport squads think this is an essential information. Prevention technicians has the answers more scattered. This is an information that the extinction groups appreciate. Depending on the forest fire types the methodology to extinct the fire could change (Martínez Ruiz 2000).

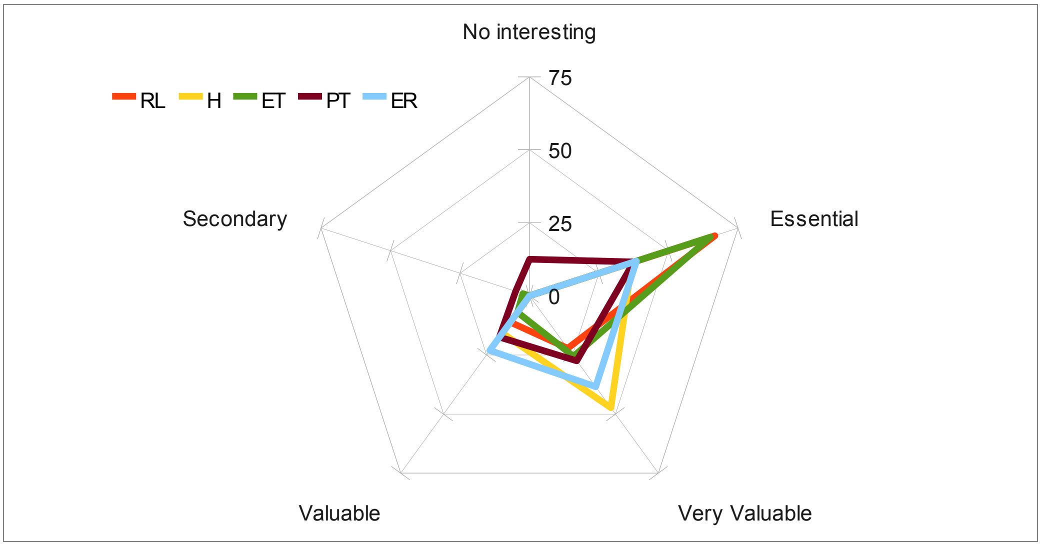

Figure 19: Value of forest fires types(surface, canopy, high density or low density) for the respondents. Value are in percentage.

Value of fires's type (%)	Global	RL	H	ET	PT	ER
No interesting	4.03	0	0	0	12.5	0
Secondary	2.42	0	0	2.33	5	0
Valuable	13.71	11.11	15.79	6.98	17.5	23.08
Very Valuable	30.65	22.22	47.37	25.58	27.5	38.46
Essential	49.19	66.67	36.84	65.12	37.5	38.46

Table 16: Value of forest fires types(surface, canopy, high density or low density) for the respondents. Value are in percentage.

Figure 20 and table 17 show the vegetation value in the forest fires and surrounding area for the respondents. The prevention technicians is the group with highest percentage of people that consider this information essential, moreover also have the highest percentage of no interest. Preventive works are base on vegetation. More than 50 % of people working in extinction consider this information essential, but the rural squads have the highest value as very valuable information, this is a group with a more active role than planing role.

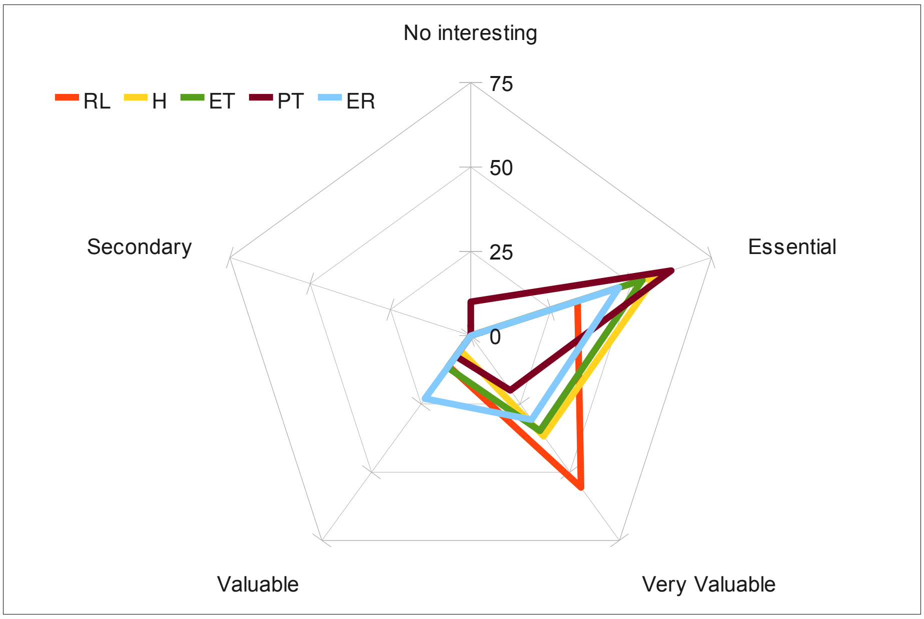

Figure 20: Value of vegetation in the forest fires and surrounding area for the respondents. Values are in percentage.

Value of vegetation (%)	Global	RL	H	ET	PT	ER
No interesting	3.23	0	0	0	10	0
Secondary	0	0	0	0	0	0
Valuable	10.48	11.11	5.26	11.63	7.5	23.08
Very Valuable	31.45	55.56	36.84	34.88	20	30.77
Essential	54.84	33.33	57.89	53.49	62.5	46.15

Taula 17: Value of vegetation in the forest fires and surrounding area for the respondents. Values are in percentage.

Figure 21 and table 18 show location of the extinction units location value for the respondents. This is an essential information for almost all the groups except for the rural squads. It is curious to see how the highest essential value is in prevention technicians, one group that doesn't work in extinction. Rural squads have the lowest essential value, despite that they think it is very important information. No one of extinction groups think this information is secondary or not interesting. Location can be use in context aware service and to prevent the unit isolation in a forest fire (Martínez Ruiz 2000).

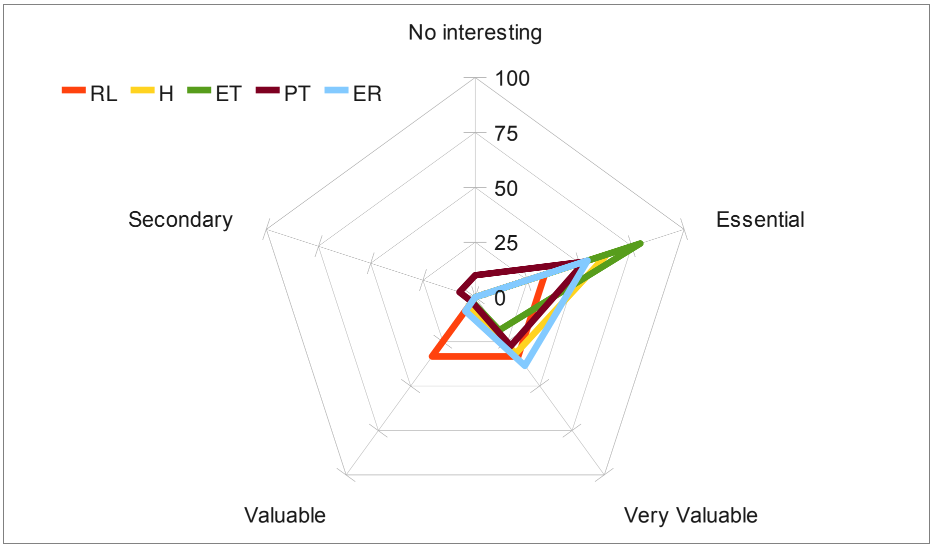

Figure 21: Value of extinction units location for the respondents. Value are in percentage.

Value of extintion units location (%)	Global	RL	H	ET	PT	ER
No interesting	3.23	0	0	0	10	0
Secondary	2.42	0	0	0	7.5	0
Valuable	5.65	33.33	5.26	2.33	2.5	7.69
Very Valuable	26.61	33.33	31.58	18.6	27.5	38.46
Essential	62.1	33.33	63.16	79.07	52.5	53.85

Table 18: Value of location of extinction units for the respondents. Value are in percentage.

Figure 22 and table 19 show the value the surveillance units location for the respondents. This is the information with a lower percentage of importance. Only the prevention technicians (40%) which has the role of the surveillance and design the surveillance routes consider this is an essential information. This information is important to don't overlap the surveillance areas.

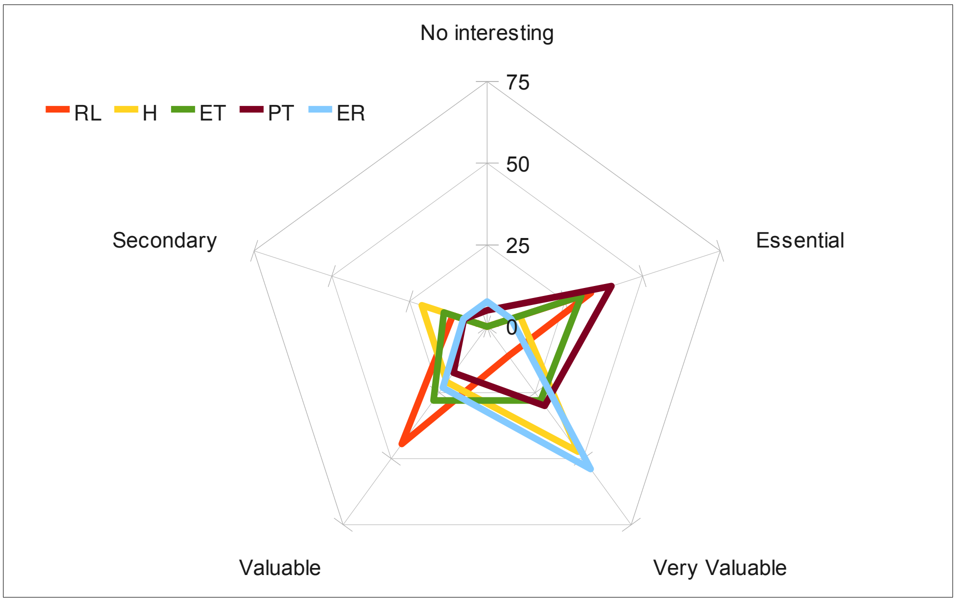

Figure 22: Value of location of the surveillance units for the respondents. Values are in percentage

Value of survillance units location (%)	Global	RL	H	ET	PT	ER
No interesting	2.42	0	0	0	5	7.69
Secondary	12.1	11.11	21.05	13.95	7.5	7.69
Valuable	24.19	44.44	21.05	27.91	17.5	23.08
Very Valuable	33.06	11.11	47.37	27.91	30	53.85
Essential	28.23	33.33	10.53	30.23	40	7.69

Table 19: Value of location of the surveillance units for the respondents. Values are in percentage

Figure 23 and table 20 show current weather conditions value for the respondents. All the groups (more than 50% of respondents) think this is an essential information. Another time the rural squads have the lowest value but close to 50 %. Depending on the weather conditions the firer have a different behavior and the level of fire risk is higher or lower (Estrela Navarro et al. 2005).

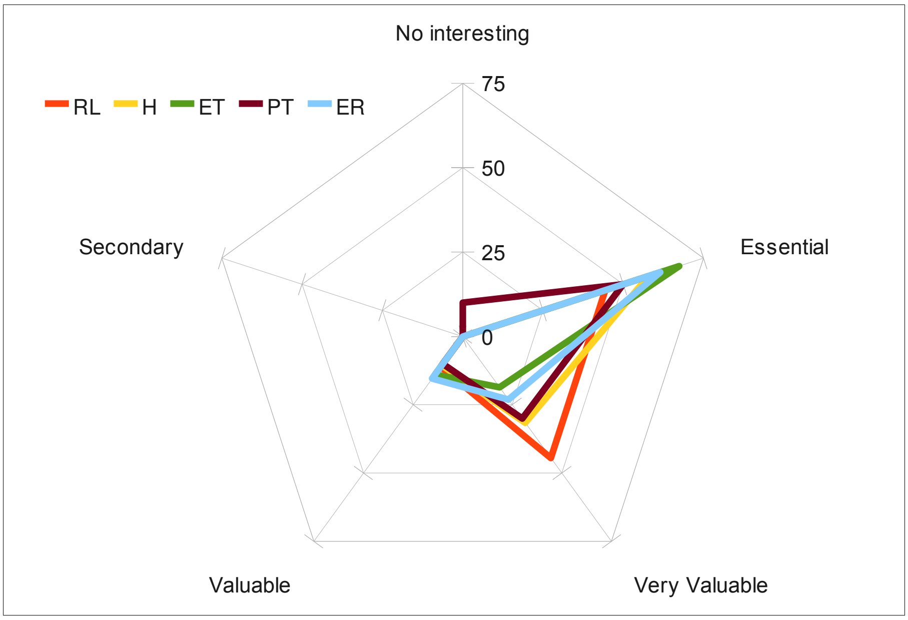

Figure 23: Value of actual climatological conditions for the respondents. Values are in percentage

Value of actual weather (%)	Global	RL	H	ET	PT	ER
No interesting	3.23	0	0	0	10	0
Secondary	0	0	0	0	0	0
Valuable	12.1	11.11	10.53	13.95	10	15.38
Very Valuable	26.61	44.44	31.58	18.6	30	23.08
Essential	58.06	44.44	57.89	67.44	50	61.54

Table 20: Value of actual climatological conditions for the respondents. Values are in percentage

Figure 24 and table 21 show weather forecast value for the respondents. These values are similar to the actual weather conditions. The respondents give a little bit more importance to the weather forecast. The Environmental rangers exactly the same results here and in the table 20.

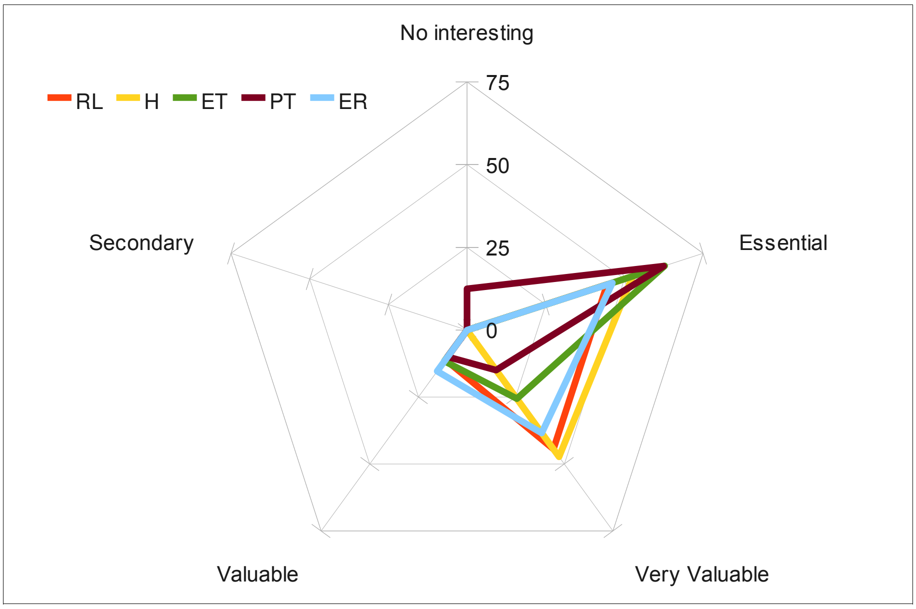

Figure 24: Value of weather forecast for the respondents. Values are in percentage.

Value of weather forecast (%)	Global	RL	H	ET	PT	ER
No interesting	4.03	0	0	0	12.5	0
Secondary	0	0	0	0	0	0
Valuable	9.68	11.11	0	11.63	10	15.38
Very Valuable	28.23	44.44	47.37	25.58	15	38.46
Essential	58.06	44.44	52.63	62.79	62.5	46.15

Table 21: Value of weather forecast for the respondents. Values are in percentage.

Figure 25 and table 22 show roads state value for the respondents. Only environmental rangers have a value over 50 % as an essential information. This group has to patrol the forest, therefore they need to know which are the state of the forest roads. Road state is important when the vehicles have to get the fire location. Vehicle going trough a road that is blocked is wasting a precious time when a fire spreading along the forest. It is also an important information for evacuation could be the difference between live or dead. This information requires a constant update.

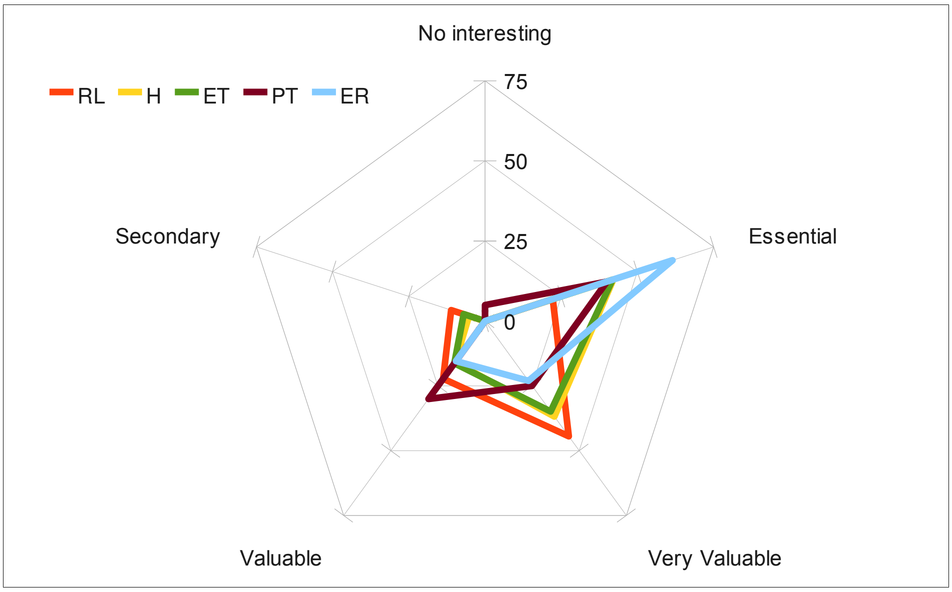

Figure 25: Value of roads state for the respondents. Values are in percentage.

Value of roads state (%)	Global	RL	H	ET	PT	ER
No interesting	1.61	0	0	0	5	0
Secondary	4.03	11.11	5.26	6.98	0	0
Valuable	20.97	22.22	15.79	16.28	30	15.38
Very Valuable	31.45	44.44	36.84	34.88	25	23.08
Essential	41.94	22.22	42.11	41.86	40	61.54

Table 22: Value of roads state for the respondents. Values are in percentage.

Figure 26 and table 23 show water points state value for the respondents. This information is essential for most of the groups with values bigger or close to 50%. Only 37.5 % prevention technicians think this information is essential. The water points are distributed along the forest areas. To have information of its state helps to decide if is better go to recharge the vehicles tanks to one point or to another. The importance of this information depends on the utility of the water tanks for the forest fire extinction.

Value of water poins (%)	Global	RL	H	ET	PT	ER
No interesting	3,23	0	0	0	10	0
Secondary	0	0	0	0	0	0
Valuable	10,48	11,11	15,79	2,33	15	15,38
Very Valuable	35,48	44,44	26,32	39,53	37,5	23,08
Essential	50,81	44,44	57,89	58,14	37,5	61,54

Table 23: Value of water points state for the respondents. Values are in percentage.

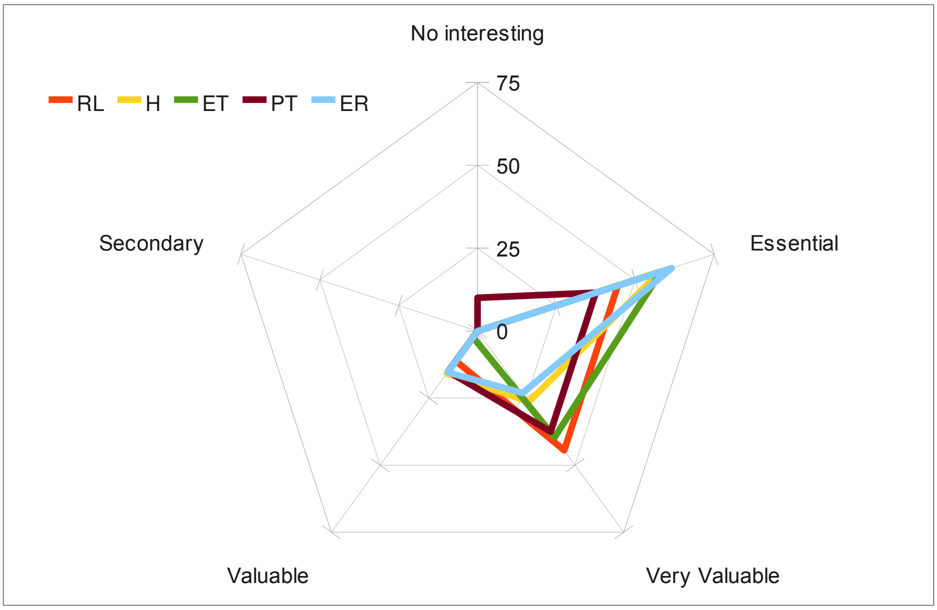

Figure 26: Value of the water points state for the respondents. Values are in percentage.

The figure 27 and table 24 show inhabited points location value for the respondents. This information is essential for the 74.5% and the 52.5% of extinction and prevention technicians. This is because the first priority in a forest fire is to save human lives. Therefore know where are the inhabited places close to the forest fire or in the direction of a forest fire spread is essential. This is also important on surveillance or to make the preventive forest fire plan. Result shows that depending if your are working in planing task or working directly in the fire front this information is more valuable or not. Only 22% of rural squads think this is an essential information.

Value of inhabited places (%)	Global	RL	H	ET	PT	ER
No interesting	1.61	0	0	0	5	0
Secondary	1.61	0	0	0	5	0
Valuable	12.9	22.22	10.53	11.63	10	23.08
Very Valuable	28.23	55.56	42.11	13.95	27.5	38.46
Essential	55.65	22.22	47.37	74.42	52.5	38.46

Table 24: Value of inhabited points location for the respondents. Values are in percentage.

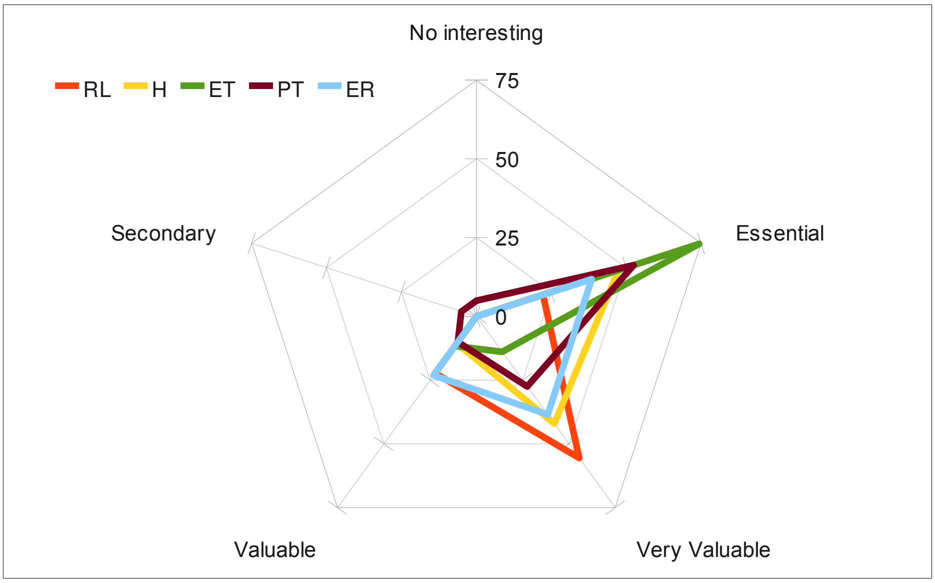

Figure 27: Value of inhabited points location for the respondents. Value are in percentage.

Table 25 shows an overview of what it is essential information for the respondents in question 14. The Extinction technicians is the group with some values close or bigger than 75% for inhabited points location, fire front location and extinction units location. Rural squads only considered the fire front location and forest fire types as essential. Futures fire location isn't essential for any of the groups. Road state is essential only for the environmental rangers. The groups have different information requirements.

	RL	H	ET	PT	ER
Fire front location					
Future fire front location					
Forest fires types					
Vegetation					
Extintion units location					
Survillance units location					
Weather conditions					
Weather forecast					
Roads state					
Water points state					
inhabited points location			74.42		

Tabla 25: Percentage of respondents that thinks the information is essential. White means less than 50%. Yellow means values between 50% and 75%. Orange means more than 75% of the respondents think is a essential information.

- **Analysis of the question 8.** ¿How often do you use applications like google earth, google maps, or viamichelin,...?

Technicians as is show in figure 28 and table 26 are the groups with most Internet map application frequently use, at least once a week. Helitransport squads are the ones that use more often these tools, 42.11% use this tools every day. Most of the respondents have used this kind of tools. Only a reduce number of respondents never have use this tools. Therefore generally speaking they can manage or understand the spatial information provide in a similar way.

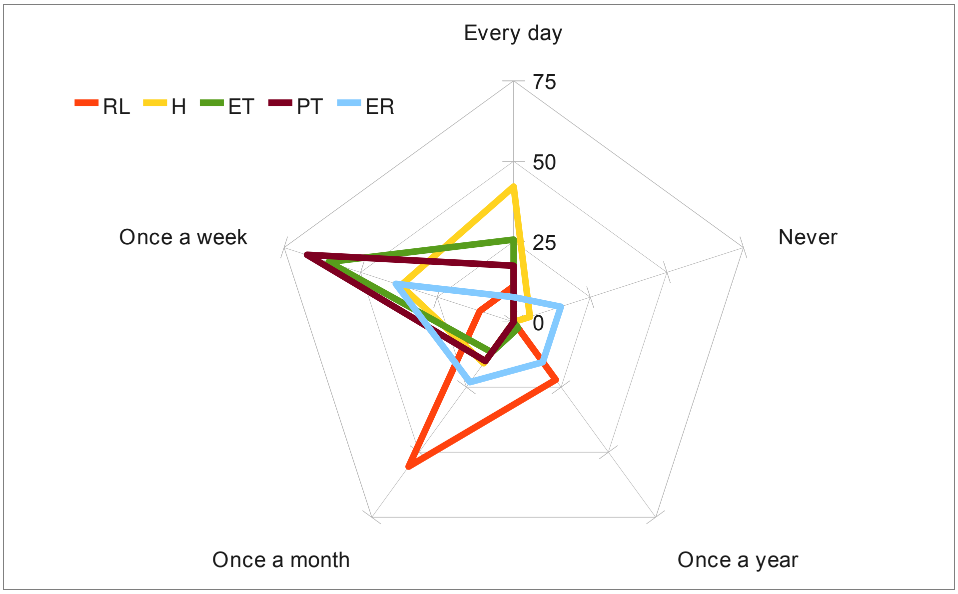

Figure 28: How often the respondents use applications like google earth, google maps, or viamichelin,... Values are in percentage

Web map applications (%)	Global	RL	H	ET	PT	ER
Every day	22.58	11.11	42.11	25.58	17.5	7.69
Once a week	53.23	11.11	36.84	60.47	67.5	38.46
Once a month	16.94	55.56	15.79	11.63	15	23.08
Once a year	4.84	22.22	0	2.33	0	15.38
Never	2.42	0	5.26	0	0	15.38

Taula 26: How often the respondents use applications like google earth, google maps, or viamichelin,... Values are in percentage

- **Analysis of the question 9.** ¿How often do you use GIS software like GVSIG, ArcGIS, Miramon or others?

Figures 29 and the table 27 show the results for this question. The background of the people working in forest fires is very diverse. Prevention technician is the group which most frequently use the GIS software. People with a technical background have some basic knowledge of GIS. The forest engineers, which work like technician in extinction and prevention us to develop prevention projects and extinction planing with the help of a GIS software. Only a 10.48% of the people in global have worked with this kind of software so they can manage the spatial information with these tools at least the basic ones. The 66.67 % of the rural squads have never used this tools (this is a group with less background in GIS), despite that 100% have used at least once a year web map application. In global professional GIS tools are use less than the general public GIS tools.

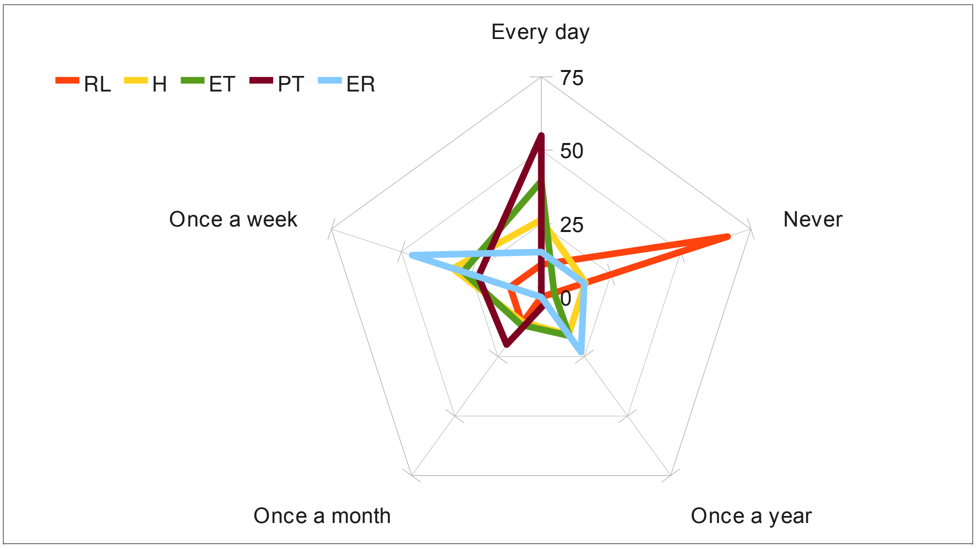

Figure 29: How often the respondents use GIS software like GVSIG, ArcGIS, Miramon or others. Values are in percentage.

GIS Software Use (%)	Global	RL	H	ET	PT	ER
Every day	37.9	11.11	26.32	39.53	55	15.38
Once a week	27.42	11.11	31.58	27.91	22.5	46.15
Once a month	12.9	11.11	10.53	11.63	20	0
Once a year	11.29	0	15.79	16.28	2.5	23.08
Never	10.48	66.67	15.79	4.65	0	15.38

Table 27: How often the respondents use GIS software like GVSIG, ArcGIS, Miramon or others. Values are in percentage.

- **Analysis of the question 10**. ¿How often do you us web map services, using map visualizers or WMS links from your region or state ?

  The WMS service allows the user to display a remote layer in a local or web application as a background layer (OGC n.d.). The use of this service require a basic knowledge about the GIS tools. Figure 30 and the table 28 show the answers to this question. The percentage of the respondents that have never used web tools or GIS software are 2.42% and 10.48% respectively. The percentage of respondents that have never used WMS service are 16.13%. Therefore some respondents doesn't know how to connect to this service or this service doesn't provide interesting information. Nevertheless the use of this service is inferior to the web map applications or GIS software.

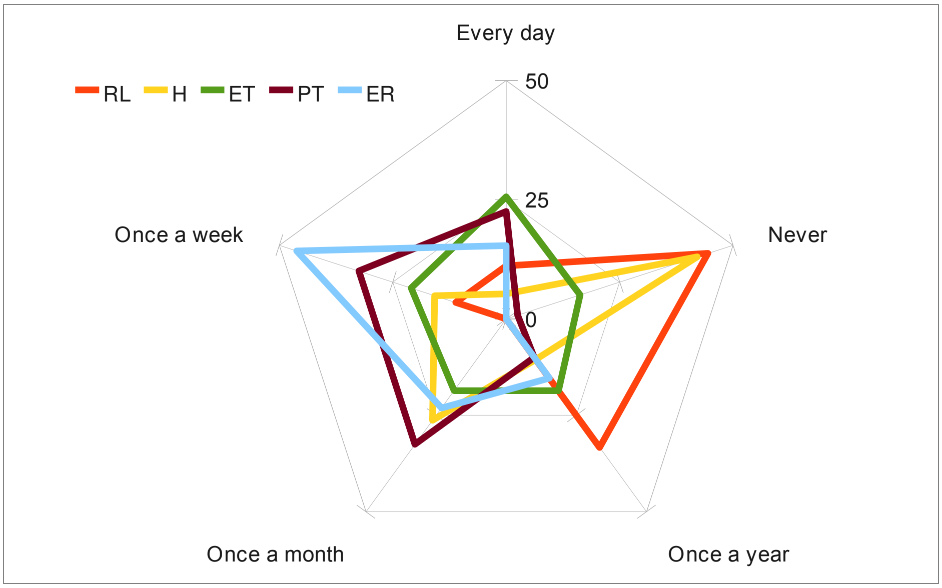

Figure 30: How often the respondents use web map services, using map visualizers or WMS links from your region or state. Values are in percentage.

WMS service use (%)	Global	RL	H	ET	PT	ER
Every day	19.35	11.11	5.26	25.58	22.5	15.38
Once a week	25.81	11.11	15.79	20.93	32.5	46.15
Once a month	23.39	0	26.32	18.6	32.5	23.08
Once a year	15.32	33.33	10.53	18.6	10	15.38
Never	16.13	44.44	42.11	16.28	2.5	0

Table 28: How often the respondents use web map services, using map visualizers or WMS links from your region or state. Values are in percentage.

- **Analysis of the question 11**. In your work related with the forest fires ¿Which maps do you use?

Figure 31 and table 29 show the answers to this question. Rural squads are the group that only use topographic maps (66.7%), some people of this group has some knowledge of GIS tools (33.33%) and web maps applications (100%). Despite that they never use an extra information that this tools can provide to them to make maps. The other groups mainly use topographic maps but also an extra information of WMS maps or personalized self-done maps. Around the 25.1% of the global users need more information than the topographic maps or WMS layers. They could make its one maps using the GIS tools.

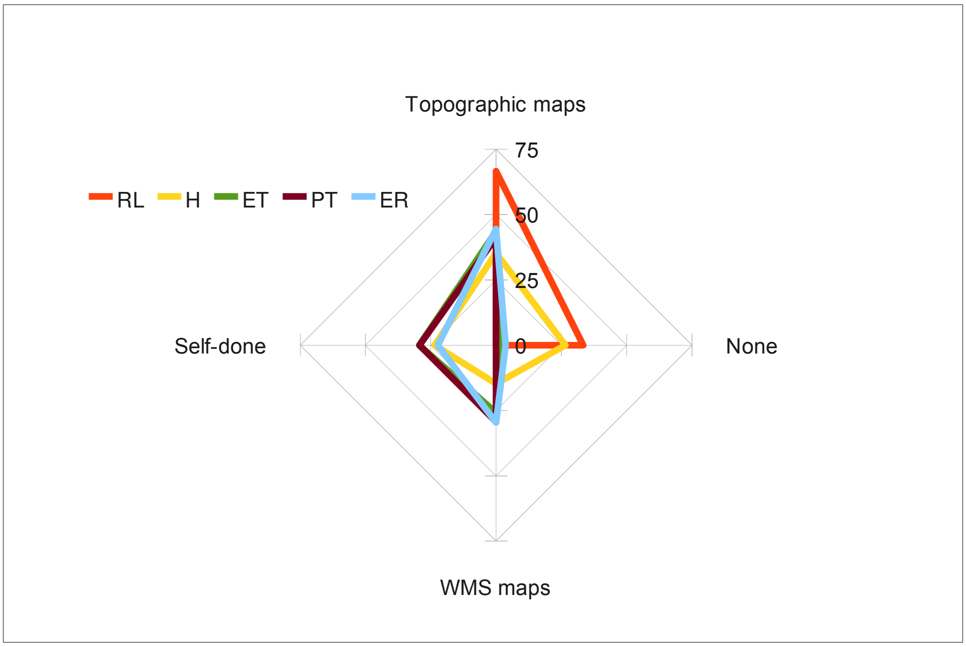

Figure 31: Answers to the question, in your work related with the forest fires ¿Which maps do you use?. Values are in percentage.

Kind of maps use (%)	Global	RL	H	ET	PT	ER
Topographic maps	42.51	66.67	35.29	43.53	41.3	44.44
Self-done	26.72	0	23.53	29.41	29.35	22.22
WMS maps	25.1	0	14.71	25.88	29.35	29.63
None	5.67	33.33	26.47	1.18	0	3.7

Table 29: Answers to the question, in your work related with the forest fires ¿Which maps do you use?. Values are in percentage.

- **Analysis of the question 12.** ¿How many time do you have in your work related with forest fires to look at the maps?

  Figure 32 and table 30 show the results to this question. Groups that work more in the forest (not in an office) are the ones with less time to look at a map or never use a map. Technicians group which work more in an office is the one which highest percentage of constantly work with maps (51.6% ET 75% PT). To design an application for emergency is important to reduce to 0% the people that doesn't have time to look at a map. This could be done delivering spatial information like an alert (Botts et al. 2008) or a simple map easy to understand. Only the 4.84% of global respondents that use maps have less than 5 minutes to look at a map.

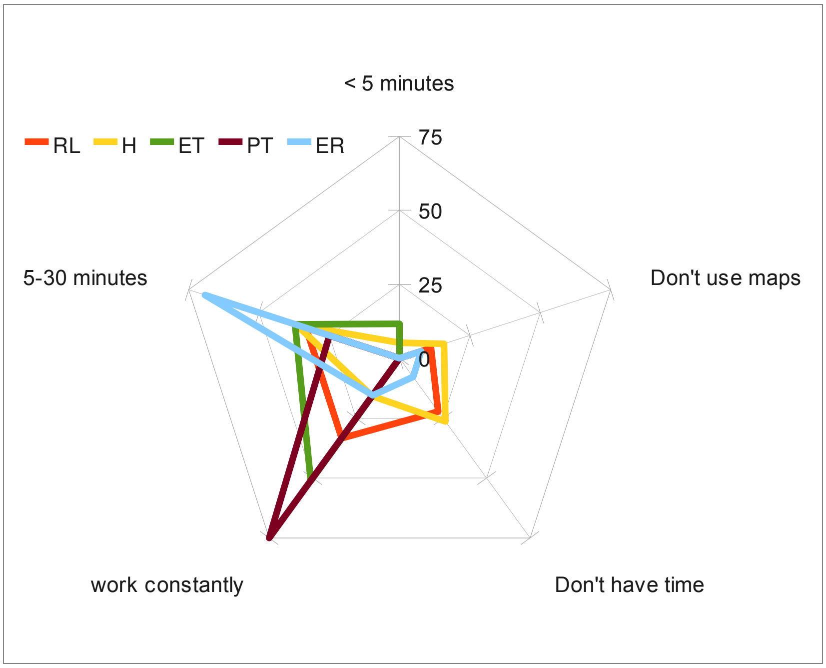

Figure 32: Answers to the question, ¿How many time do you have in your work related with forest fires to look at the maps?. Values are in percentage

Time to look at a map (%)	Global	RL	H	ET	PT	ER
< 5 minutes	4.84	0	5.26	11.63	0	0
5-30 minutes	36.29	33.33	36.84	37.21	25	69.23
Work constantly	48.39	33.33	15.79	51.16	75	15.38
Don't have time	6.45	22.22	26.32	0	0	7.69
Don't use maps	4.03	11.11	15.79	0	0	7.69

Table 30: Answers to the question, ¿How many time do you have in your work related with forest fires to look at the maps?. Values are in percentage

- **Analysis of the question 15**. In your work related with forest fires ¿Which media communication devices do you use and how long?

Table 31 shows results about use of radio device. Radio device is use mainly to communicate orders between a central office and people in the forest. The 44.35% of the respondents use the radio. The 40% of the prevention technicians don't use the radio. Prevention technitians use to develop their work in an office an its communications in the forest doesn't require the extra coverage of the radio. This device isn't the most suitable to communicate the spatial information. Moreover only coordinates or place names can be communicate, also exist a misunderstood possibility of the message.

Time use of radio(%)	Global	RL	H	ET	PT	ER
Don't use	17.74	0	15.79	6.98	40	0
10.00%	12.9	0	15.79	9.3	15	23.08
25.00%	12.1	22.22	0	11.63	15	15.38
50.00%	12.9	0	15.79	18.6	7.5	15.38
>50%	44.35	77.78	52.63	53.49	22.5	46.15

Table 31: Answers to the use time of the radio. Values are in percentage.

Figure 33 and the table 32 show the results for use time of e-mail. Comparing this results with the radio use, e-mail use is smaller. The advantage of the e-mail comparing with the radio is that the message sent is more clear and is possible to attach maps or links to a map.

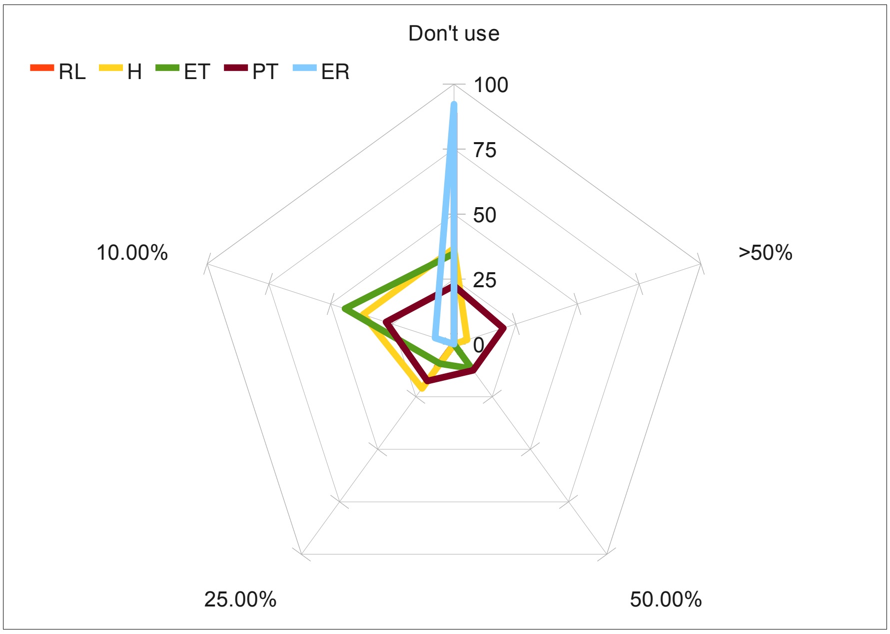

Figure33: Answers to e-mail time use. Values are in percentage.

Time use of e-mail (%)	Global	RL	H	ET	PT	ER
Don't use	41.13	88.89	36.84	34.88	22.5	92.31
10.00%	30.65	0	36.84	44.19	27.5	7.69
25.00%	12.9	11.11	21.05	9.3	17.5	0
50.00%	8.06	0	0	11.63	12.5	0
>50%	7.26	0	5.26	0	20	0

Taula 32: Answers to e-mail time use. Values are in percentage.

Figure 34 and table 32 show results for time use of the cell phone. Cell phone use is wide spread along the professionals. Moreover use of cell phone is wide spread along the civil society. Despite that use of the cell phone has a coverage problem in the forest and mountainous areas. The use time of the cell phone is divers. The cell phone has a better quality of sound than the radio communications (when there is a good coverage). Cell phone has less problems of misunderstood of the message regarding to the quality of the sound than radio.

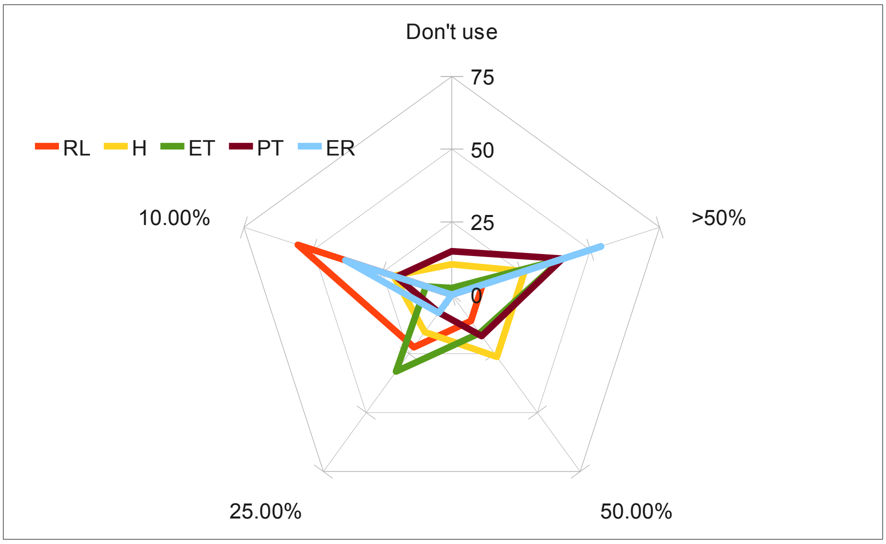

Figure 34: Answers to the time use of the cell phone. Values are in percentage.

Time use of cell phone (%)	Global	RL	H	ET	PT	ER
Don't use	7.26	0	10.53	2.33	15	0
10.00%	20.97	55.56	21.05	9.3	20	38.46
25.00%	18.55	22.22	15.79	32.56	7.5	7.69
50.00%	16.13	11.11	26.32	16.28	17.5	0
>50%	37.1	11.11	26.32	39.53	40	53.85

Table 33: Answers to time use of the cell phone. Values are in percentage.

Figure 35 and table 34 show the results for time use of SMS. SMS is not very use in time along the different groups comparing with the previous system. The advantage of this system is that the message could be received and send when the user have a short time of coverage. Wheres to speak by the cell phone you need a long time and good coverage quality (Brown et al. 2007).

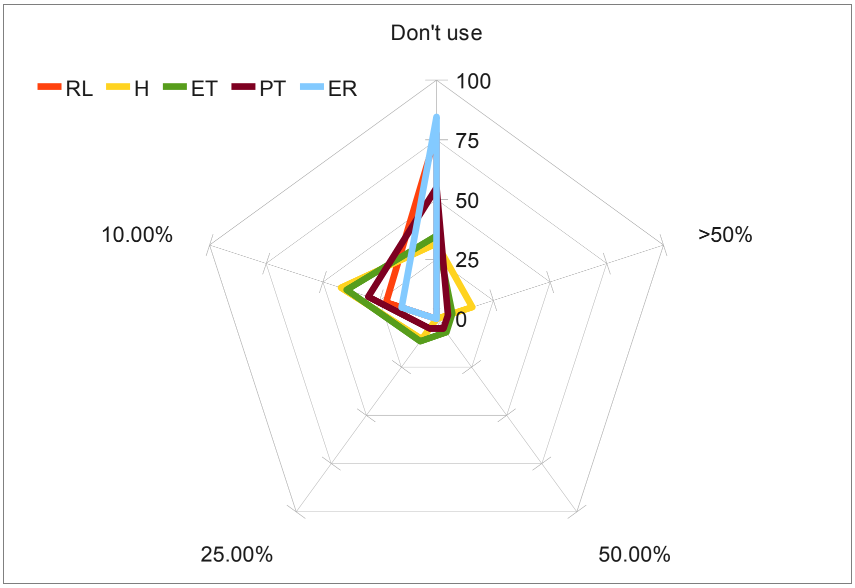

Figure 35: Answers to time use of the SMS. Values are in percentage.

Time use of SMS(%)	Global	RL	H	ET	PT	ER
Don't use	49.19	77.78	31.58	34.88	55	84.62
10.00%	33.06	22.22	42.11	39.53	30	15.38
25.00%	7.26	0	10.53	11.63	5	0
50.00%	4.03	0	0	6.98	5	0
>50%	6.45	0	15.79	6.98	5	0

Table 34: Answers to time of the SMS. Values are in percentage.

Figure 36 and the table 35 show the results for time use of the pocket-PC or smart phone with Internet connection. This device has a huge potential to deliver spatial information in forest fire context (Shi et al. 2009). Pocket-Pc use is very small, for instance the environmental rangers never use these devices (100%). The other groups have some use but it isn't wide extend among the people.

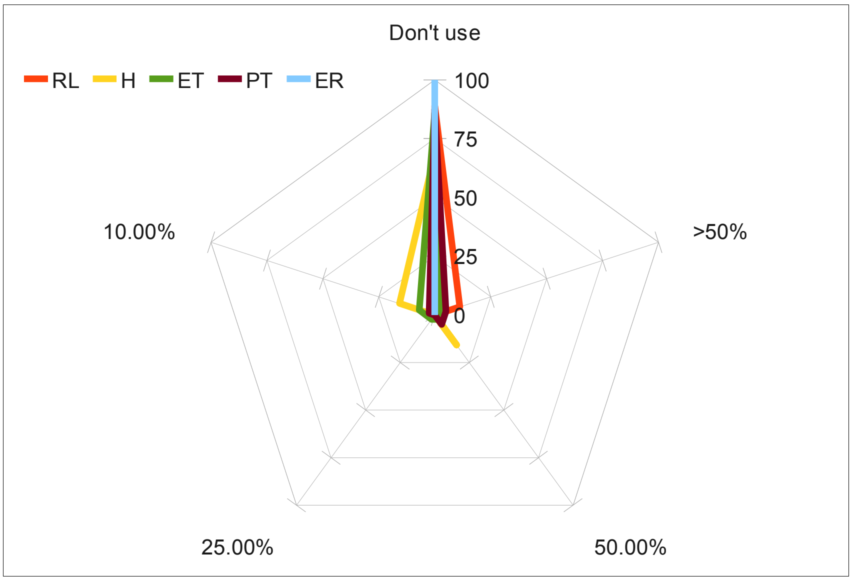

Figure 36: Answers to the use time of the pocket-PC or smart phone. Values are in percentage.

Time use of pocket-PC (%)	Global	RL	H	ET	PT	ER
Don't use	85.48	88.89	68.42	86.05	87.5	100
10.00%	5.65	0	15.79	6.98	2.5	0
25.00%	0.81	0	0	2.33	0	0
50.00%	4.84	0	15.79	2.33	5	0
>50%	3.23	11.11	0	2.33	5	0

Table 35: Answers to the use time of the pocket-PC or smart phone. Values are in percentage.

Communication in forest fires context is mainly by radio and cell phone, follow by e-mail and SMS. Pocket-PC which have more potential to deliver spatial information in the forest context is the one less use. Table 36 show a comparative in global use time.

	Radio	E-mail	Cell phone	SMS	Pocket-PC
Don't use	17.74	41.13	7.26	49.19	85.48
10.00%	12.9	30.65	20.97	33.06	5.65
25.00%	12.1	12.9	18.55	7.26	0.81
50.00%	12.9	8.06	16.13	4.03	4.84
>50%	44.35	7.26	37.1	6.45	3.23

Tabla 36: Global comparative of the use time of the different communication media in forest fires context.

- **Analysis of the question 16**. Could you write downs, ¿What alerts or advices you receive related with forest fires or preventive works or surveillance?

Table 37 show the number of people that receive an alert. Frecuentlyt alerts are fire alerts, preemergency level, and fire squads involve in forest fires extinction. Following those are, alerts related to the weather conditions terrain and vegetation conditions, and route instructions to get fire location. All the alerts received can be mapped, and be delivered in a digital map or a layer to be included in a SDI.

- **Analysis of the question 17**. Could you write downs, ¿What alerts or advices you communicate related with forest fires or preventive works or surveillance?

Table 38 show the number of people that communicate an alert. The alert more communicated is the fire alert, then are coming vegetation and terrain conditions, fire evolution, fire squads request, weather conditions and fire squads involved. Like in the previous question, all the alerts received can be mapped, and be deliver in a digital map or layer to be included in a SDI.

Alerts in	Fire alert	Level preemergency	Fire squads involve	route to the fire	Weather condition	Vegetation an terrain conditions	Fire type	Survellance location	Inhabitant places	Electric lines	Water points	Preventive works	Make cartography
RL	3	4	0	0	0	0	0	0	0	0	0	0	0
H	14	4	5	4	2	2	2	0	1	0	1	0	1
ET	30	4	10	0	3	2	0	1	1	1	0	0	0
PT	16	12	1	1	4	2	0	0	0	0	3	2	2
ES	9	7	1	1	0	0	0	0	0	0	0	0	0
Global	72	31	17	6	9	6	2	1	2	1	4	2	3

Table 37: Answers to the question, What alerts or advices you receive related with forest fires or preventive works or surveillance.

Alerts out	Fire alert	Level preemergency	Fire squads involve	Fire squads request	Fire evolution	Fire type	Route to the fire	Weather condition	Vegetation an terrain conditions	Forest road conditions	Inhabitant places	Electric lines	Water points	Preventive works	Make cartography	Burned area	Orders
RL	6	0	0	0	1	0	1	2	1	0	0	0	0	0	0	0	0
H	6	1	4	3	6	4	2	5	6	0	1	0	2	0	0	1	0
ET	13	2	5	7	7	7	0	6	9	0	4	1	1	0	0	2	5
PT	11	3	1	0	1	0	0	1	2	2	1	1	3	1	2	2	3
ES	9	0	1	6	4	1	3	2	3	0	2	0	0	0	0	0	1
Global	45	6	11	16	19	12	6	16	21	2	8	2	6	1	2	5	9

Table 38: Answers to the question, What alerts or advices you communicate related with forest fires or preventive works or surveillance.

5.3 Discussion

Spatial features are recognized when people use them in paper maps or digital maps. In forest fires the spatial information being manage is the one with a relation with the issue, topography weather conditions and vegetation. If people use to see the information in a map, automatically will appreciate the relationships with the space.

The interpretation of the spatial information is very important in an emergency context where the information is changing constantly. Errors in surface interpretation could be avoid using a 3D view. A topographic map also can be use with not too much interpretation error (St. John et al. 2001). Following standards or common rules to draw the features could improve map interpretations without legend. The quantity of different spatial information show in view is also important to interpret a map. Display only the information required is better, less is more (Alvarez 2007).

Each group have different spatial information requirements, depending if they are doing an extinction task, preventive task, or working from an office giving orders or receiving. Information that for one group is essential for another group have not got any importance or is not as important. Display only the information need, for each specific user and for a work context, will simplify the task of spatial analysis, and increase the value of this information (Richter et al. 2008).

GIS tools knowledge by the forest fire professional is wide spreed. They know at least the basic GIS concepts, moreover the GIS or map web tools are wide extended inside the forest fires professionals. The general public GIS tools could be a better way to communicate the spatial information. This media require less final user effort to understand the spatial information. WMS service is not known or not used by all people that use GIS applications. This service needs some extra knowledge to connect to it. Predefine the service connections depending on the user could help to simplify the use of the GIS applications and spread the access to this technology.

Paper topographic map is the most wide extend support for spatial information in forest fire context (for field work). Some people need extra information from different sources or new information generate by the user. The GIS tools are the only way to ensure the management of this amount of spatial information. The respondents have some basic knowledge to manage this information with tat least a general public GIS tools

People mainly use the radio and cell phone to communicate. It is not possible to use only one of this two devices because sometimes you have a radio coverage and not a cell phone coverage and vice-versa. A device with Internet connection is the only way to ensure spatial information delivering in a GIS format. Nevertheless these devices have a low use on forest fire context.

Depending on the task is being develop the available time to look at a map differs. There is less time when a task is more close to emergency context (not prevention). Reducing the complexity of a map could help to interpret a map in less time and with less error (Richter et al. 2008).

Alerts in forest fires can be delivered like oral message, write, SMS, e-mail or like a map.. A user is constantly receiving alerts and sending alerts, all this alerts can be mapping. The GIS collaborative tools can help to simplify the process of mapping and distribution of these alerts (Camarero Puras & Iglesias 2009). Deliver this alert like a map or spatial layer, like terrain features surrounding, alert location or vegetation conditions, simplifies information comprehensiveness.

6 CONCLUSIONS AND FUTURE WORK

Forest fires have two different tasks, prevention and extinction. Spatial user requirements in those fields are different. Nevertheless both have a common node, a connection. Prevention technicians, try to minimize the forest fire hazard and the impact of this event when it happens. They are in charge of the surveillance and incipient forest fires detection. Extinction professionals take the information given by the preventions professionals (fire locations, hazard areas, route to the fire,...) and start their work in an emergency context.

Forest fires extinction is going on in a terrain. Terrain features have a direct relation with fire behavior. Survey respondents has a clear understanding of spatial information like terrain, slope, vegetation and so on. Other spatial features that respondents are not used to manage as a layer are not seen as part of the geographical context. In future work will be interesting to test if the information is managed properly with a simple GIS tool.

A uniform application for all the users involve in forest fire is possible but is usefulness. Requirements in prevention are different from requirements in extinction Inside those groups specialization task require different spatial information. The survey has show how people in charge of a forest fire needs wide view on what is going on, whereas firefighters in fire front line only need what is happening in its surroundings.

Like civil society there is two requirements of GIS tools. General public tools mainly are use for information visualization. Professional tools are use to survey analyze, and create new information. People in an emergency task mainly use visualization GIS tools, wheres for planning are being use the professional GIS tools. Prevention technicians has more time to analyze spatial information, indeed their requirement to manipulate and process spatial information are bigger than in extinction.

The Survey results show a great variety of alerts, send and receive. All professionals receive different alerts depending on his task. There should be mandatory alerts to send and receive, but each user could decide which complementary alerts likes to receive.

Lack of devices for mobile connection and the Internet coverage is a challenge to deliver the spatial information. The survey results show how most user devices in forest fires context are radio and cell phone. This situation requires an extra effort to improve the Internet access among professionals.

Spatial information is constantly changing, vegetation is in evolution, forest roads are being repaired or have been cut during a hard rain, water tanks are empty or at half of its capacity, forest fires risk is changing every day and so on. Update all this information requires a huge work. Actually people working in prevention, forest engineers and environmental technicians are in charge of environmental information updating. Actually up-to-date information only work at one scale level, state, regional or province, to produce official data that are going to be use later in a forest fires as a source data. Nevertheless. However forest fires use to happened at local scale involving one or some municipalities (Ministerio de Medio Ambiente 2006). Conclusively extinction is carried out at local scale using a regional or state scale spatial information.

Nowadays is possible to improve and update the spatial information faster in an emergency context. After the earthquake in Haiti (January 12, 2010) collaborative tools like OpenStreetMap (OSM n.d.) has become a solution to mapping Haiti roads and streets after the earthquake. These tools provide to rescue and humanitarian teams update information to deliver the food and medicines efficiently. Forest fires can have an advantage using collaborative tools, VGI, PPG, to get up-to-date information about the roads, water points, vegetation or forest fires detection.

SDI technology can be use by forest fires professionals to get required information access avoiding politician borders between regions or state. Nowadays it is possible to access to a forest road network of two different providers. Despite this information is display as different layers. Connectivity problems are solved but semantic problems still remains to display spatial information like homogeneous layer. In an emergency context is essential to display information as simple as possible.

Survey result has contributed to know user GIS knowledge, spatial information requirements and its management. Future challenge for forest fire management SDI are how to deliver of personalized spatial informations, taking into account geographic context and professional task. It is still a challenge to display spatial information efficiently keeping it as simple as possible. WEB 2.0 techniques and social network, could improve data updating and delivering for forest fire context.

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