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TELECOMMUNICATION SUPPORT SYSTEMS IN COMPLEX HUMANITARIAN EMERGENCY SITUATIONS

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Abstract

Based on the suggestions of the Tampera Conference, all countries have to ensure telecommunication support during all kinds of emergency situations, catastrophes and other disasters caused by human actions or natural forces. This obligation refers to the state and its organizational levels as well as to corporations and organizations that perform, or are the part of, telecommunication services of the country. Furthermore, obligation relates to the planning, preparedness, acting, and quick relief of telecommunication systems in emergency situations, at the same time having the objective of coordination, introduction and acceptation of regulations and protocols, as well as legal regulations. Convention suggestion emphasized usage of public mobile telecommunication networks for early alert and informing in emergency situations, as well as defining the operative procedures of telecommunication support.

This paper describes the model entitled "Telecommunication Support Systems (TSS) in Complex Humanitarian Emergency Situations" that is applied in one of the Croatian counties as an example of the Urban Emergency Planning and Response concept. The system contains several subsystems which perform their function via a mobile phone network: sending SMS (Short Messages Services) to the mobile phone of the users located in the area exposed to the danger, locating lost or endangered persons by their mobile phone, etc. All these TSS functions are connected to the local emergency centre and, in interaction with GIS support, the number of inhabitants integrated in the system can be determined. As has been previously described, such a system is based on a mobile phone network and its development, thus facing the Realities of the Third Millennium**.**

Introduction

Recent tragic events in the United States end elsewhere, accompanied with an apparent increase in frequency and scope of natural and technological disasters, clearly illustrate the need for high quality telecommunication services. Telecommunication support to civil defence and other emergency services essentially contributes to lowering the risk to human lives and property, and, at the same time, covers the public information and communication needs in such situations.

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Important activities connected with public safety, with special emphasis on civil defence and emergency relief, are currently being undertaken within several national, regional and international organisations. Croatia undertook the procedure for laying down the "Law of protection and rescue", which introduces implementation of regional "Centres 112" as PSAB service (Public Safety Answering Points). The implementation of the law would affiliate Croatia to the European system of unique telephone aid numbers. Establishment of Centres 112 demands very complex intervention within information and telecommunication systems in order to achieve high technological services levels, increase efficiency of first aid and, generally, interventions in diverse emergencies and catastrophes. Experiences of the United States and European countries will surely help the process of system conceptualisation in Croatia. Even though the progress in information and telecommunication technology in Croatia is not so fast, all countries have the same challenge of how to utilize all possibilities of technological progress. Furthermore, almost all countries face the problem that part or all of the telecommunication system belongs to the private sector, therefore the jurisdictional and other frameworks and principles of telecommunication services costs have to be worked out as the general public interest. However, privacy is a very sensitive matter and demands further research in differentiating public safety from private interests. The problem of standardisation of the different technologies and setting up the interfaces between users' systems can be solved in the same context. In Europe, a number of projects, such as LOCUS (1), ROSETTA and CGALIES (2), have been launched, with the same objective: to identify some of the technological standards as well as cost estimation of the introduction of different technologies for emergency services telecommunication support. At the end of February 2002, ETSI (3) organised its first workshop with "Emergency Telecommunications (ET)" as a topic, where experts could get insight into European and American projects that go toward standardised interoperable telecommunications functions and services, as well as the concept of incorporating mobile phones in Emergency Services System due to their wide use and huge technical capabilities. One of the reports (2) shows the number of emergency calls from mobile phones within the European Union (EU), that, for the last year was 40 million calls, which represents 50 - 70% of total emergency calls. Furthermore, the report emphasises that in 3,5 million calls from both fixed and mobile phone networks, people were not able to give their precise location, which caused delay in the intervention. During traffic emergency intervention it was pointed out that in 20 – 40% of serious injuries, survival of injured people depended on professional medical help within two hour intervals, thus indicating the importance of the possibility to precisely locate the emergency site and optimally guide the emergency brigade. Jean-Luc Wybo and H. Lonk (4) pointed out the paradox of relatively low integration of information and communication technology (ICT) in Emergency Management (EM), even though ICT has great potential to "improve the resilience of organisations during the management of emergencies, by providing the right information in due time to anticipate evolution and take appropriate decisions".

Problem description, and approach to the telecommunication support system conceptualisation

In order to successfully integrate the telecommunication system into the concept of "Emergency Management" of a certain country such as Croatia, it is necessary to undertake a series of activities with the objective to enable the telecommunication system to survive, provide quick relief and give support during emergencies, with sufficient capacity to enable the functioning of various Emergency Services. In principle, the telecommunication system that offers support during emergencies consists of two parts:

1. telecommunication infrastructure,
2. operative procedures and software for different functions during emergencies.

While the aforementioned classification is rather rough, it does point out the need for a different approach to the each segment.

Telecommunication infrastructure

Telecommunication infrastructure can be very vulnerable, especially the part related to PSTN (Public Switched Telecommunications Network), namely, the fibre-optic network as the largest component of the system.

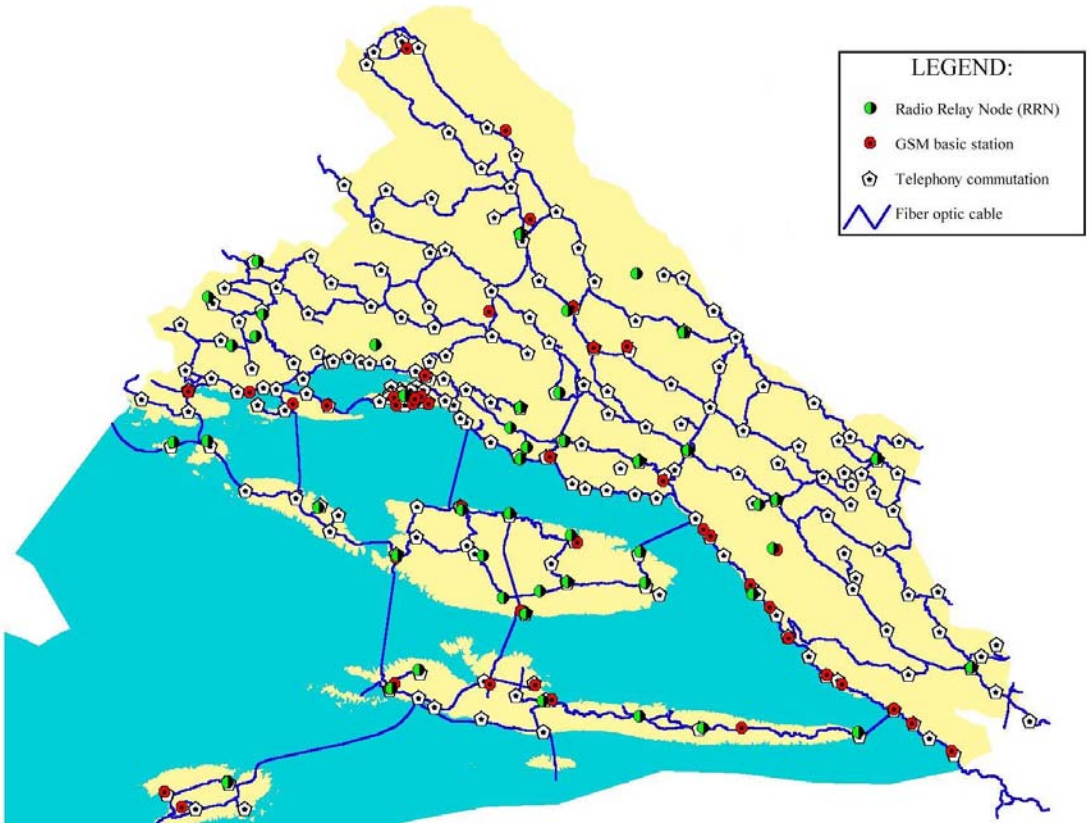
Implementation of "Telecommunication Support System" (TSS) is shown on Split-Dalmatia County, which is one of the biggest counties in Croatia, situated on the Mediterranean coast. The telecommunication system of Split-Dalmatia County is used as a pilot project for vulnerability analysis assessment using GIS tools.

Previous analysis and comparisons with other countries' experiences pointed out the most frequent causes of system malfunctioning (5) which, generally, can be divided into two groups:

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

Earthquakes, floods, fires, atmospheric hazards, landslides, etc, belong to the group of natural factors, while different technological accidents, or insufficient data about an 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 1: Telecommunication system of Split - Dalmatia County



The aforementioned thematic maps are basic and provide source data about the system to be analysed. Looking at Figure 1 it can be seen that there is good coverage of the County with fixed

and mobile networks, and importantly, a huge number of commutation nodes that enable alternative (by-passed) connections of different parts of the region in the case of direct connection interruption. Also, interruptions of the fibre-optic 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 ADSL (Asymmetric Digital Subscriber Line) connections. The fixed network, mostly containing fibre-optic installations, is often endangered by lightening coming through the energy supply system, floods, torrents, and partly by forest fires. In Dalmatia, torrents can cause serious damage to the infrastructure, due to its high power caused by terrain slope. By performing more detailed analysis of hydrological data, it is possible to estimate the probability of high water or torrents occurrences, thus the vulnerability of fibre-optic installation. Using GIS, 16 critical areas with points of close contact with the high-voltage network, torrents and the fibre-optic network were identified, thus multiplying probability for network interruption, as well as indicating potential system vulnerability. Possible terrain movements endanger fibre-optic infrastructure as well, because most of the County belongs to the earthquake zones 8 and 9 indicating high earthquake risk. However, by grouping of fire damaged areas, it is easy to notice zones extremely exposed to forest fires. These zones are in correlation with standard fire risk indicators, such as forest fire risk index, moisture index, land dryness index, vegetation index, etc. By using GIS tools (6) it is possible to group fire zones and get new homogenous zones with fire risk degree.

Table 1 displays the summary outlook of risk degree of the telecommunication system of Split - Dalmatia County, based on four criteria. As a result, it is possible to establish attributive valuation of the telecommunication system vulnerability within a scale of five possible ranks: from 1 (very high) to 5 (not significant). In Table 1, magistral fibre-optic routes are noted, because their interruptions can cause significantly more damages in the whole telecommunication system. Point (area) 6 has the highest vulnerability rank (very high vulnerability). Area 6, situated near commutation node "Sinj" is in the possession of RR station, so special attention about possible establishment of telecommunication routes via this station has to be paid.

Table 1- Summary outlook of the County telecommunication system

No. of the critical point (area)	**Earthquake zone**	**Fire risk degree**	**Vulnerability rank**	**Comment**
1	6	high risk	moderate (3)	magistral route
2	6	moderate risk	not significant (5)	
3	7	high risk	high (2)	
4	8	moderate risk	high (2)	magistral route
5	9	moderate risk	high (2)	magistral route
6	9	high risk	very high (1)	
7	8	moderate risk	high (2)	
8	7	high risk	high (2)	
9	7	moderate risk	less significant(4)	
10	7	high risk	high (2)	
11	8	low risk	moderate (3)	
12	8	moderate risk	high (2)	
13	9	low risk	moderate (3)	magistral route
14	9	low risk	moderate (3)	magistral route
15	9	low risk	moderate (3)	magistral route

16	8	moderate risk	high (2)	

Based on the data about risk degree of routes, alternative routes or use of RR connections are being planned. Due to the increasing number of public mobile telecommunication network users (PLMN – Public Land Mobile Network) in Croatia, that is 1,7 million on a little more than 4 million inhabitants, it is important to include PLMN infrastructure into "Telecommunication Support System (TSS) in Complex Humanitarian Emergency Situations". Report of CGALIES (2) project states that by 2003, two thirds of all Europeans will have a mobile phone. A primary characteristic of Split – Dalmatia County is a huge number of tourists during summer months, therefore, it is necessary to enable the use of their mobile phones on Croatian territory for any kind of emergency calls, thus making them safe. Moreover, development of the MEI (Minimum Essential Infrastructure) concept by applying multicriteria analysis defines foundation of the system that takes over telecommunication support in emergencies for the whole County. One of the crucial problems of telecommunication system functioning in emergencies is stability of the Electric Power System that supplies all devices. With regard to the fact that a part of the telecommunication system can work autonomously using its own aggregates and most of the users have cell phones, mobile telecommunication can be used as a basic tool for communication in emergencies, as well as in situations when the Electric Power System is out of order. By applying multicriteria analysis, among 120 existing GSM base stations, seven "GSM - Emergency Stations" are chosen according to the following criteria: possession of electrical power aggregates, covering the areas with high residence density, covering the most endangered areas, having the most alternative routes to other nodes, etc. These GSM base stations cover the most densely populated territories of the County, all important tourist places and the most frequented roads. Estimating the general stability of telecommunication infrastructure, as well as its vulnerability, it can be concluded that thanks to the fact that the fibre-optic network placed in the cable distribution duct is the basis of the fixed network of the telecommunication system, low vulnerability related to fires, torrents, earthquakes and other hazards is recognised. Large numbers of radio relay (RR) and commutation nodes enable an alternative telecommunication network in emergency situations. High system vulnerability related to energy supply can be solved by implementing existing electrical power aggregates, as well as installing new ones at the end-users involved in the emergency management system, because most of the communications can be performed by Internet.

Operative procedures and software for different functions during emergencies

Regarding operative procedures and software for different functions during emergencies, it is essential to increase functionality of the existing telecommunication system infrastructure. Part of the activity within this segment is related to standardised interoperable telecommunications functions and services, with the intention that survived devices and units from different operators (corporations) with different protocols can work as a unique system. For example, "roaming" between two operators has to be established (Cronet and VIP), which have GSM base stations on the County territory, by means that survived base stations could overtake calls from both networks. However, during relief of telecommunication functions it is necessary to use all resources regardless of different operators.

Another part of the activity is related to the definition of the various procedures and software within Emergency Management, enabled by contemporary technology. Establishment of Centre 112 provides an opportunity to increase functionality and quality of telecommunication system support in different Emergency Services.

Application of "Telecommunication Support Systems (TSS) in Complex Humanitarian Emergency Situations".

The forthcoming text shows illustrative examples of the application of "Telecommunication Support Systems (TSS) in Complex Humanitarian Emergency Situations".

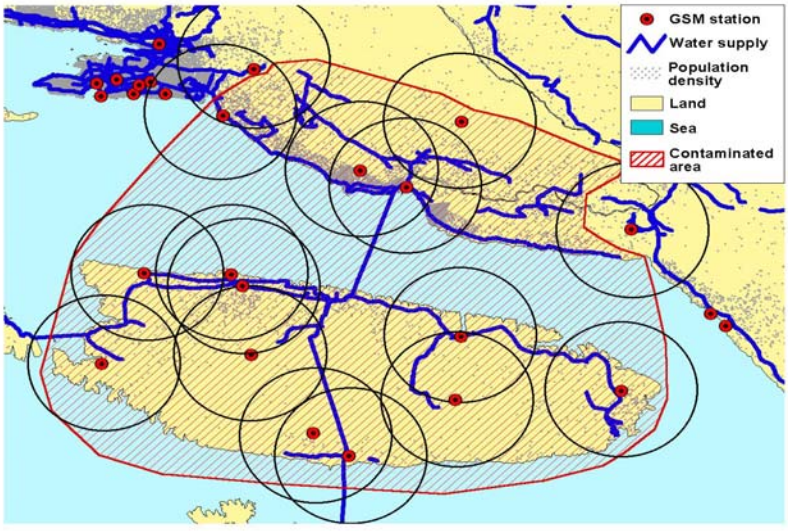
Scenario 1 – contamination of water supply system

Biological or chemical terrorist attacks on the water supply system have occurred in one part of County. More frequently, in the vicinity of a water chamber, a spillage from a cistern carrying hazardous chemicals has occurred, thus drinking water quality and the health of inhabitants and tourists in the area have been endangered.

The procedure of Centre 112, besides alerting technical services to eliminate contamination, is partly directed at alerting inhabitants not to drink the water and put their health in danger, because it is technically impossible in a short period to stop water flow into the system. To alert inhabitants, besides conventional methods (sirens, TV and radio), a telecommunication system can be used in the following way:

- After a warning about water contamination is sent, GIS support with data about the water supply system is activated in order to determine the endangered territory.
- After determination of endangered territory borders, all fixed landline connections are identified by MSAGA (Master Street Address Guide), as well as fax and Internet prepaid users. They are all supplied from the computer with textual messages not to drink water.
- Regarding the fact that a large number of people, as well as tourists, are outdoors, in intention to alert them, all GSM stations are identified within and near the endangered territory.
- All mobile phones that are in connection to the GSM base station via Cell Broadcast (CB) system are alerted by SMS (Short Messages Services) not to drink water and to call information centre.
- For the mobile phones that are in roaming connection with the alarm GSM base stations, an identification via ID is performed, and they receive messages on their language (it is supposed that it is one of the European languages or if it is not, message could be sent in English).

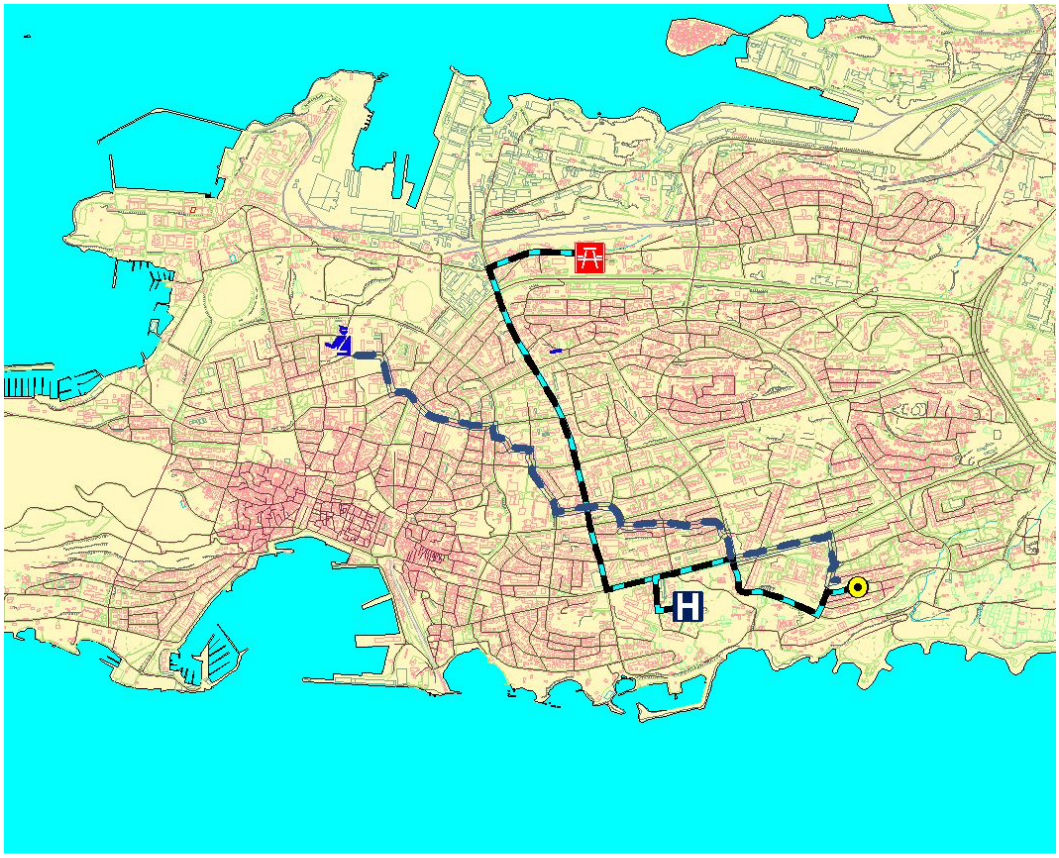
Figure 2: Layout of the area and GSM base stations included in the alert procedure
Explained model support can be used in any other "Complex Humanitarian Emergency Situations" such as earthquakes, consequences of terrorist attacks, etc, when lives and health of inhabitants of a certain area are endangered.



Scenario 2 – emergency call in urban areas

The following example presumes that a gas explosion has been occurred in one of the buildings in the town of Split (urban place) causing a fire and injuries to the people. The call was from the fixed landline network, so the Centre 112 located the emergency place (yellow point) on the existing digitalised map of the town (scale 1:5000) using MSAGA (Master Street Address Guide). The dispatcher in the Centre chooses the nearest police station (policeman symbol) and by "Network" software and option «Find best route» defines the fastest and most convenient route to the emergency point. The same procedure is being performed for the fire brigades and ambulance cars (H symbol). GIS contains thematic layers with positions of hydrant valves, so the fire brigade can be supported with information about the best valves regarding the water pressure.

Figure 3: GIS support for locating emergency call and definition of intervention routes

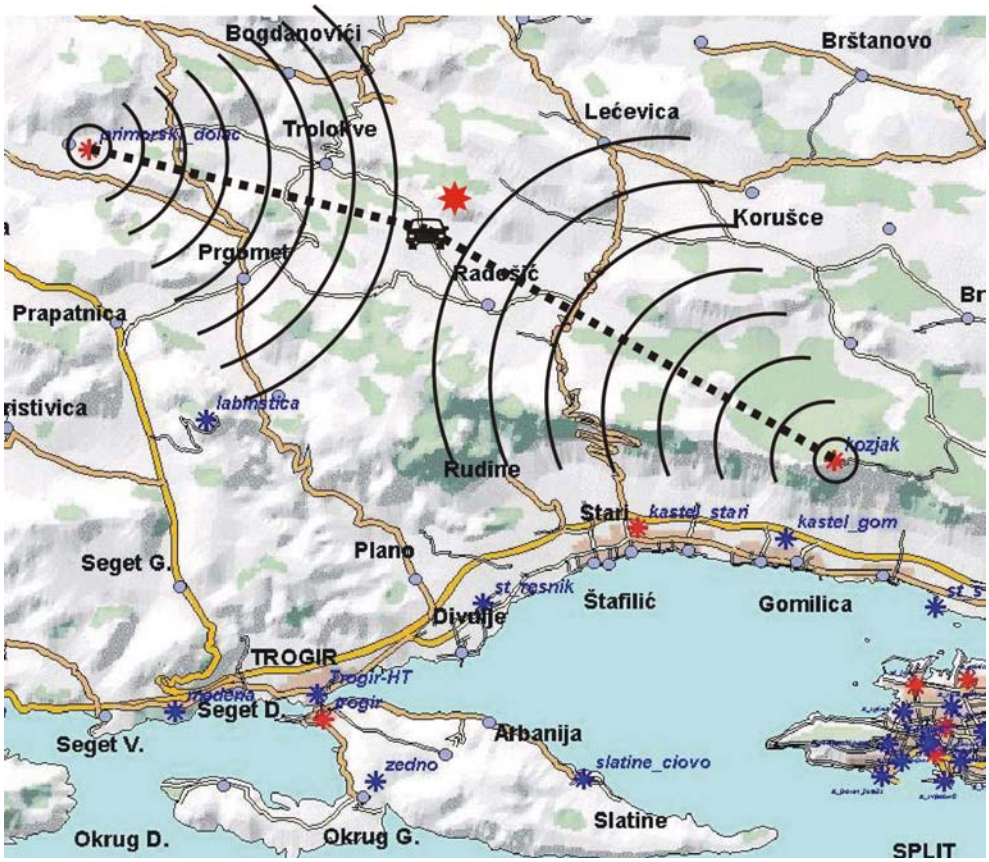


Scenario 3 – fire location based on mobile phone calls

For Split – Dalmatia County, as well as for the whole northern Mediterranean region, during summer there are a huge number of wildfires, which spread very fast, causing risk to property and human lives and health. Therefore, it is very important to promptly notice the fire, determine precise location and start with the intervention. Warnings about wildfires usually come from inhabitants, which are not able to give precise information about fire location, so it is necessary to locate the caller, and according to their position, locate the fire. Figure 4 shows a situation where a warning about a fire is sent by a mobile phone from a car, with the description that the fire site is approximately 300 meters in front - left from the car. In the Centre, a procedure for mobile phone

location via GSM base stations, which receive a signal from sender (caller), is launched, so an approximate fire site is determined and an alert to the nearest fire brigades is sent. Another possibility is to use GIS for identification of all phone prepaid connections nearby a fire site, and using Centre 112, inform them about the fire and eventually include them in the intervention. If there is a bigger fire that causes risk to the roads, all mobile phones in the cars on the nearby roads are identified and informed about possible road blockage via CB (cell broadcast) system. The described procedure can be used in any urban or sub-urban areas with the condition that during the modelling phase all GIS thematic maps with adequate information have to be prepared. However, higher density of GSM base stations enables more precise call location and fire site position. Report of CGALIES (Coordination Group on Access to Location for Emergency Services) (2) project states that possible precision in urban areas is 25 – 150 meters, in sub-urban areas is 100 – 500 meters, and on the highways and waterways is 100 – 500 meters.

Figure 4: Layout of locating the vehicle that sent warning about wildfire via mobile phone

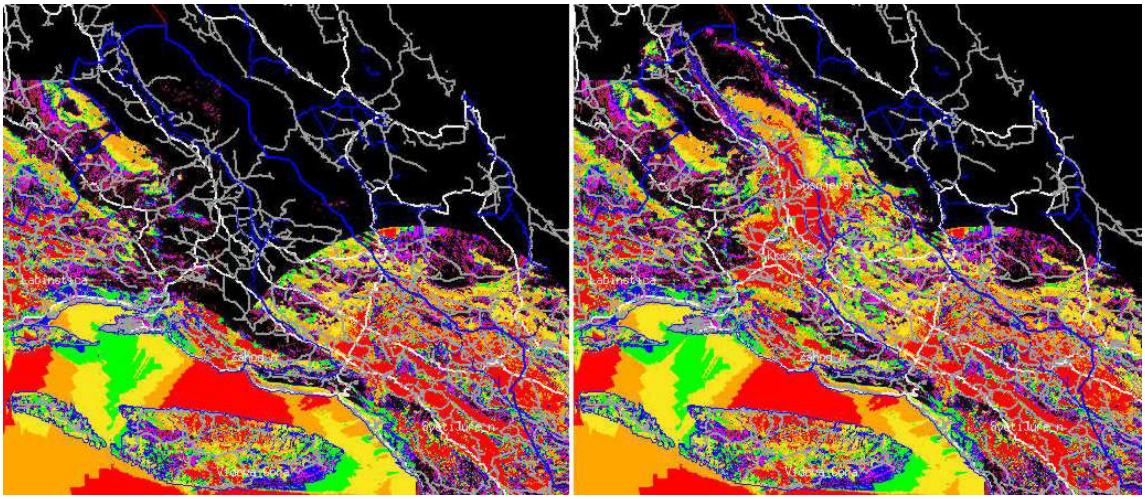


Scenario 4 – locating of GSM stations during emergencies

Loss of supply or physical damage of GSM base stations caused by natural disasters (earthquakes, heavy storms, etc) or damaged by any other cause, disable telecommunication services by mobile phone, which is important during emergencies. As a function of recovery and restoration of telecommunication services in the endangered area, during the planning phase it is necessary to predict implementation of temporary base stations at previously determined locations, at the locations of damaged base stations. Placement of temporary base stations can be performed by

helicopters or by any other manner if adequate equipment exists. Figure 5 shows the endangered area (on the left) and survived base stations after a natural disaster. In the middle of the left part of Figure 5 there is an area with a lot of roads, but left without signal (black). By placing two mobile base stations at previously prepared locations (on the right), mobile network services are improved.

Figure 5: Layout of hearing before (left) and after (right) placement of two mobile base stations



Conclusion

Affiliation of Croatia in the unique European system PSABA and establishment of Emergency call Centres 112 initiated conceptualisation of "Telecommunication Support System (TSS) in Complex Humanitarian Emergency Situations". Classification of the telecommunication emergency support system to the part related to "telecommunication infrastructure" and the part which deals with "operative procedures and software" for different functions during emergencies resulted in the conclusion that existing infrastructure has more possibilities than it is used for in operational and planned telecommunication support in emergencies. The basic problem within the segment of "telecommunication infrastructure" is estimation of its vulnerability and efficient planning of its relief. Studies on "operative procedures and software" demand intensive research in order to use all technological possibilities offered by the telecommunication system. Achieving synergetic effect (4) is possible by intensive application of GIS support and, generally, information technology.

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