Decision Support System for Disaster Communications in Dalmatia

Juraj Buzolic
Croatian Telecom - Telecommunication Center Split, 21000 Split, Sinjska 4, Croatia
e-mail: juraj.buzolic@ht.hr

Nenad Mladineo and Snjezana Knezic
Univ. of Split, Faculty of Civil Engineering, 21000 Split, Matice Hrvatske 15, Croatia
e-mail: mladineo@gradst.hr, knezic@gradst.hr

Keywords: Disaster Management, DSS, GIS, Telecommunications

Abstract

Taking into account that Dalmatia (Croatian region), due to its natural characteristics is exposed to the dangers caused by natural or some other catastrophes, within DPPI (Disaster Preparation and Prevention Initiative) a project for telecommunication and information support during emergency situations is conceptualised. Within the project a decision support system (DSS) is developed. The objective of DSS is to support decision processes in the phases of preparation, prevention and planning of protection system from natural and other catastrophes, as well as in phases throughout intervention during emergency situation in the telecommunication segment. Basic module of such conceptualised DSS is GIS of the area covered by project with all necessary data about the region. Using combination of GIS and multicriteria methods, according to the dominant natural catastrophes such as earthquakes, floods, weather, wildfires and others, data about vulnerability of telecommunication system are generated. Other modules of DSS contains alternative plans of telecommunication system functioning during natural catastrophes, based on the system vulnerability, such as: automatic using of optic fibre rings and SDH equipment, as well as physical intervention into the system on the planned positions (positioning of mobile GSM and other stations, and other alternative solutions through fixed telecommunication network) and logistic operation as giving priority to the certain users, changing the area code numbers, establishment of alternative routes, etc.

1. Introduction

An ever increasing frequency of catastrophes and natural disasters with ever more serious consequences demands ever more serious preparations and joining of knowledge, information and available resources for an adequate response. One of the issues of the huge economic and safety importance in every civilised country, as well as in Croatia, is

an establishment of protection and rescue systems for catastrophes or other emergencies. Such events, like catastrophes and various emergencies, in Croatia (in post-war period) caused an average damage grater than 800.000,00 US$ (or 300 millions US$ per year). Obviously, damages varied according to their intensity and types, from year to year. Big experience in protection and rescuing of people and goods Croatia gained during the aggression and war when 14 thousands people died, 30 thousands were injured and direct material damages were about 30 billions US$. During the war in Croatia, especially in 1993., Ministry of Defence created modern and efficient protection and rescue system for people, goods and environment in emergency situations according to the models of some countries, NATO members. Reforming the system into civilian one, during 1994., the whole system disintegrated and lost its importance and functionality (Molak, 2001).
In the beginning of the year 2000 Pact on Stability for Eastern Europe promoted the building of a closer regional cooperation in the field of recovery from catastrophes and managing in catastrophes. Making of the initiative for creating of a joint regional strategy for development of preparedness for catastrophes and the strategy of prevention arose from these initiatives. This initiative, under the abbreviation DPPI (Disaster Preparedness and Prevention Initiative), is particularly oriented on achieving of the full regional cooperation, either in training, or in acting, and on overcoming gaps between international and local efforts in case of facing catastrophes which go beyond the borders and capacities of a particular country.
Joining aforementioned tendencies, University of Split in cooperation with Croatian Telecom – Telecommunication Centre Split started a pilot - project of telecommunication support in emergency situations. The project is applied (concretised) to the area of Split – Dalmatia County. Taking into account extraordinary importance of telecommunications in emergency situations, this project puts together different knowledge and information technology tools in the process of building an efficient Decision Support system (DSS) which serves telecommunication support in emergency situations. Such DSS improve operative and institutional capacities for response in the emergency situation, thus increasing total efficiency and organisational level of the emergency management system.

2. Conceptual framework for DSS development

Split - Dalmatia County is the biggest administrative and political unit of Dalmatia, and, at the same time, one of the biggest counties in Croatia. It covers almost 14.000 km^2, whereas land covers 4.536 km^2. It is situated in central part of eastern Adriatic coast with numerous islands, where 7% of total County inhabitant of 475.000 live on five biggest ones. Beauty of coast and sea, plenty of historical monuments, as well as soft Mediterranean climate make this area very attractive for numerous tourists, that, on the other side, conditions responsibility for their safety and pleasant stay.
This region, like other countries of northern Mediterranean (Portugal, Spain, French, Italy and Greece) belongs to the areas with high fire risks during the summer months, therefore all the investments in "Disaster Management" have direct and positive effect on the tourism as basic economic branch. Exposure to earthquakes, torrents and other natural

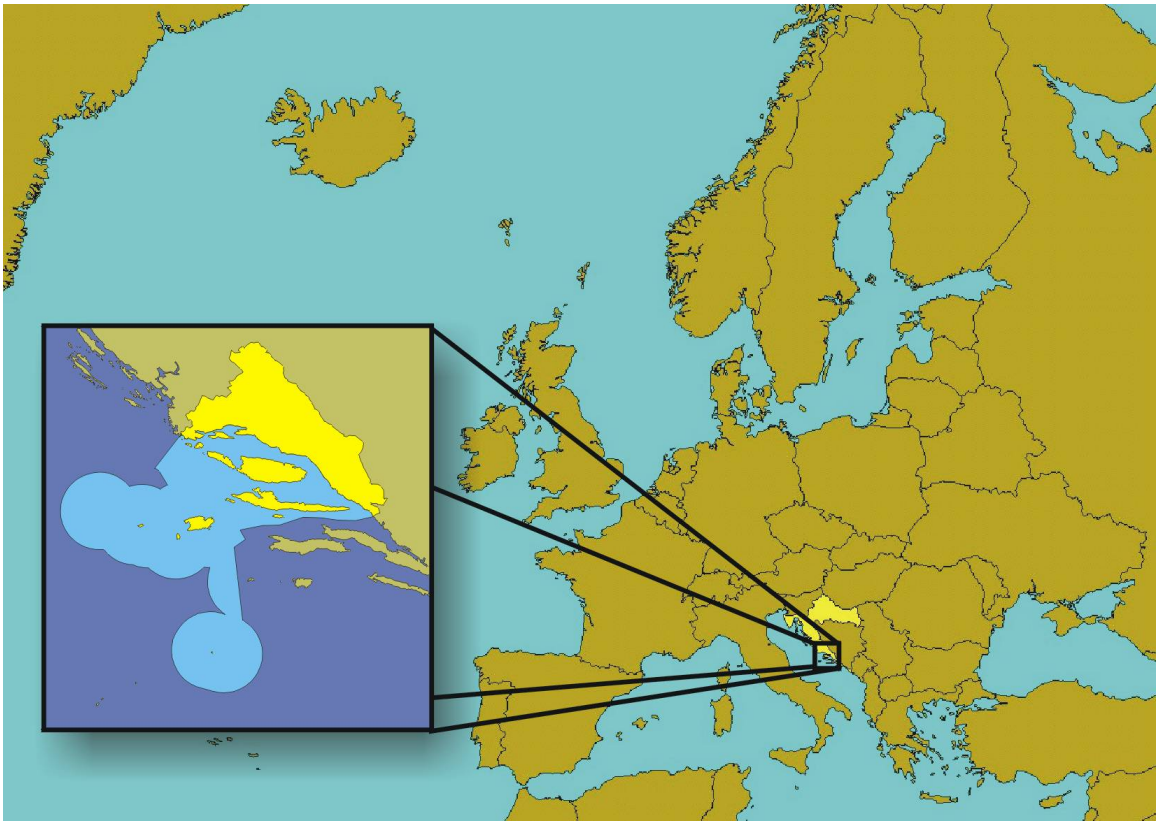

Figure 1: Layout of Split - Dalmatia county location in Europe

hazards, as well as technological accidents demands very sophisticated approach to DPPI development, meaning "Decision Support System for Disaster Communications" (DSS-DC).

According to the experience of the most development world countries, basic attention has to be focused on the protection and functioning of "critical infrastructure". Namely, it is noticed that particular segments of national infrastructure are so important, that its disabling or destruction have catastrophic impact on general country safety. In the group of "critical infrastructure" the most frequently specified are: telecommunications, energetic system, gas and oil storage and transport, banking and finance, different transportation methods, water supply systems, emergency services (including medical, police, firefighting and rescue services) and government activities. "Critical infrastructure" is like blood flux in human body and by its "cutting off " functioning of the whole system becomes questionable. Even though there is a lot of thinking about intended (terrorist) attacks on "critical infrastructure", catastrophes, natural hazards and human accidents are very often causes of infrastructure collapse. Even superficial analysis point out that inside "critical infrastructure" telecommunication system is especially critical segment, on which "lies" mutually connected computer networks that very often observe flows of energy, water, financial service, transportation services, etc. At all levels, government institution relys on same networks and infrastructure, so that the information revolution and the introduction of the computer onto virtually every dimension of our society has changed how our economy works, how we provide for our national security, and how we structure our everyday lives (Clinton, 2000). Therefore this

project emphasises the problem of telecommunications, and, practically, elaborates it as basic segment of "Disaster management" for Split - Dalmatia County.
During the last ten years, on the county area, a very power telecommunication infrastructure was built, where optic - fibre network makes its skeleton, as well as numerous telephone commutation and GSM basic stations. This infrastructure should be able, without any further investments, to take over telecommunication support in monitoring and collecting of information about potential and actual emergencies, co-ordination and management of operative acting on the site, as well as distribution of manuals and reports to all relevant institutions.
DSS philosophy is based on paradigm "Data - Dialog - Models", meaning "user" communicates with the computer on the natural language (mainly through menus), and special interfaces enable data base management and model management, that are able to communicate mutually, as well. Concerning all functions of the various services and units included in activities of preparedness, prevention, response and relief in catastrophes and other emergencies, DSS based on effective system of distributed data bases and GIS applications is satisfying technological solution that guaranties high level of effectiveness. Therefore, conceptualised DSS is divided in a number of segments (modules) that will be additionally built in the further phases. Basic module is GIS that comprise information sub-systems about spatial and other data and serves the other modules with data and information, as it is shown on Figure 2. Very important module of DSS is model base that contains models of the multicriteria analysis that are inevitable for various estimation and valorisations. In the functional sense DSS is focused on support to the activities connected to:
Segment A: planing, preparedness and prevention;
Segment B: response;
Segment C: relief and remediation planing.
In segment A it is very important to assess vulnerability of telecommunication system. Various models of DSS are used for assessment as it is explained in the following chapter.

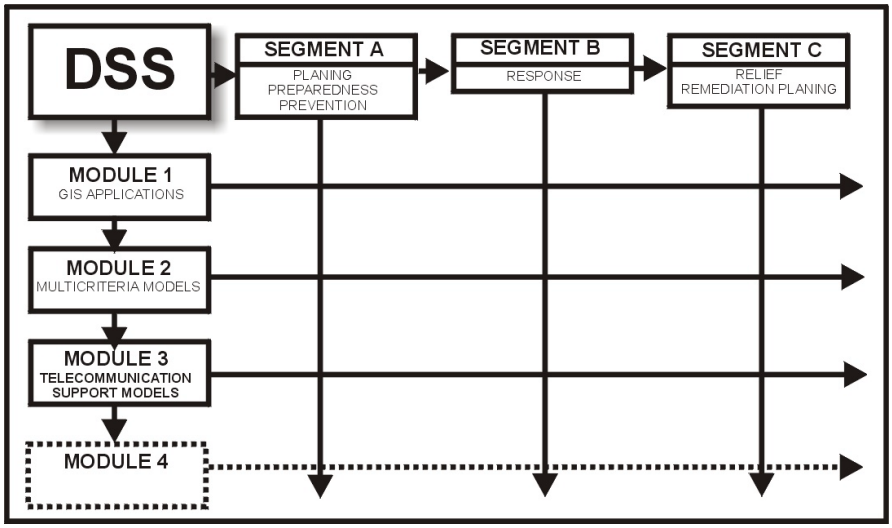

Figure 2: Conceptual framework for DSS development

3. Telecommunication system vulnerability assessment

By using various DSS modules the methodology for exact assessment of vulnerability related to existence and reliability of telecommunication system was developed. As a basis for such assessment some parts of GIS that contains thematic layers with data about certain type of the way the telecommunication system can be endangered. Previous analysis and comparisons with other countries experiences, pointed out to the most frequent causes of system malfunctioning that, generally, can be divided into two groups:

- causes generated by various natural factors,
- causes generated by human activities (directly or indirectly).

Earthquakes, floods, fires, atmospheric hazards, landslides, etc, belongs to the group of natural factors, whilst different technological accidents, or insufficient data about installation location are included in the group of the most frequent malfunctioning of the system caused by human activities.

With regard to the fact that the fibre optic cable network is the basic telecommunication infrastructure of Split - Dalmatia County, a lot of "physical threats" to its functioning have been analysed. Figure 2 shows one of the DSS modules related to contents of "GIS application - telecommunication system" with following thematic layers: commutation nodes, fibre optic cable network, GSM basic stations, and radio relay nodes (RRN).

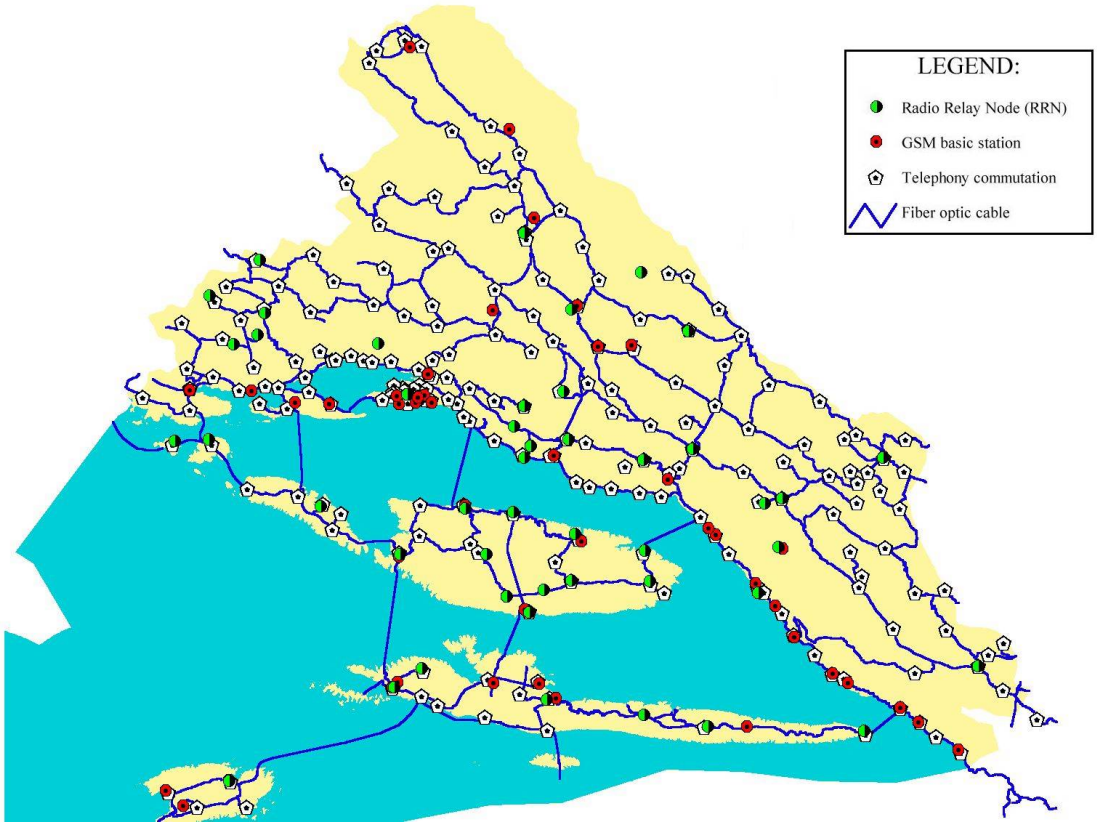

Figure 3: Telecommunication system of Split - Dalmatia County

Looking at the Figure 3 it can be seen good coverage of County with fixed and mobile

network, and as very important, a huge number of commutation nodes that enables an alternative (by-passed) connections of different parts of the region in the case of direct connection interruption. Also, interruptions of fibre optics network can be substituted with radio relay connections, so important County centres where various emergency services are situated are covered with connections from a number of directions. Almost the whole network is built in the digital technology enabling ISDN (Integrated Services Digital Network) and partly ADSC (Asymmetric Digital Subscriber Line) connections. Fixed network, mostly containing optic fibre installations, is often endangered by lightening coming through energy supply system, torrents, and partly by forest fires. Figure 4 shows the result of the overlay of thematic coverages with data about high-voltage network and torrents that are 10 m in distance from optic fibre network, or crossing it.

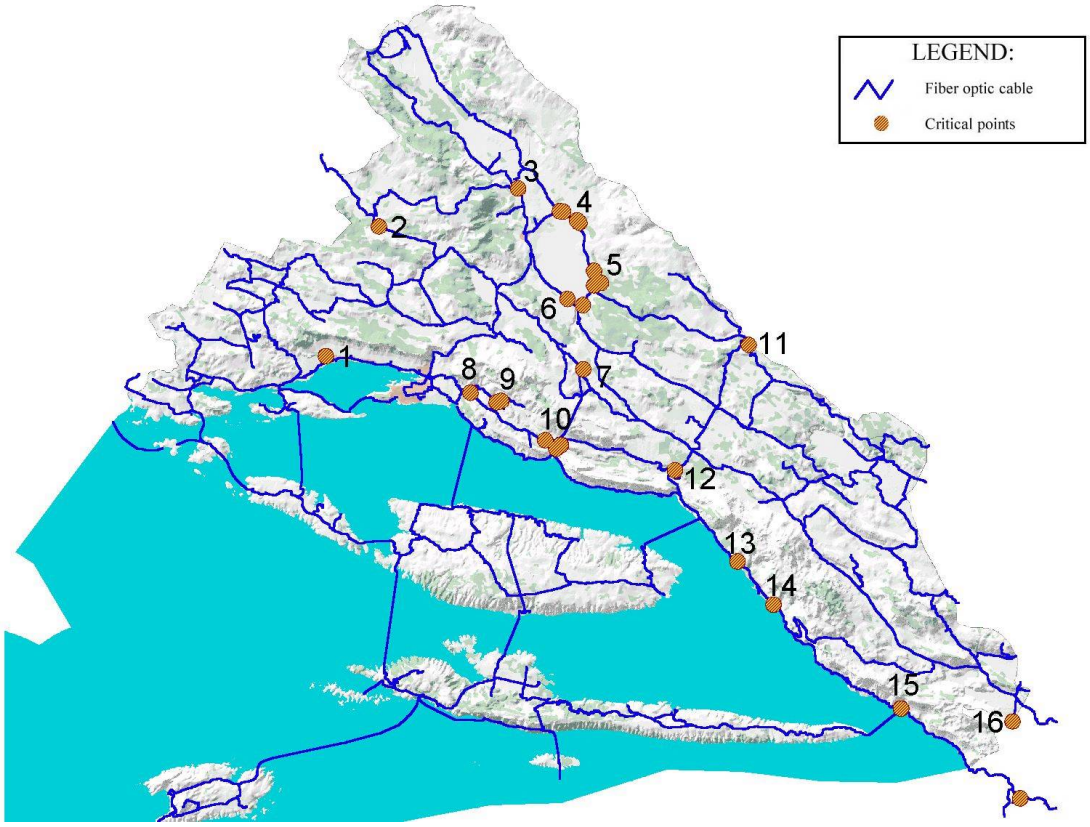

Figure 4. 3D layout of County and critical points with regard to the danger from lightning (besides high-voltage networks) and torrents

On Figure 4 it can be seen 16 critical areas with the points of the close contact with high-voltage network, torrents and fibre optic network, thus multiplying probability for network interruption as well as indicating potential system vulnerability. Figure 5 shows thematic layout with data about earthquake zones. It can be noticed that most of the County belongs to the earthquake zones 8 and 9 indicating high earthquake risk.

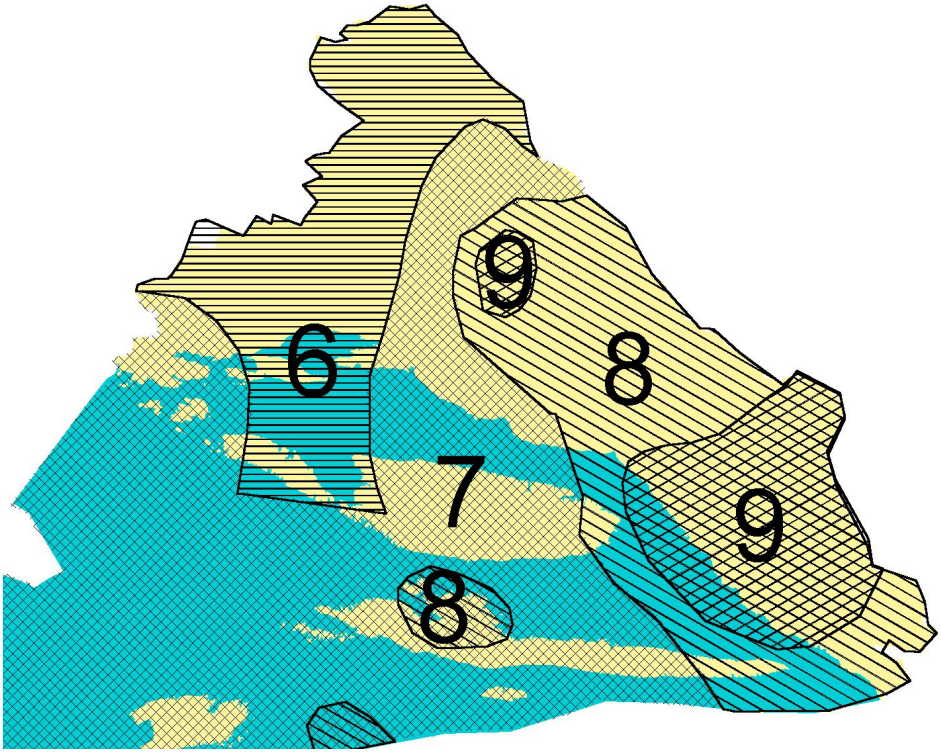

Figure 5. Layout of the earthquake zones of the County

By overlaying the earthquake zones and identified critical areas of fibre optic network, a new indicator is evaluated. Namely, in the earthquake zone 9 there are areas enumerated as 5, 6, 13, 14 and 15, while the areas enumerated as 4, 7, 11, 12, and 16 belong to the earthquake zone 8. Climate conditions, as well as Mediterranean vegetation make the whole region extremely endangered by fires. Last year the year 2000 was very "hot", when 19.378 hectares was burnt. Figure 6 shows fire sites on the areas covering more than 50 hectares, for period 1995. - 1999, and for the year 2000, separately.

By grouping of fire damaged areas, it is easy to notice zones extremely exposed to the forest fires. These zones are in correlation with standard fire danger indicators, such as forest fire risk index, moisture index, land dryness index, vegetation index, etc. By using GIS tools it is possible to group fire zones and get new homogenous zones with fire danger degree. In the zones of explicit fire danger there are critical areas 1, 3, 6, 8 and 10. From the previous analysis, area 6 has the highest vulnerability degree, and, however, adding the fire danger indicator this area has the first rank with regard to general vulnerability indicator. Area 6, situated near commutation node Sinj is in the possession of RR station, so a special attention about possible establishment of telecommunication routes via this station has to be paid.

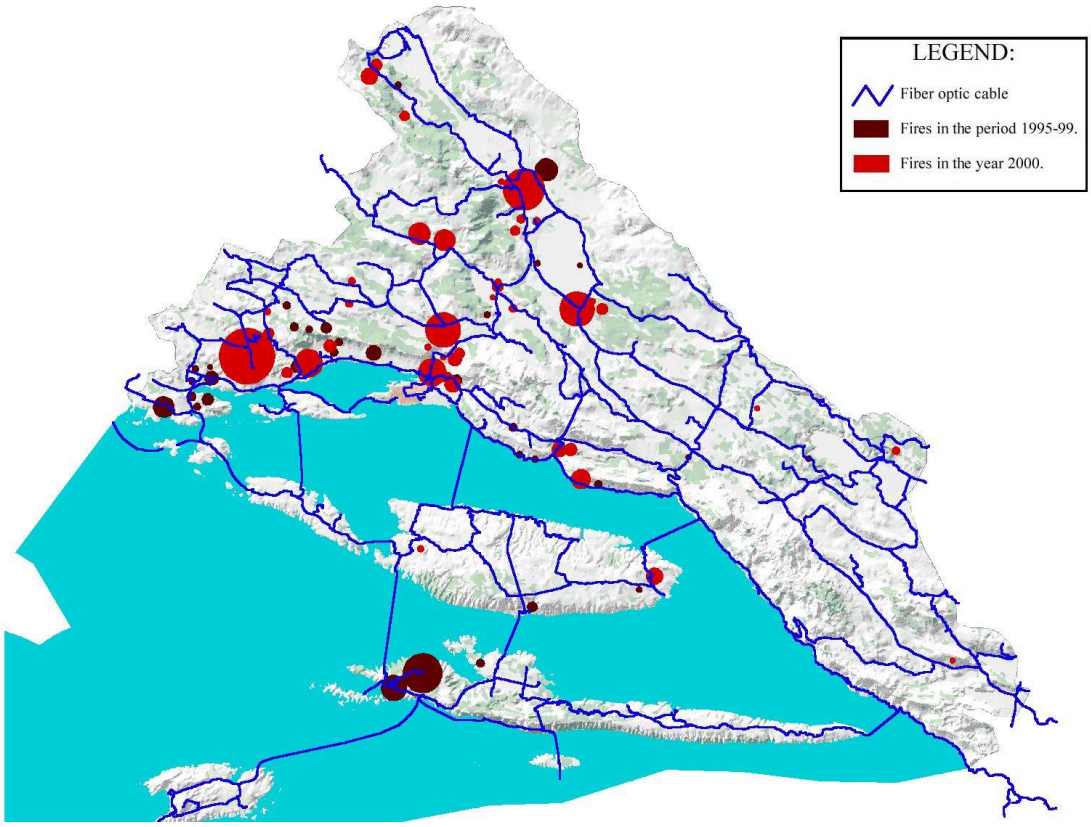

Figure 6. Thematic layer with rather big fires in the period 1995-99. and in year 2000.

4. Defining of minimal infrastructure basis for telecommunication support in emergencies

Development of MEI (Minimum Essential Infrastructure) concept by applying multicriteria analysis defines foundation of the system that takes over telecommunication support in emergencies for whole County. One of the crucial problems of telecommunication system functioning in emergencies is stability of Electric Power System that supplies all devices. With regard to the fact that a part of telecommunication system can work autonomously using its own aggregates and most of the users have cell phones, the mobile telecommunication can be used as a basic tool for communication in emergencies. Figure 7 shows existing GSM basic stations and their audibility.
By applying multicriteria analysis, GSM basic stations are chosen according with criteria: own electric power aggregates, covering the areas with high residence density, covering the most endangered areas, having the most alternative routes to other nodes, etc. One of the DSS modules provides input data for the multicriteria analysis. There is an interface between GIS and multicriteria analysis that serves as a communication link. Therefore, during the modelling phase of DSS, all data for the multicriteria analysis have to be taken into account. Another models use those data, as well. Data characteristics also show that they are connected to the space and their interpretation assumes placing them into the certain space.

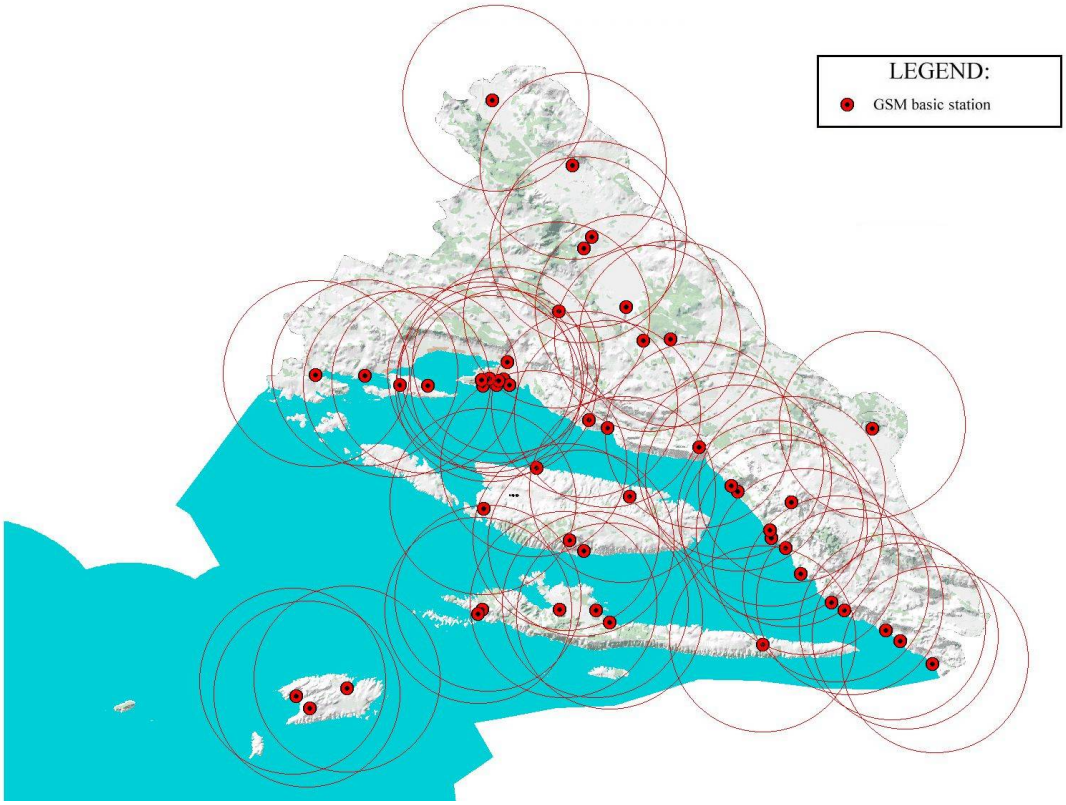

Figure 7. Layout of existing GSM basic stations and their audibility

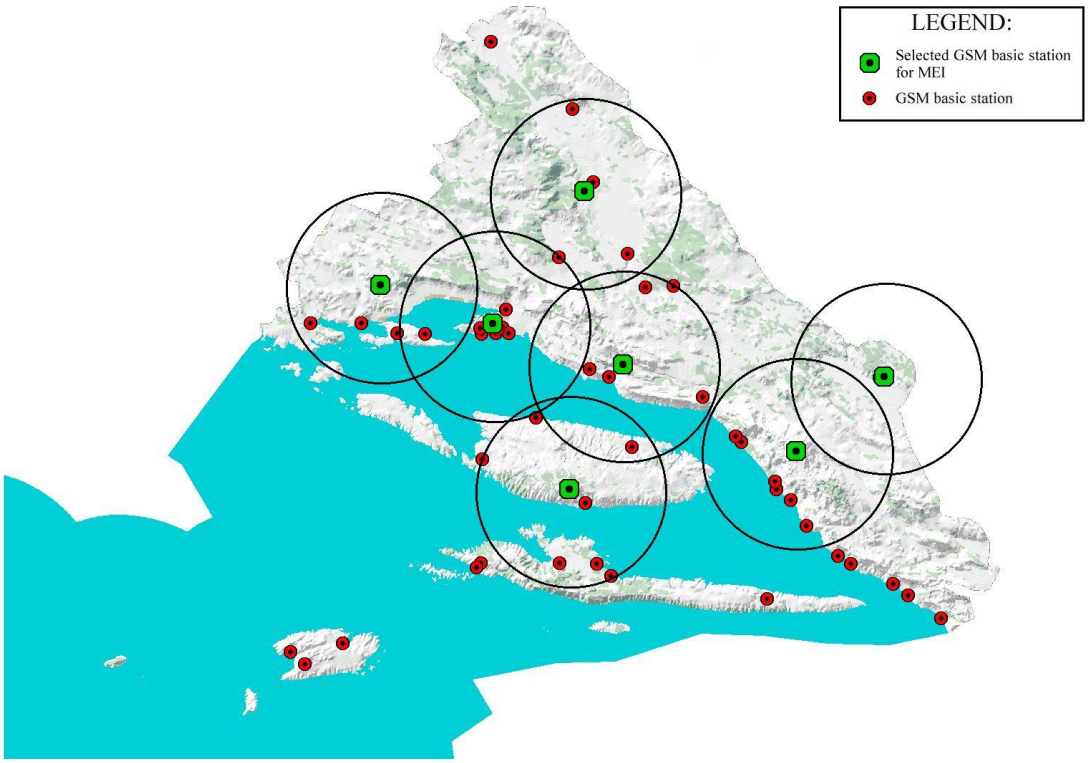

Figure 8. Layout of GSM basic stations for MEI telecommunication system insurance

Combination of an overlay technique in ArcView and PROMETHEE multicriterial analysis results with solution for basic MEI system as it is shown on Figure 8.

4. Conclusion

Vulnerability analysis and assessment of telecommunication system in Dalmatia pointed out to the critical part of the system as well as to the possible ways of MEI function establishment in emergencies. Thanks to the fact that the fibre optic network placed in the cable distribution duct is basics of the fixed network of telecommunication system, low vulnerability related to fires, torrents, earthquakes and other hazards is recognised. Big numbers of radio relay and commutation nodes enable forming of capabilities for response, reconstruction and recovery of telecommunication network in the emergencies. Putting in function available aggregates, as well as installing the new ones at the end-users (hospitals, fire brigades, police, government, etc.) involved in the emergency management system can solve high system vulnerability related to energetic supply.

References

1. Buzolic J., Mladineo N., Knezic S., GIS based fire protection management for fire risk zones, Management Information Systems incorporating GIS and Remote Sensing, Brebbia (ed.). Wessex Institute of Technology Press, Southampton, UK, 2000.
2. Mladineo, N., Lozic, I., Knezic, S., Mlinaric, D., Radica, T., "An evaluation of multicriterional analysis for DSS in public policy decision", European Journal of Operational Research, North-Holland, No. 61, pp. 219-229.,1992.
3. Molak B., "Emergency Management in Croatia", Proceedings of international congress" Fire protection", Sibenik – Croatia 2001.
4. Clinton B., president document "National Plan for Information System Protection ver. 1.0", White House – USA 2000.

Juraj Buzolic has finished Faculty of Electrical Engineering in Split in 1977. In year 1984 he got his degree as a Master of Science. Nowdays he manages the Telecommunication Center Split. He spent his working life developing telecommunication system in Croatia.

Nenad Mladineo is Senior Lecture at the Faculty of Civil Engineering, University of Split. He received his Ms.Sc. in application of Decision Making from University of Zagreb. His current research interests are in application of decision making process, GIS tools, organisational science and, especially, decision support systems in various engineering fields.

Snjezana Knezic is Assistant Professor at the Faculty of Civil Engineering, University of Split. She received her Ph.D. in application of DSS in civil engineering from University of Split. Her current research interests are in application of information technology, organisational science and, especially, decision support systems in various engineering fields.