Application of GPS Survey Methods for Burnt Forest Areas Monitoring[1]

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KEY WORDS

1	K010	Forestry
2	K083	Monitoring
3	K131	GPS

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ABSTRACT

This is the result of a collaboration between the Emilia-Romagna Regional Administration and the firm SISCAM, for the testing of an effective methodology which, by using an informatic system operating an PC and exploiting GPS, permits an operative joint exploitation of photographic and cartographic material for the rapid monitoring of areas envoloped by forest fires.
Tests and evaluations were carried out on all necessary passages starting from the survey plan to the implementation of the Forestry Informative System and to the resulting and non-cartographic data.
The potential use of 23 cm photogrammes in the SISCAM program was also assessed and explicitly applied to the orthogonalisation of the images and to the handling of the photogrammetric equipment.
Considering the time required from the survey to the cartographic restitution, the method used was altogether valid and, seeing the procedures potentiality, was worthy of further investigation.

Introduction

The following study concerns:
- having a database method use of GPS equipment which was finalised specifically to the cartographic survey of the two areas overrun by fire and the successive input of dates obtained inside the GIS operating on PC in ARC-VIEW base system given over to collecting and the processing of the Forestry Inventory Data of the Emilia-Romagna Regional Administration.
- Assessment of the operative possibilities and economic advantages of the use of GPS data linked to informatic systems for the correction of aerial photogrammes, taken for rapid monitoring of small vegetated areas enveloped by forest fires.

The survey work and the data processing of GPS was carried out by technicians and collaborators of the Landscape, Park and Natural Heritage Department of the Emilia-Romagna Regional Administration with the co-operation of the Italian State Corps of Foresters. The photogrammetric elaboration was carried out by the firm SISCAM.
The programme evolved with the following aims.
- To assess the operative possibilities of the GPS equipment in the cartographic field.
- To evaluate the possibility of an integrated use of aerial shots and GPS data for territory studies.
- To test the correct rapid intervention methods to adopt with the scope of monitoring areas involved in natural calamities (forest fires in this case).

Research Areas

Two areas were chosen as experimental objectives. They were both ravaged by two forest fires , probably caused by arson, on the 2nd August 1995. These areas are situated in the mountainous part of the Province of Bologna, along the trunk road 64 (Porrettana) which runs into the Municipal territories of Marzabotto (loc. Sibano) and Vergato (loc. Tabina).
The fire, possibly caused by the same person (in both cases it broke out simultaneously between 12 a.m. and 12.30 a.m.) and began from the trunk road and spread over the highway up to the over hanging belts.
The first of these two sites (loc. Sibano) could be divided into three different typologies:
- a steeply sloping, shrubby strip set on fire many times, taking in the highway and immediate neighbouring areas;
- a relatively flat cultivated area;
- a woody zone (especially small oaks) situated at high altitude.

The second arson area (loc. Tabina) was almost completely composed of degraded shrubbery, the result of many fires over the past few years, and the excessively clayey soil.
The extention of these burnt up areas was visually assessed by the personnel of the State Forestry Corps (CFS) but no precise carthographic survey or photographic monitoring was carried out.

Scope of the Research

The scope of this research was to make:
- a precise planimeter of the areas overrun by fire;
- to verify the topographic accuracy of the survey through GPS gathering of the elements present in cartography and to confront these results with the Regional Technical Cartography (CTR), on a 1:5.000 and 1:10.000 scale (this procedure was also necessary to positioning in the graphic elaboration of the survey in the CTR);
- to verify the possibility to run a complex database specially assigned to survey forest fires through the datalogger of the GPS system (in this case the combustion indication report used by CFS) using the options of running a Pfinder 3.00 program (Trimble software run by GPS);
- to verify the survey time in the countryside and the difficulty to function in complex conditions;
- to establish a minimum and maximum surface where the GPS survey was adapt;

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- to establish, also, a methodology of intervention which renders to the maximum the survey potentiality;
- to test the difficulty in the processing data, in the corrections and in their transfer from GPS to GIS (ARC-View 2.1 in our case) and eventually assess the correct procedure of data transfer;
- to verify performance time in general of the informatic process from differential corrections to the cartographic production and to test the technical level necessary to carry out each operation;
- the search of an adequate format of digitization (and consequent filing) of photographic material which would consent running on PC programs without reducing excessively the informative contents;
- construct a digital terrain model starting from GPS data and through this make corrections and georeferencing of the archived photographic material;
- to relate between these and different types of data the archived photogrammes to make query procedures of a complex type;
produce cartographic process for use in planning (particularly the creation of an orthophotomap 1:10.000 scale of the areas burnt up by fires to use in the studies of the dynamics of fire propagation).

Equipment and methods

Base

The Trimble Pathfinder Mapping System was used for the GPS survey. In particular the 12 channel Community Base Station was used as a reporting station for differential corrections. It receives signals from 12 satellites and makes the necessary corrections to insure sub-metric precision measuring in post-processing. This station is set up inside the Department of Planning, Planning and Environment of the Emilia Romagna Regional Administration and is connected to a Compact Dome receiver aerial stabilised in a precise position in a free field of vision over the top of the building. It is activated when necessary and is used for all the GPS survey activities of the Landscape, Parks and Natural Heritage Administration. The base was found at about 20 km from the operating point during these tests, so guaranteeing sub-metric precision when surveying.

Rover (GPS mobile)

The rover which was used is a Trimble Pro XL implemented with a datalogger CMT MC-V. The ProXL is an eight channel receiver which works both in Real Time and Post Processing modes, and using this last mode it is able to give a sub-metric precision.
The datalogger CMT MC-V (implemented with 1MB of memory in the version we used) was chosen for its extreme hardiness and was designed to be used in all types of environmental conditions, it permits the management of personalized databases to store data during survey.

Aerophotographic instruments

The two areas under examination were singled out in two pairs of stereoscopic photogrammes (colour slides), being part of the shots, 1:13.000 average scale, of the 1974-1976 Regional Administration coverage actualised for the production of technical cartography in 1:10.000 and 1:5.000 scale. This material was chosen not only for its use in the production of regional cartography but because it was included in the phase of remote sensing for the Regional Foresters Inventory and was therefore, free of charge, immediately at the disposal of the forestry technicians, making it ideal for fixing operative methods at low cost. The use of these photogrammes was not compromised by their age, as the forest typologies involved in fires are stable and have not changed over the past twenty years. Further more, the use of old but available material proved to be useful in calibrating, in an extremely precise way, the real operative possibilities of the system.
The whole informatic sector involving the processing of the photogrammes was carried out a personal Computer Compaq 486 50 Mhz. The choice of working on a PC was necessary to keep low level costs of managing and also to keep the operative difficulties at equally low levels.
It is foreseen that the user can be not only the not exceptionally skilled personnel, but also a technical staff in possession of only a basic knowledge of informatics,and they can be the exclusive users of this type of equipment.

Survey

The procedure methods of the GPS survey, one for each area, was carried out over two days (11th and 22nd August 1995).
Immediately before undertaking the survey, preliminary work was done (assignment planning and check in of the land equipment). The forest fire survey was effected by two Regional technicians assigned to GPS and by a team of CFS as guide and controller of the results. The GPS technicians covered, on foot, the whole perimeter of the two fires and implemented the information in database during the march.
Walking back at the end of the survey, an observation was made of the principle road conditions (SS64) and of the access to the burnt areas (known datum was chosen for its verified instrumental precision which is necessary for the rapid cartographic positioning).
This procedure was carried out by positioning the aerial GPS on the roof of the car (using the suitable magnets supplied) and storing a series of descriptive data en route.

DPGS

The differential corrections were calculated in post processing immediately on return to base, using software Pfinder equipped with ProXL system. After the corrections were made, the geographic co-ordinate of various points were transformed from DATUM WGS84 (approved GPS system) in ED50 UTM projection with the scope of rendering the survey overlay possible on the existing cartography.
The technique of differential corrections was chosen for post processing work as, when it is not necessary to work within a certain time and then connect it via radio to the rover base, this technique makes the survey procedure quicker and economical.

Photogrammeter processing

The slides were digitized using a 600 d.p.i. scanner limiting collecting to the concerned areas, in such a way as to minimise the processing time. Seeing that the morphology of the area concerned presented not indifferent variations of quote, the simple production of a digital photoplan did not guarantee a sufficiently correct representation. For this reason ORTHOMAP (SISCAM) software was used.
The images were orientated externally using the "space resection" method, giving the system the focal point of the photocamera used for the shots and a sufficient number of visible co-ordination points on the image. The software, therefore, processed the initial images in function of the points

collected with the GPS, transforming them from central projections into geometrically correct orthogonal projections. The images treated in this way can be used for calculating surfaces,overlaying vector and raster elements relevant to them, theme input and handling inside a GIS. The data originating from the survey with the GPS was also processed by software HIFI (commercialised by SISCAM) which enable to carry out three dimensional designing.

Data transfer Into the Forestry Informatic System

The data gathered and processed in the way described above was further handled with the aim to be taken out and stored in the Forestry Informatic System of the Emilia-Romagna Regional Administration. This is a GIS, partly autonomous, but interconnected,of the Regional Informatic System (SIR) operating on PC in ARC-View within which, not only data-base from SIR is stored data (point) originally from the Regional Forestry Inventory ,but the limits and aspects of the parks and of the State reserves and forests.

The transfer of GPS data from rover to ARC-View is done in various stages:

1) the transfer of data from rover to PC by means of software Pfinder supplied with the GPS system;
2) the differential corrections in automatic of data gathered though the software Pfinder;
3) the eventual manual corrections of corrected data using software Pfinder;
4) the transfer from the format by means of software Pfinder to the format ARC-Info[5]
5) the transfer from the format to ARC-Info to the format ARC-View by means of the software ARC-Info;
6) the orthoimages produced by the ORTHOMAP system are in format TIFF and therefore directly readable by ARC-View.

Results

Examining closely each single objective, the results can be summarised as:

- the areas ravaged by fire were easily mapped and the topographic precision of the survey was verified and assessed extremely satisfactory up to the 1:5.000 scale even if no post-optimisation of the surveyed tracks was used;
- a file, relative to the forest fire survey, used by the command station of the CFS, was implemented in the rover without much difficulty, using directly the data editor inside Pfinder. It was also noticed the uselessness of a great part of this file, for the survey in the country, which in the GPS survey could be simplified in the parts concerning the fire protection procedure and a major data input (also points) of station descriptions could be acquired;
- the survey of the two areas carried out on two separate days, for a total of 10 complesive working hours in the country, was:

6 hours for the survey of the Sibano area, more complex in form and so with longer boundaries to be covered and not easily accessible forestry topsoil;

4 hours for the Tabina survey, more regular in form and almost entirely covered with degraded shrubby topsoil making it more accessible.

The survey time takes in:

1) the apparatus preparations and setting off from the base;
2) the reaching of the area to be surveyed;
3) the mounting-up of the rover components and control of their functioning;
4) the marking out of the fire boundaries (which was done covering, on foot, the external perimeter of the burnt up areas and their "zoning", taking into consideration the cultivation typology which previously existed;
5) the return to the stand whilst monitoring the track conditions;
6) the dismantling of the rover components and the recharging of the batteries and datalogger;

- the complex orographical situation of the territory (steeply sloping, extremely irregular and numerous accessibility problems, above all, in the Sibano area) did not influence the time factor of the survey. Neither was the apparatus limited by these factors. The capacity of the technician to work in difficult conditions, keeping constant attention to the controls of the instrument, resulted decisive;
- the number of people involved in the country survey, was over estimated in respect to the real needs. An optimal team could be made up of two people, a GPS technician and the other as a back-up and guide;
- the GPS survey presents the same problematic and time factor for rapid ground survey and this kind of survey seems to have the same operative limits. The minimum dimensions, similar to those surveyed in this work, seemed ideal for monitoring without a too accurate planning of the mission. Larger or more difficult areas, however, necessitate an accurate survey programme from an operative view-point to the logistic one;
- the pre-processing and correction of the data system did not result particularly complex and is well handled by Pfinder. The major difficulties were, on the contrary, found in the corrections of the precision and in the transfer of data in format GIS. These changes were not completely tolerated by the program and needed the continuous intervention of the technician. Other limits were found in the impossibility of direct data transfer from by Pfinder to ARC-View. This limit made us adopt the specific mode of ARC-Info and hence work stations and technicians would be able to manage them;
- the data processing was carried out, each time, on return from the country survey, by a technician with informatic skills adequate to working with Pfinder and ARC-View (in PC mode) and capable of some work on ARC-Info. During the course of an hour, corrected surface data was collected (processing entirely done on Pfinder) while the emission of data in ARC-View and cartographic processing required three hours for the Sibano area and two and a half hours for Tabina;
- the format TIFF was defined as the digitizing and archiving format of photographic material which permits the collection of digital material to run on PC without reducing the informative content;
- a digital terrain model was set up starting from GPS data and through this the archived photographic material was corrected and georefenced;
-a complex quering of the archived photogrammes was likely because it was possible to relate between them, and with other types of data;
- an orthophotomap was drawn on 1:10.000 scale of the areas covered by forest fire to be used in the studies of the dynamics of fire propagation

After data processing ,the following were obtained:

a) the amplitude of the areas and their boundaries which were transmitted immediately to CFS to be confronted with the results from previous reconnaissance carried out;
b) a group of territorial elements corrected and ready to be run on GIS;

[5] This and the following operation can be automatic using the option PathFinder 3.1 and Arc-View 2.1 it is, however, inconvenient as it is impossible to transfer the feature.

c) through ARC-View 2.1 maps were drawn up of the areas under examination including the main and secondary roads. These elaborations were printed onto a translucent support and overlapped on the Regional Technical Cartographic (CTR) using the roads as anchorage and control points. Copies in 1:5.000 scales were specially made and delivered to the CFS;
d) the orthoimages from two photogrammes, taken in flight in 1976, onto which the boundaries of the forest fire areas and the contour lines (taken from CTR 1:10.000 scale) were overlaid. The files produced (1:10.000 and 1:5.000 scale) were inserted in ARC-View 2.1 and joined to data base obtained from the GPS survey;
e) the three dimensional grid, including the map showing slopes, the functional slants to the evidencing of the dynamics of the forest fires.
The experimentation carried out was aimed to use to the upmost the technical aspects achieved from the GPS survey.
The GPS instruments used for the survey showed to be easy to use, extremely flexible and solid and therefore efficacious to survey over limited time periods and in difficult conditions. This instrument could be used successfully by staff who are unskilled in informatics, after a brief period of specialised training.
Greater difficulty was found during the organisation of inserting the survey in the GIS, together with the need for more specialised technicians, this was above all to avoid a chaotic data input and total disorganisation of relating to GIS.
In all this series of data the following work is foreseen:
- themes input (digitalization of areas to which certain information is associated);
- building up of an informative system in which functions are attached, in every area, at lower levels and to which, in their turn, elements (further images, vector drawings, texts etc.) are linked. This process can be developed infinitely.

Conclusions

Only partial and quite limited results were given, considering the informatic instruments used. These results are, however, important to determine:
- an outline of the operative methodology to use when handling photographic materials (of different kinds and not necessarily photogrammetric) together with cartographic material;
- to evaluate the different informatic structure working on a PC which has the most versatile operative mode and is economically convenient which makes it attractive and suitable to use even in small corporations.
This is only the first stage of the research which will be further investigated and amplified especially in the study of the informatic modes appropriate to use as GIS for territorial planning.