

# Automated Fire and Flood Hazard Protection System (AUTO-HAZARD PRO)

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**ABSTRACT:** *AUTO-HAZARD PRO*, a European Commission-funded research project (EVG1-CT-2001-00057), integrates real-time and on-line fire and flood hazard management schemes into a GIS-type platform. The system will be run on an operational mode in Disasters Management Centers and in connection with local resource management agencies across hazard-prone EU areas. Specific tasks will be to develop: (i) an environmental and technological Data Base Management System, with electronic information (i.e., fire occurrence, topography, soils, weather, vegetation, land use, administrative and technical resources) and digital mapping capabilities for natural hazards/fire protection and effects mitigation, and environmental impact assessment; (ii) a Decision Support System dealing with proactive planning and emergency management of real-time fire episodes, including fuels management, socio-economic criteria, a priori risk forecasting, automatic fire detection and optimal resource dispatching. Collection, input, storage, management and analysis of the information depend on advanced and automated methodologies using remote sensing, GPS, digital mapping and GIS. The system will be supported by an operational weather forecasting system that will supply regular 72-hour weather forecasts and down-scaled forecasts in the areas of interest. Field sensors of autonomous fire detection will be linked to the Operations Center within *AUTO-HAZARD PRO*, where the alarm signal will be evaluated to stimulate proper responses. Short-term dynamic fire and flood danger indices will be developed for better and realistic prevention and pre-suppression planning. Proactive development of such information infrastructure, with the use of computers and the integration of ground and satellite technologies, will assist not only in fire prevention and post-fire rehabilitation planning, but also during a fire outbreak using fire growth simulation models for prompt (human and technical) resource dispatching, initial attack and effective damage mitigation.

## 1 INTRODUCTION

Automated Fire and Flood Hazard Protection System (*AUTO-HAZARD PRO*) is a European Commission-funded research project which has been designed to improve the level of technologi-

cal development on fire, and the resulting flood hazard, management in Europe and therefore to help authorities on taking the appropriate actions to protect the environment and human lives. Improvement of the scientific knowledge about technological and biophysical fire processes should minimize environmental degradation and optimize ecosystem management strategies, contribute to the design of emergency response procedures, and help to assess wildfire's role on vegetation damage, wildlife changes and air pollution in various scales. Since fires have regional and local detrimental effects on the environment, human life and property in rural and urban areas, improvement of the technological knowledge on this subject yields important economic and social impacts.

The main objective of the AUTO-HAZARD PRO is to integrate real-time and on-line wildfire hazard and post-fire management schemes into a GIS-type platform. The prototype system will be centrally run on an operational mode in Disasters Management Centers and in connection with local resource management agencies across hazard-prone EU areas. Specific tasks will be to develop:

- An environmental and technological Data Base Management System, with electronic information (i.e., fire occurrence, topography, soils, weather, vegetation, land use, administrative and technical resources) and digital mapping capabilities for natural hazards/fire protection and effects mitigation, and environmental impact assessment;
- An on-line Decision Support System dealing with proactive planning and emergency management of real-time fire episodes, including fuels management, socio-economic criteria, a priori risk forecasting, automatic fire detection and optimal resource dispatching.

## 2 METHODS AND DELIVERABLES

The AUTO-HAZARD PRO project has been divided into ten (10) Work Packages (WP) that follow the logical phases of its work cycle (Figure 1). Each WP corresponds to a major sub-division of the project and has one lead participant. The project will have duration of 30 months and combine the efforts of 7 partners and 2 end-users, from 3 country-members of the EU (i.e., Greece, Spain, and the Netherlands). Participating Institutions include:

1. University of the Aegean, Department of Geography (**UAEG.DG**), Mytilene, Greece (Coordinator)
2. Institute of Accelerating Systems and Applications (**IASA**), Athens, Greece
3. G. Karavokyris & Partners Consulting Engineers Ltd (**GKP.CE**), Athens, Greece
4. TECNOMA S.A. (**TECNOMA**), Madrid, Spain
5. Netherlands Organization for Applied Scientific Research (**TNO.FEL**), Physics and Electronics Laboratory, The Hague, Netherlands
6. Carlos III University of Madrid, Department of Computer Science (**UCAR.DCS**), Madrid, Spain
7. Space Imaging Europe S.A. (**SIE S.A.**), Athens, Greece (Subcontractor to **UAEG.DG**).

The project has officially the end-user participation, contribution and support of state agencies responsible for natural hazards confrontation in these countries. In Greece, the project consortium cooperates with the General Secretariat for Civil Protection (GSCP) of the Ministry of Interior. The consortium through the Spanish partners will be in close cooperation with the Council for Environment of the Madrid Region that provides services of prevention, mobile vigilance and assistance to forest fire fighting and control operations, including fire evaluation and assessment and control of displaced resources. Both end-users will act as a steering group to the consortium and will participate in all project meetings with a key role in system requirements generation and system/trial evaluation. The next two Tables show the Work Packages (Table 1) and the Deliverables (Table 2).

Table 1: Work package list

<b>WP No.</b>	<b>Work Package Title</b>	<b>Lead Participant</b>
1	Project management, dissemination and exploitation of results	UAEG.DG
2	Field and satellite data acquisition, and digital mapping	UAEG.DG
3	Atmospheric modeling and weather forecasting	IASA
4	Forest fire detection system development	TNO.FEL
5	Database architectural design and management	UAEG.DG
6	Risk forecasting and fire propagation simulation	UAEG.DG
7	Hydrologic modeling for burned areas	GKP.CE
8	Emergency Management Web Site development	SIE S.A.
9	Software application and network infrastructure development	UCAR.DCS
10	Field tests and validation of results	TECNOMA

Table 2: Deliverables list

<b>Deliverable No.</b>	<b>Deliverable Title</b>
D1	Project Management Guidelines
D2	Project Detailed Workplan + Quality Plan
D3	Progress Report
D4	Annual Scientific Report
D5	High Accuracy Digital Maps
D6	Database of the operational weather forecasts
D7	Meteorological maps
D8	Multi-spectral data acquisition system
D9	Second Progress Report
D10	Flood model
D11	Fire season trial multi-spectral detection system
D12	Second Annual Scientific Report
D13	Multi-purpose Electronic Data Base
D14	Database Management System
D15	Fire Danger Index
D16	Fire Weather Index
D17	Fire Hazard Index
D18	Fire Risk Index
D19	Fire Behavior Index
D20	GIS simulation on hazards events
D21	Flood forecasting
D22	Flood risk index of burned areas
D23	Final Scientific Report
D24	Forest fire detection system
D25	Internet Map Server presenting the results
D26	User-manual
D27	On-line and Real-time Decision Support System on an Advanced Computer Application

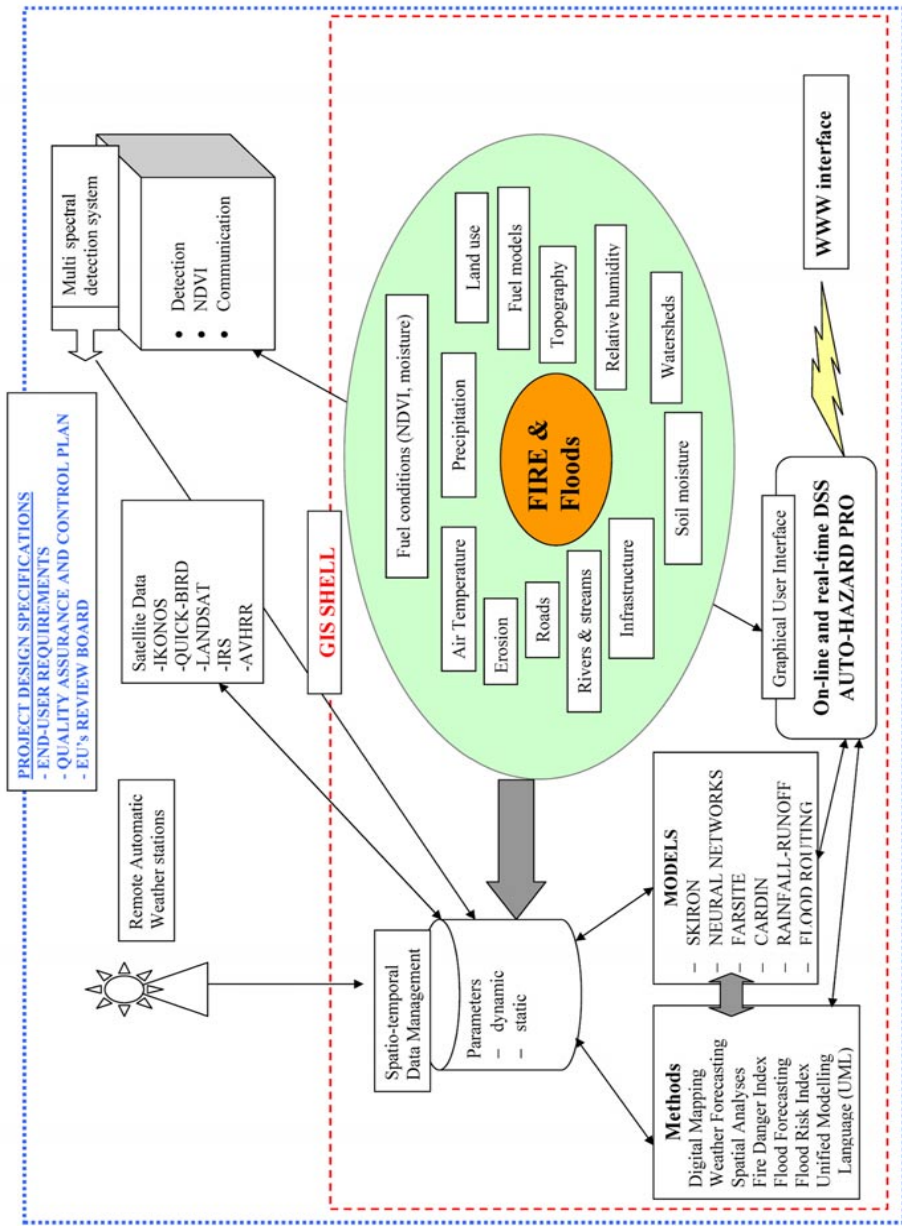


Figure 1. Project design specifications

Development of the AUTO-HAZARD PRO system will be accomplished on three study areas; in *Lesvos* Island of Greece for wildfires, in *Samos* Island of Greece for floods and in the *Madrid Province* of Spain for wildfires with the potential to later encompass whole regions of EU countries on operational basis.

The development of a real-time hazards management system is considered essential to serve the environmental protection and management needs of the European Union, providing information that have spatial and temporal attributes. For this objective, integrated ground and satellite technologies will be applied in the AUTO-HAZARD PRO using advanced tools and models of past and present research for the inventory, mapping and monitoring of geomorphology, land cover and use and atmospheric processes.

Natural hazard protection (e.g., from wildfires and floods) requires the use of large volumes of data that change continuously over time and space, creating both the need and the opportunity to automate the tasks. Within the framework of the current project, the consortium is in the process of purchasing Remote Automatic Weather Stations (RAWS) that will be installed on pre-selected areas of the study areas, in order to continuously record and transmit in-situ meteorological data and to inform the officers responsible with the prevention and suppression of forest fires and floods. The entire system will be supported by an operational weather forecasting system (SKIRON) that will supply regular 72-hour weather forecasts and, in addition, down-scaled forecasts in the areas of interest. The weather forecasting system will also provide a reliable multi-purpose and -use meteorological database and general information for the flood forecasting module.

In the project, data from various Earth Observation Satellites will be used to extract geographic information useful to study and monitor the wildfires and floods. The whole island of Samos will be covered by IKONOS monoscopic data of summer 2000 (before, during and after the wildfires). Additionally, using an external DTM, we will orthorectify and mosaic the various strips of Samos in order to generate a unique ortho-coverage of Samos. For the *Lesvos Island*, it is considered to evaluate the interest of using 2.5-meter multi-spectral Quick-Bird images that will cover 900-1000 km<sup>2</sup> of the island. Various characteristics such as road networks, infrastructures, land-use boundaries, watersheds etc. will be extracted from the Quick-Bird data. A DTM of Lesvos Island will also be acquired from external sources. In terms of the *Madrid* study area, we will order 2.5-m multi-spectral Quick-Bird images covering an area of approximately 400 km<sup>2</sup>. Quick-Bird data will be purchased by the km<sup>2</sup> that allows the flexibility to focus on the specific areas of interest. In addition to satellite images processing, land use maps and vegetation maps (NDVI) will be extracted from existing maps and Landsat TM data to overall prepare digital maps of high accuracy (i.e., vegetation, fuels, fire danger, fire prevention and suppression resources).

Within AUTO-HAZARD PRO, a large-scale dynamic Fire Danger Index will be developed for determining preparedness levels and also as an important element of the decision making process for the dispatching of forces to a starting fire. This index is a basic tool to forecast the conditions that are favorable for the start and spread of wildfires in specific days and hours and will be composed by the Fire Weather Index, Fire Hazard Index, Fire Risk Index and Fire Behavior Index (Figure 2):

- Fire Weather Index (FWI) which will be based on data received by RAWS and the weather forecasting system. Atmospheric temperature, relative humidity, precipitation and wind fields will be the main variables in this index.
- Fire Hazard Index (FHI) which will be based on data extracted by satellite images. Fuel models and fuel moisture will be the main variables in this index.
- Fire Risk Index (FRI) which will be based on socio-economics databases and classification results from satellite images. Land-use change stress, anthropogenic structures and socio-economic indices will be the main variables in this index. The role of this index is to predict human-caused fires either by accidents or arsons.

- Fire Behavior Index (FBI) which will be based on topography, weather and fuel of the study areas. The role of this index is to characterize a potential fire ignition regarding its probability for spreading.

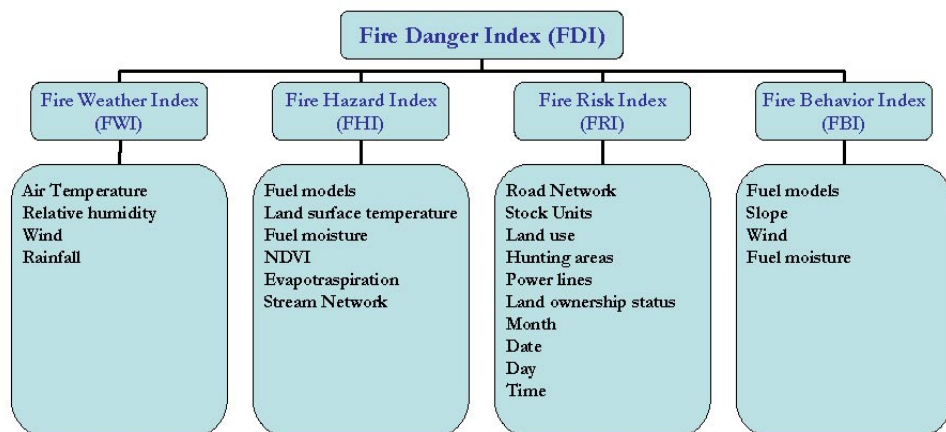


Figure 2. Fire danger index

It is known that short detection time is the major factor for successful fire management. Thus, another critical component of the AUTO-HAZARD PRO system is a new Fire Detection System that integrates a multi-spectral camera on a scanning pan-tilt unit. The alarm message is sent to the operational center where the operator can request a false color image for visual confirmation of the starting fire. This new multi spectral concept is a major step forward compared with the starting B&W approach, in that the availability of multi-spectral camera opens the way to the multi-spectral (using special selected wavelengths) smoke detection solution. Based on new available hardware and experience, a working forest fire detection system (multi-spectral scanning platform) will be developed and demonstrated during the summer of the last year of the project.

Field sensors of autonomous fire detection can be linked to the operations center within AUTO-HAZARD PRO, where the alarm message will be evaluated by the operator to stimulate proper responses. The operator has the option to ask for an image to perform a visual confirmation of the fire detection. The images can also be used to monitor the fire incident. Ground and airborne forces will be in contact with the center not only to dispatch when a fire explodes and to adjust positions and patrol/control routes in case of fire behavior changes, but also to preventively manage resources at stake according to fire risk indices.

Finally within AUTO-HAZARD PRO, the proposed flood modeling methodology relies on the following concepts:

- Adaptation of rainfall-runoff models to assess flood and erosion hazards
- Development of a simplified catchment-specific meta-model approach for use on flood forecasting, incorporating meteorological forecasting data
- Development of flood risk index methodology for intact and burned areas
- Meteorological and hydrologic data compilation and analysis for pilot application
- Application of a flood forecasting methodology in specific pilot case in the island of Samos.

### 3 QUALITY MANAGEMENT PLANNING

The best way for AUTO-HAZARD PRO to ensure that its results are appropriate, of good quality and are suitable for exploitation is to adopt a fairly open policy of communicating and cooperating with others. AUTO-HAZARD PRO will be part of established Networks and the dissemination mechanisms designed within the EESD framework and DG-XII in general. Particularly, the project is open not only to negotiation with other DG-XII projects and clusters that wish to join or make use of the project's work, while project work is ongoing, but also to participate in Workshops organized by the EC Projects and other parties, with an aim to coordinate technical activities, exchange views and information and transfer know-how.

AUTO-HAZARD PRO will activate formal and informal cooperation with a number of working groups. The promotion of project results to these groups will enhance the diffusion and awareness of the project's achievements in Europe and worldwide. The target groups of this project are all national, regional and local authorities responsible to take decisions and manage forest fires operations throughout Europe, and mainly those in high-risk areas (e.g., Mediterranean regions, Continental highlands, etc.).

The delivered products and services to the end-users of the project (e.g., the General Secretariat for Civil Protection in Greece and the Council of Environment of Madrid in Spain) will be achieved through quality assurance and control (QA/C) planning. The QA/C activities will provide compatibility of the project components, minimize procedural and technical errors, and guarantee the usefulness and efficiency of the final products. The quality management planning includes concrete measures for the project's internal procedures, management, quality assurance and quality organization (Figure 3).

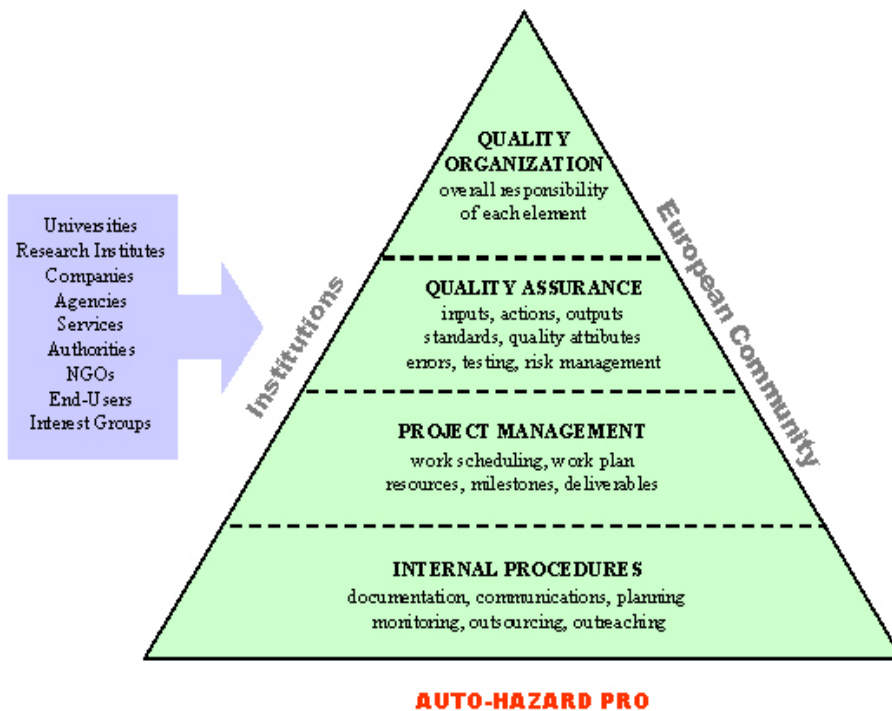


Figure 3. Pyramid structure of the quality management plan

The project AUTO-HAZARD PRO will contribute to the improvement of the quality of life, health and safety, both directly and indirectly through the improvement in scientific underpinning of fire and the associated flood hazard management. AUTO-HAZARD PRO will assist building an infrastructure of people and equipment, as well as short-term rehabilitation, in close association with local resources with a view to facilitating the relief efforts and preventing the impact of the forest fire incident from worsening. It will ensure adequate preparedness for fire risks by using a suitable early warning and intervention system. The development of prototype products and technologies within AUTO-HAZARD PRO as well as the operational nature of them within the State services will increase the need for more specialized and trained personnel to fully operate final applications and optimize the productivity and effectiveness levels of existing staff.

Especially in areas of high risk, AUTO-HAZARD will contribute to the implementation of integrated forest protection plans, comprising measures to reduce hazards and to institute and improve systems of prevention and monitoring. In addition, this project through the inter-disciplinary cooperation and operational groups across Europe will assist regional authorities on designing strategies on improvement of forest fire control and help on minimizing the effort and cost required for solving fire problems in Europe.

#### 4 CONCLUSION

AUTO-HAZARD PRO is conceived as an environmental risk management system for real-time and on-line operation. The overall approach that will be used in AUTO-HAZARD PRO capitalizes on existing work, combining it in an innovative way, but also adds some new concepts and includes the development of new and useful hazard management tools.

Proactive development of the pertinent information infrastructure, with the use of computers located both centrally (i.e., Disasters Management Centers) and locally (i.e., resource management agencies), will assist in developing the contingency strategies comprising of fast and realistic prevention and pre-suppression planning, real-time fire suppression operations, and rehabilitation of burned areas.

The GIS support and computer-based fire modeling of AUTO-HAZARD PRO will be providing additional knowledge to the fire dispatcher. Logically then, the system, without replacing the dispatcher, will be supporting his decisions, leading to better overall responses especially under critical and/or complex conditions. So, within AUTO-HAZARD PRO, the DSS has the important role of connecting the technology acquisition and identification information resources with the methodologies and previous experiences in handling environmental disasters. Finally, the project will reinforce the ability to carry out risk assessment linked to forest fires, and contribute to the development of verification and management tools relating to Member States and EU regulations, as well as to other international commitments.

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