

# Holistic Approach to Forest Fire Protection in Split and Dalmatia County of Croatia<sup>1</sup>

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## Abstract

The paper describes the Holistic approach to the Forest Fire Protection (HFFP) in Split and Dalmatia County. This HFFP model, unique in Republic Croatia, has been started in 2003. and it is now in its realisation phase. The model integrates not only various, technical and non-technical forest fire preventive measures, but also the long-term energy supply based on Biomass-Solar-LPG district heating and tourism and recreation. It is particularly suitable for big Dalmatian islands like Brac, Hvar and Vis. Our approach is based on three topics, trying to integrate technical fire protection measures, economic use of biomass, tourism and recreation using: (a) advanced forest fire monitoring system conceived of a network of automatic video monitoring stations, (b) organised system for collection of forest logging after forest fire thinning and clearing, its chopping and use as a commercial biomass fuel in communal district heating and cogeneration plants and (c) systematic clearance of forest corridors not only as easy access routes for firemen, but also as routes for sport, recreation and village eco-tourism.

## Introduction

Croatia belongs to countries with high forest fire risk. In summer seasons seven coastal counties in Croatia and in particular the Adriatic islands are permanently exposed from high to very high fire risks, due to densely-spaced conifer forests, very warm climate with low level of humidity and lot of tourists visiting various coastal and islands regions.

Split and Dalmatia County is on the top of this list. In Split and Dalmatia County there are 256.538 ha of forests and woodlands, mostly state-owned (227.623 ha) under management of state firm "Croatian Forests". Based on data provided by them 5.14 percent belongs to timber forests, 11.76 percent to macchia Mediterranean, 2.2 percent to stump forest, 44.16 percent to bush mixed with forests, 12.12 percent to brushwood and 24.61 percent to grass and grass-dominated land.

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Fire seasons 2000 and 2003 were particularly catastrophic. In the year 2003 in Split and Dalmatia County wildfire occurred 133 times and the total burned area was 10.028 ha “(fig.1)”. The direct damage of the lost forests including fire fighting costs was assessed at the level of 16 mil.€.



**Figure 1**—Typical landscape of island Hvar after 2003 forest fires (photo provided by Split and Dalmatia County)

The total biomass burned down volume during 2003 in all littoral areas including islands was 220.000 m<sup>3</sup> of which 125.000 m<sup>3</sup> was in Split and Dalmatian County. The energy equivalent of this burned down biomass in Split and Dalmatian County is nearly 85 percent to the value, which were needed to cover the present yearly domestic hot water (DHW) demand for 1,5 million of residents in the coastal counties. Presently, more than 90 percent of the DHW in the littoral area is being prepared by electrical boilers. If we assume the present price of electricity, the lost of money equivalent were around 50 mil.€, so we estimate that the total direct and indirect damage of the lost woody biomass in 2003. in Split and Dalmatian County was 66 mil.€.

After the fire season 2003 Split and Dalmatia County authorities together with Faculty of Electrical Engineering, Machine Engineering and Naval Architecture University of Split have initiated the comprehensive study of the forest fires in their region and as a result the new holistic approach to forest fires protection, including fire prevention, fire fighting and post fire recuperation planning was conceived (Stipanicev and Hrasnik 2004)

The high fire damage costs are due to a lost of biomass, olive oil trees, vineyards and agriculture fields. There are in addition fire-extinguishing costs as well as the costs of environmental sanative measures, which in many cases are very high. Therefore, the basic aim of a fire protection program was the lowering of wildfire risks. Costs of many preventive fire protection measures, which are not established in

the field as yet, are mostly quite low in comparison to the total wildfire burn down damage.

## Present state of forest fire protection in Dalmatia

From all fires in the region, about one half are the result of individual carelessness and other reasons coming from human behavior or man made structures (like 0,4 kV power transmission lines). The other half is due more or less due to pyromaniacs.

The fire hazards in Dalmatia are very high particularly during the summer; mostly because very dry and hot weather and presence of lot of people because Dalmatia is tourist region, but enhanced forest fire risk is present also in autumn and spring during certain agricultural field work. In the last couple of years the state authorities try to enhance the forest fire prevention and fire season preparation, so every year the appropriate action plan is defined and accepted by the Government with all prevention tasks, responsibilities and terms for their preparation. The legislation concerning forest fire prevention is also quite good but the problem is that usually in practice fire prevention tasks are applied only formally or there are not applied at all.

Forest fire prevention is normally based on three activities:

- Regular forest thinning and cleaning particularly in high risk areas close to the railway and under the high voltage long transmission lines.
- Clearing the forest corridors and easy access routes for fire vehicles and fire fighters.
- Establishment of system for forest fire early warning based on a field monitoring stations.

The law concerning forest fires and yearly action plan define the obligation of regular forests thinning and clearing, but due to high cost of these activities they are not properly applied. The character of Dalmatian vegetation is such that the wooden biomass collected by thinning and clearing could not be used in conventional heating systems present today in Dalmatia, so these activities are only expenses to organisations responsible for their execution. They don't know what to do with conifer slush because it couldn't be sell for use in conventional stoves, so often it is possible to find stacked slush on the field where it was collected, for example close to the high voltage long transmission lines.

High cost is the reason why there are not enough forest corridors. "Croatian Forests" has yearly plan for cutting new corridors according to their financial possibilities.

Forest fire early warning is completely based on a human visual monitoring. The visual monitoring practice exists only on some small areas, which are quite insignificant to the region as a whole. Although the law said that the monitoring station in high risk areas has to be established every 10 km that is hardly achieved, particularly because in summer time the whole county is more or less high risk area. There are no modern methods of video monitoring as yet in the whole region. The direct consequence of no systematic monitoring are too long delays of fire alarms,

which are additionally not well covered by information when and where the fire occurred. Most fire alarms are coming from residents by their GSM calls. Based on low reliability of such non-professional information, the fireman management has to do a nearly impossible mission.

In cases when pyromaniacs lay the fire, they choose forest areas, which are not approachable by vehicles and which are quite impassable and impenetrable, even by the man. Also, they well use the weather forecasting and fires are laid down when strong winds are blowing. At such circumstances, the delayed wildfire alarm always results in a large environmental disaster and loss of property

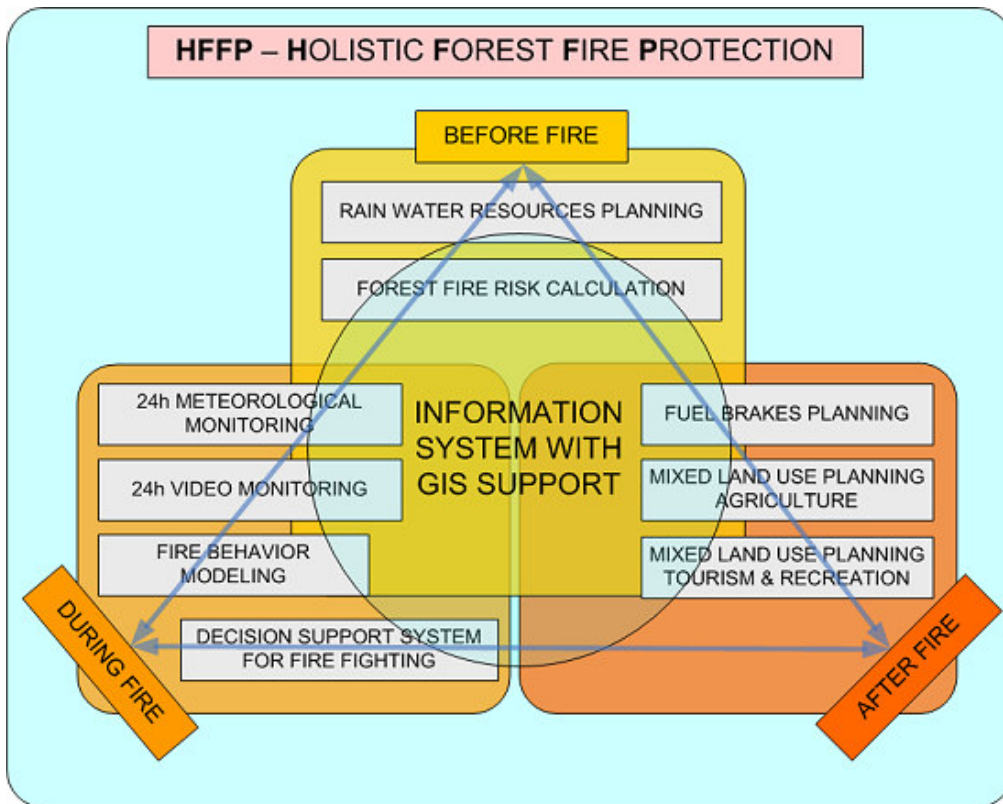
To conclude let us say that the real situation concerning forest fire prevention is far from satisfactory. Every summer we all bear witness to superhuman efforts of the fire fighters in Dalmatia, particularly on the islands. The damage caused by forest fires is not even bigger only due to quite good fire fighters organisation. The fire fighting professional intervention forces are located on each Dalmatian island and coordinated from the regional centre in Trogir. Good coordination between fire fighters, military responsible for fire fighting airplanes and helicopters and state agencies, results in short intervention time and efficient fire fighting, but as it is well known that “*it is better to prevent, then to cure*”, still a lot has to be done on forest fire prevention. Our holistic approach is primarily targeted to those tasks but other fire activities were included too.

## Split and Dalmatia County holistic forest fires protection program

Our holistic approach is primarily targeted to the fire prevention, but fire fighting and post fire recuperation planning are also concerned. The **Holistic Forest Fire Protection (HFFP)** program includes diverse actions and measures and the most important are “(fig.2)”:

- Thinning the forests by cutting and removing densely spaced trees, pruning trees and cutting shrubs to minimize forest fire risk.
- Clearing the forest corridors and easy access routes for fire vehicles and fire fighters.
- 24-hour automatic video monitoring based on video cameras sensitive in visible and near infra-red spectra with video data collecting in regional centers and automatic alarm generation caused by automatic recognition of forest fires smoke during the day and forest fires flame during the night.
- 24 hours monitoring of local meteorological data (temperature, wind speed and direction, humidity, moisture, pressure, rain precipitation and sun radiation) using independent network of mini meteorological stations.
- Calculating in more detail the fire risk index for micro locations, using, in addition to meteorological data, also vegetation maps and fuel type data.
- Advanced information technology use in forest fire fighting (GIS support, forest fires behavior modeling using real time meteorological data and vegetation maps).

- Planning the necessary treatment of vegetation, in order to provide two kinds of fuel brake, where the first is designed to reduce the fire extension and the second limits the fire effects on the target, which could be a certain settlement or a group of houses in the forest vicinity.
- Planning a new kind of “mixed land use” where forestry, cattle-breeding, agriculture, rural tourism, sport and recreation and health tourism motivate the community to take more care on the fire prevention measures.
- Planning the rain-water resources located on the land heights and hills, which is normally used in the agriculture and in case of fire, water is used to feed the extinguishing appliances.



**Figure 2**—Split and Dalmatia County Holistic Forest Fire Protection program (HFFP)

Such measures when systematically used as a part of an overall local and regional fire prevention management system can be very effective and could reduce the fire hazards to a value, which is about one third of the present fire risk.

A lot of these preventive actions for fire protection are based on data collection and early preplanning procedures. However, without appropriate data bases and effective information system such planning can not be performed. As a part of our holistic measures for fire protection in the Adriatic region, the information system capable to cope with preventive tasks, fire fighting tasks and post-fire recuperation is planned and designed (Stipanicev, Stula, Vuko, 2006).

On the European level there are a number of examples and efforts in this direction, but they are usually limited to certain tasks only, e.g. to fire risk calculation and forest fire damage assessment (EFFIS, 2007), forest fire risk prediction and fire fighting management in Galicia (Alonzo-Betanzos and others, 2003) or fire fighting optimization (PIROMACOS, 2007).

The main difference between these projects and our HFFP program is in the fact that HFFP efforts are primarily concentrated on the preventive actions, where the main goal is to find economically viable holistic approach in order to assure long term financing of such actions.

### Economic aspects of HFFP program

The HFFP program was supported by the Department for economic development of Split and Dalmatia County because our main idea was not only to rise the forest fire protection on higher level, but also to create benefits for local economy and to find appropriate economic approach in order to assure long term financing of forest fire prevention activities.

Commercial use of collecting biomass, tourism, recreation, sport and agriculture could give benefits to both, fire prevention activities and regional economy. Also HFFP program could reduce cost of fire fighting activities and post fire recuperation and that saves additional money “(fig.3)”.

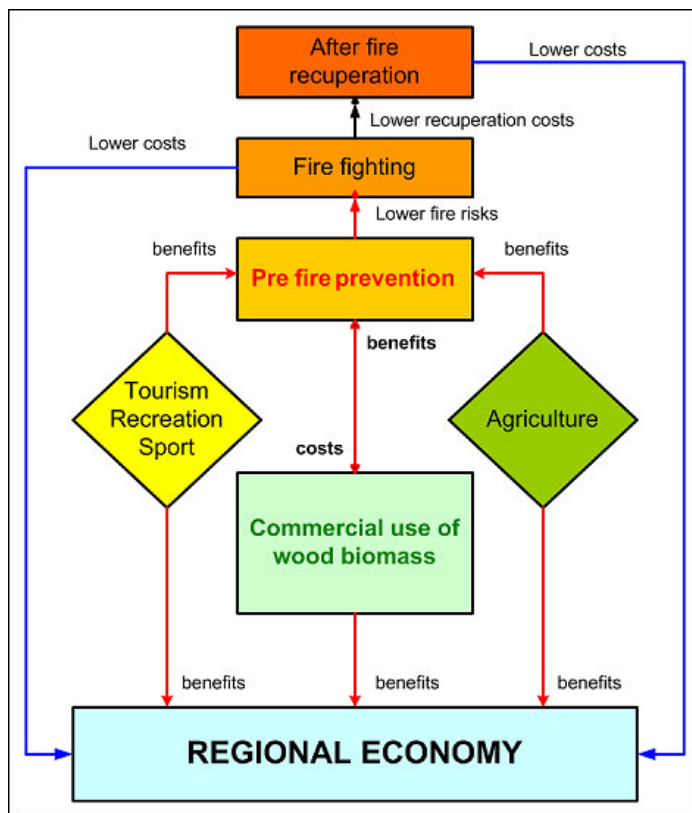


Figure 3—Economic aspects of Holistic Forest Fire Protection program

The clue is to use the residential population (very extensive) work for collecting biomass from the local area and use it locally in the combined heat and power (CHP) plants, which supply the district by energy carriers, like heating, hot water, cooling and electricity, which are transported to distances from 5-25 km and thereafter locally distributed to their end users, by means of piping networks and national (or local) electrical grid. The primary energy source, which is needed to feed the communal energy plant, shall be covered to a large extend (depending on the locally available quantities of wood fuel) by renewable energy sources, like biomass and solar energy. Local solid biomass shortage is only temporal, because in time periods of few years only, a plantation of young trees could cover the energy demand. Meanwhile, LPG could be successfully used to bridge the short-term wood fuel shortages.

The total present heating and cooling potential in Split and Dalmatian County is annually about 3 TWh for households and tourism. Forest and woodland biomass in Split and Dalmatia County in 2004 was estimated on the level of 3.224.470 m<sup>3</sup> and annual increase was estimating to 50.480 m<sup>3</sup>. In 2003 forest fires, 125.000 m<sup>3</sup> of forest biomass was burned. Converting these values into corresponding energy equivalent, characteristic for typical Mediterranean vegetation, annual forest increase correspond to 0,14 TWh and in 2003 totally 0.35 TWh of energy was burned.

In the concept of district heating and district cooling (DHDC), combining biomass and solar energy it could be possible to cover high percentage of present heating and cooling demands. The yearly wood fuel costs are estimated to 20 mills. €/year, which is deemed to cover the yearly labor, overhead and equipment costs for the fire prevention. Taking into account the actual energy price the total investment including the financing costs can be paid back in a time period estimated in the range of 6-8 years.

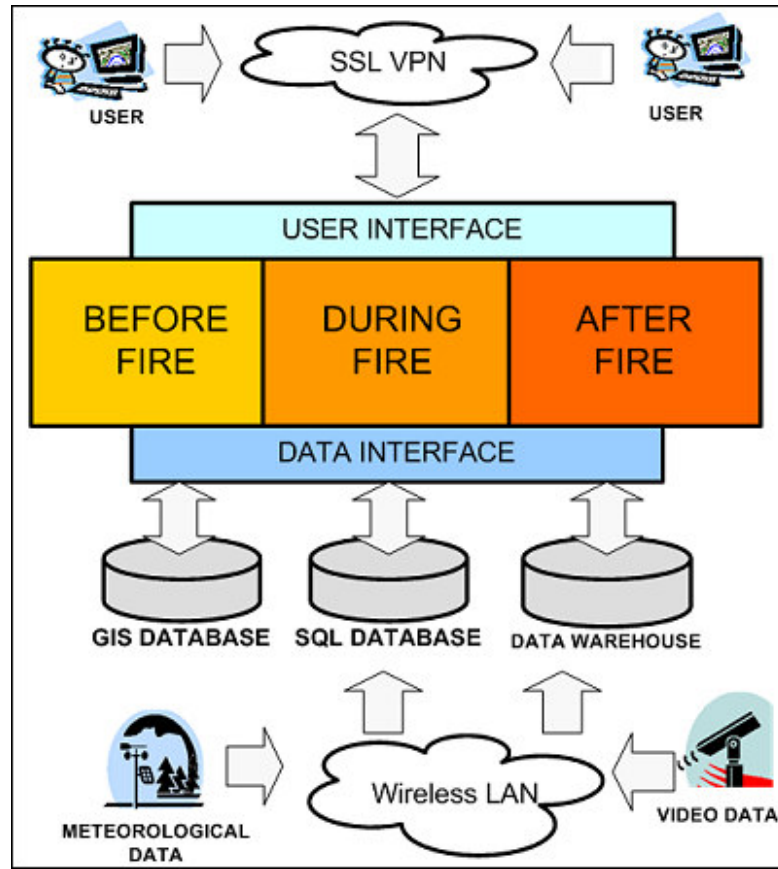
The forest corridors, easy access routes, passable and penetrable forests, make possible foresting, agriculture, cattle breeding, and also some new forms of commercial tourism, like rural, recreational and health tourism. Also, these activities will offer a plenty of new opportunities to families to build-up their existence for the years to come.

The last, but not the least, the wind potential, in particular on the islands, can be used not only to supply electricity to the end users, but also will be used as a permanent source of renewable energy for pumping stations, by pumping the rain-water to water storages on the hills, which can be used for agriculture, cattle-breeding and in the case of fires as a spare water resource.

## Information system for supporting HFFP program

Quite important part of HFFP program is the information system for supporting all forest fires activities performed before, during and after fire “(fig.4)”.

The system was conceived at the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, University of Split as a Web Information System (WIS) having three layer architecture - data layer, application layer and user layer (Stipanicev, Stula, Vuko, 2006).



**Figure 4**—Information system supporting Holistic Forest Fire Protection program

The system is based on three types of data:

a) *Real time metrological data* collected by a network of low-coast meteorological stations. These data will be used primarily for forest fire risk calculation on the level of micro location and fire behaviour modelling, but we have already emphasized that HFFP approach was deemed to satisfy more goals. Because of that meteorological data will be also used for the agriculture and tourism tasks. For example, the local meteorological data base is a good platform for determination of optimal weather conditions for some agriculture activities like plant protection or similar. Local meteorological data are also quite important for nautical tourism quite developed in Split and Dalmatia County.

b) *Real time video data* collected by a network of video monitoring stations based on cameras sensitive in visible spectra during the day and close infra-red spectra during the night. Video data will be primarily used for automatic early detection of forest fires, based on the smoke detection during the day and on the flame detection during the night, but the video network will be also used for the distant video presence in the fire management control room to overcome the difficulties of the near fire control.

c) *GIS (Geographical Information System) data bases* stores information on pure geographical data (elevations, road locations, water resources etc.), and all other



relevant information related to a geographic position, like fire history, rain-water resources locations, land cover – land use, soil characteristics, local forest corridor map, tourist routes and similar. For fire prevention planning, this module is the most important part of the information system, which is due to a fact that almost all preventive planning activities are fully based on the GIS data base.

The three main modules (BF – Before Fire, DF – During Fire and AF – After Fire) build up the system core, where each of them collects the data from sub modules. The most important sub modules are:

1. BF - Before Fire
  - 1.1. Support for Evaluation of the Set of Prevention Planning Measures
  - 1.2. Automatic Early Forest Fire Detection
  - 1.3. Fire Risk Prediction
2. DF - During Fire
  - 2.1. Planning Actions in Fighting Fire
  - 2.2. Distant Video Presence
  - 2.2. Fire Growth Modelling
3. AF - After Fire
  - 3.1. Analysis of the Impact of Fire
  - 3.2. Evaluation of the Set of Measures Necessary for Recuperation.

The application of sub modules is not limited to the one task only. For example fire growth modelling will be used both, for preventive action planning using meteorological data from the data base and for fire management using real time micro location meteorological data.

The short term measures concerned with the planning are:

a) Planning the position of video monitoring systems and location of mini meteorological stations to support primarily forest fire protection but also to support agriculture and tourism.

b) Planning the forest corridors bearing in mind not only the fire protection, but also tourism, using forest corridors as a mountain bicycle routes, or agriculture like revitalization activities in certain areas.

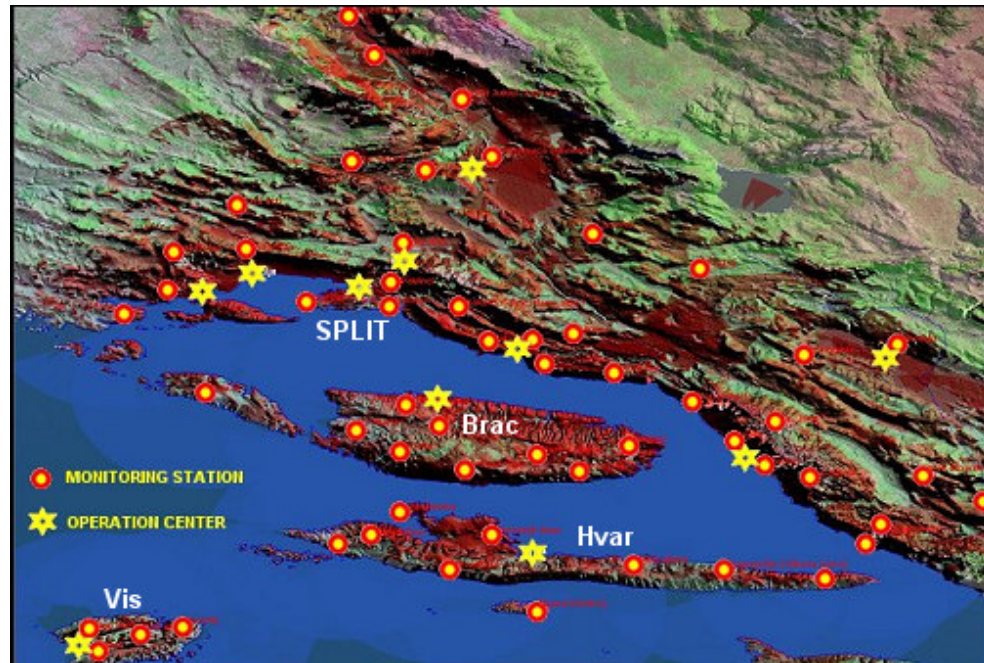
Fire prevention measures must be thorough and very extensive. If a fire prevention measures are to be fully effective, the total area under the fire protection must be included. The included area must therefore contain also those areas, which hereto never were exposed to the wildfire. Large scale thinning of forests, clearing the forest corridors, treatment of vegetation, activating of agriculture and preparing the water resources on the hills, suppose that extensive work could be adequately paid and thorough done by residential population, which could also open many new working places in the region.

## Actual state of HFFP program

The Holistic Forest Fire Protection program was presented for the first time in the autumn 2004 and since then we have been working on development of particular project parts, primarily connected with technical parts of the program. Organisational parts concerning economic use of biomass still need a lot of additional agreements and more political support.

We have been working intensively on two levels. The first one was design of forest fire monitoring network and the second one was development of certain information system parts.

Planning of automatic monitoring stations locations was a quite sensitive task because a lot of criteria have to be fulfilled. Therefore the system approach based on AHP multi-criteria decision analysis and intensive use of GIS data and GIS analyses was established (Stipanicev, Bodrozic, Vuko, 2007). The final result was the forest fire monitoring network consisting of 56 monitoring stations divided in 10 operating zones “(fig.5)”.



**Figure 5**— The project of Split and Dalmatia County forest fire monitoring network consisting of 56 monitoring stations divided in 10 operating zones (dark red color indicate land parts visible from the monitoring stations)

Such network ensures quite good coverage of all locations important from the forest fire protection point of view. The realisation is planned in three phases in the next couple of years.

Let us mention here that another county in Croatia, namely Istra County, has finished in April 2007 their forest fire monitoring network consisting of 28 monitoring stations divided in 7 zones, but their system could be a topic of another presentation.

During 2005 and 2006 three experimental monitoring stations were installed in Split and Dalmatia County, one on island Brac and two close to Split. Experiences were quite valuable and used in automatic early forest fire detection software development. This software module named iForestFire is an important part of information system supporting HFFP (iForestFire, 2007) “(fig.6)”.



**Figure 6**— Experimental forest fire monitoring station on Marjan hill (Split area) working during 2005 and 2006 fire season and two screens of **iForestFire** – intelligent **Forest Fire** monitoring system developed at the University of Split

The structure of iForestFire is also modular quite similar to overall information system structure shown in *figure 4*. The exception is that instead of modules BF – Before Fire, DF – During Fire and AF – After Fire in iForestFire we have module for user friendly manual camera control, module for advanced automatic fire detection and module for video and meteorological data archive retrieval, all of them having a strong GIS support. After two years of experimentation the iForestFire system is now in operational use.

In the next couple of years we expect the realisation of forest fire monitoring network and more intensive work on other parts of Holistic Forest Fire Protection programme.

## Conclusion

Many areas covered by forests in Split-Dalmatian County and in particular coniferous forests on the islands Brac, Hvar and Vis are mostly not approachable by vehicles, commonly the forests are impassable and impenetrable, even by a man. Also Dalmatia much suffered from forest fires in the summer time. The fire summer season 2003 was quite intensive in Split-Dalmatian County. Wildfire occurred 133 times resulting in burned down wood mass of 125.000 m<sup>3</sup>, which expressed in energy

equivalent of 0.35 TWh, could cover total present heating and cooling annual demands of 10.000 Split and Dalmatia County households.

After the fire season 2003 Split and Dalmatia County authorities together with the Faculty of Electrical Engineering, Machine Engineering and Naval Architecture University of Split have initiated the comprehensive study of the forest fires in their region and as a result the new holistic approach to forest fires protection, including fire prevention, fire fighting and post fire recuperation planning was conceived.

The main topics of Holistic Forest Fire Prevention (HFFP) program are (a) 24-hour video and meteorological monitoring including automatic early forest fire detection, (b) thinning the forests by cutting and removing densely spaced trees, pruning trees and cutting shrubs to minimize forest fire risk and their use as a biomass fuel in communal district heating and cogeneration plants, and (c) clearance of forest corridors as easy access routes for firemen in case of a fire, where at all other times same routes are available for sport, recreation and village eco-tourism.

The aim of task (b), based on the private-public partnership was conceived for two purposes, (1) to animate and make financially attractive for local inhabitants collecting of lopping, chopped wood, dry trunks, and other biomass resources on the massive scale, in order to be used as a fuel in cogeneration and heating plants and (2) to thin forests and keep the wooded area as clean and passable as reasonably possible.

Lot of these preventive actions is based on planning, which without effective information system can not be optimal. Therefore, an important part of HFFP program is information system for planning fire prevention, early detection of fire, fire fighting management and post-fire planning the recuperation of the burned-down areas.

As a result of these activities fewer fires are expected in Split and Dalmatian County. Also, a number of direct and indirect value added effects will be experienced in the local economy.

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