Supporting Critical Multi-Organization Collaboration during Response to Catastrophic Events

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The past two years have shown both the power of nature and the complexity of preparing for and responding to extreme events such as earthquakes, tsunamis, hurricanes/typhoons, and floods. These events, and future catastrophic events, will require coordination and collaboration between multiple government and non government organizations across national and state borders. This collaboration will require the discipline necessary to share common processes and procedures, and the agility to improvise plans and actions as situationally required. Information technology must be used to create an eRegion, enabling the shared situational assessments and adequately supporting the collaborative, distributed decision making to produce required decisions and future action plans. The role of information technology in developing these capabilities is discussed in the context of two seismic scenarios, the US New Madrid Seismic Zone, and the Adriatic Seismic region.

Keywords: emergency response, disaster management, situational awareness, collaborative technologies, decision making, information technology

Podpora kritičnemu multi-organizacijskemu sodelovanju v primeru odziva na katastrofične dogodke

Zadnji dve leti smo bili priča tako môči narave kot tudi zapletenosti priprav na odziv in tudi samemu odzivu na nekatere ekstremne dogodke kot so potresi, cunamiji, orkani/tajfuni in poplave. Ti in pa bodoči katastrofalni dogodki bodo zahtevali usklajevanje in sodelovanje med mnogimi vladnimi in nevladnimi organizacijami prek nacionalnih in državnih mejá. To sodelovanje bo zahtevalo disciplino, ki je potrebna pri delitvi skupnih postopkov in procedur in pa prožnost pri improviziranju načrtov in ukrepov z ozirom na situacijo. Za vzpostavitev e-regije se mora uporabiti informacijska tehnologija, s čimer bi se omogočilo skupno ocenjevanje situacije in ustrezna podpora medsebojnemu sodelovanju in porazdelitvi pri sprejemanju odločitev, kar naj bi pripeljalo do ustreznih odločitev in bodočim akcijskim načrtom. Vloga informacijske tehnologije pri razvoju teh zmožnosti je obravnavana v kontekstu dveh potresnih scenarijev, v ameriški potresni coni New Madrid in v jadranski potresni regiji.

Ključne besede: odziv v primeru naravne nesreče, katastrofični menedžment, situacijska osveščenost, tehnologije za sodelovanje, sprejemanje odločitev, informacijska tehnologija.

1 Introduction

Extreme events such as the December 26, 2004 earthquake and tsunami and the August 2005 Hurricane Katrina impact large geographical areas, often these areas controlled by multiple national and local governments. The response to extreme events requires information sharing and coordination between hundreds of government and non government organizations. The multi-jurisdictional, cross-border collaboration will require the creation of a virtual eRegion. In earlier papers, the authors have described the organizational agility and discipline critical to successful response to extreme events (Harrald, 2006), and the information technology necessary to support the situational awareness, interoperability, and collaborative decision making necessary to support this agility and discipline. (Jefferson and Harrald, 2007).

Discipline may be defined as the organizational structure, doctrine, procedures, and processes necessary to mobilize, organize, command, and control large multi-organizational response efforts. Agility, on the other hand, is the improvisation, adaptability, and creativity that are critical to coordination, collaboration, communication and successful problem solving. Discipline is the ability to operate, while agility provides interoperability. It is necessary to recognize that interoperability can not exist without the ability to operate. Over the last thirty years, the professional emergency management community has been working hard to increase the level of discipline in response systems in most areas of the world, most notably the United States. At the same time, social scientists have observed that the key to success in responding to and recovering from extreme events has been the ability to be agile-- to recognize and manage. Discipline and agility imply opposing information

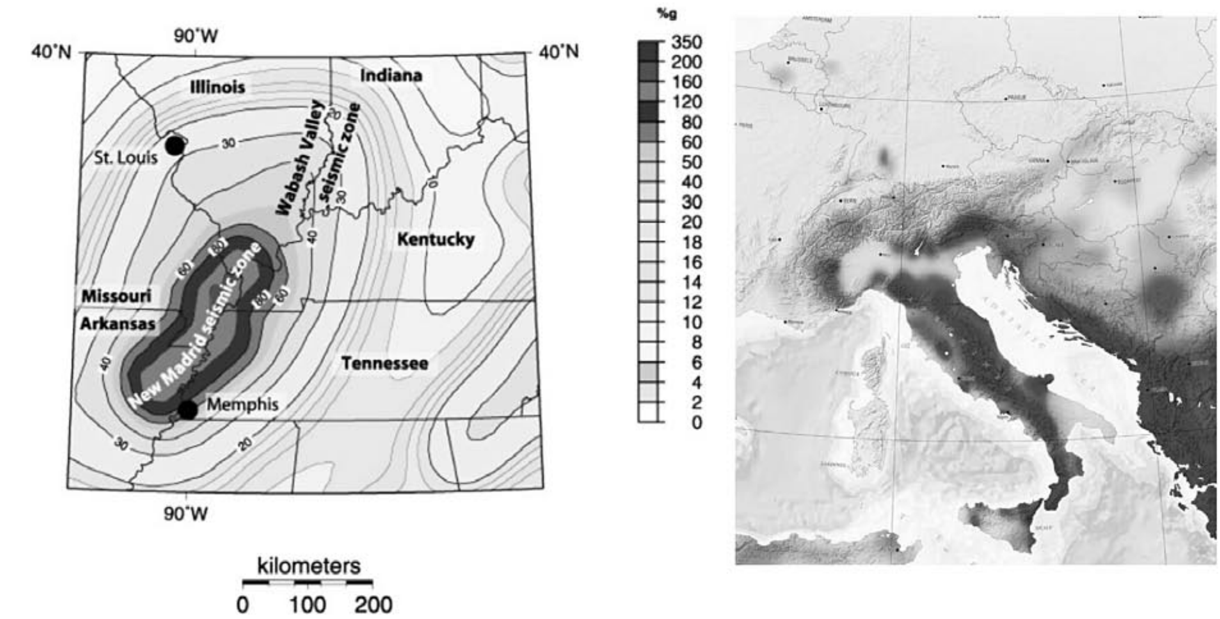

Figure 1: Comparison of the New Madrid and Adriatic Multi Jurisdictional Seismic Regions

management requirements. Discipline infers the support of rigid structures, pre-designated decision makers, and defined decision processes. This is a military command and control model. Agility implies the ability to support improvised decision making--decision makers outside of the formal organization, confronted with unanticipated circumstances and problems for which existing tactics and resources are inadequate.

Two case studies, shown in Figure 1 are used to illustrate the challenges in using information technology to enhance situational awareness and to support distributed decision making in a distributed, multi-jurisdictional environment. The first case study is derived from the Central United States New Madrid Seismic Zone catastrophic earthquake project, funded by the US FEMA. A major earthquake in this region would require the integration of the response efforts of 8 US states, four Federal regions, and several large cities such as Memphis and St. Louis. The second case study is focused on a similar seismic region surrounding the Adriatic Sea where a major earthquake could impact 4 or more countries. This scenario is the basis for a proposed living laboratory initiative to be conducted in collaboration with the ALADIN (ALpe ADria INitiative) consortium of universities. Preparedness for and response to both earthquake scenarios will require multiple jurisdictions to collaboratively share information and develop a shared situational awareness adequate for supporting resource mobilization and decision making. This will require innovative applications of technology and eventually the abandonment of physical command centers where designated people gather for face-to-face meetings and for access to information.

2 Collaborative Decision Making and Situational Awareness

Decision making is data, computationally and communications intensive, therefore it is inherently linked to information technology. Much of the recent focus in the U.S., for example, has been directed at achieving national inter-operability of voice and data communications for first responders. This focus on process and organization does not ensure that the technology will actually be useful in providing critical information to appropriate decision makers. As stated by a senior US official during the Hurricane Katrina response, "Everyone is making the point that we need information, inter-operability and communication - BUT NO ONE is articulating how it is used for decision making, how you apply it for saving lives and protecting property." We know we need information, interoperability, and communication but the challenge is using it for decision making and applying it to accomplish the main goal of saving lives and property. Technical interoperability does not address the challenge of data interoperability among organizations and the need for common terminology. Responding to extreme events requires collaboration, cooperation, and transparency by numerous organizations with different cultures and structures. These values are not embedded in the hierarchical, military model, casting doubt on the effectiveness of a military command-and-control model (Granot, 1999).

When a disaster occurs, responders must estimate the disaster's physical impacts by integrating sparse data with prior knowledge obtained through a combination of prior modelling and experience. The responders must estimate the disaster caused needs for rescue, recovery and medical support and requirements for water, food and shelter. These disaster or hazard generated demands determine the size, type, and location of response forces to be deployed. The

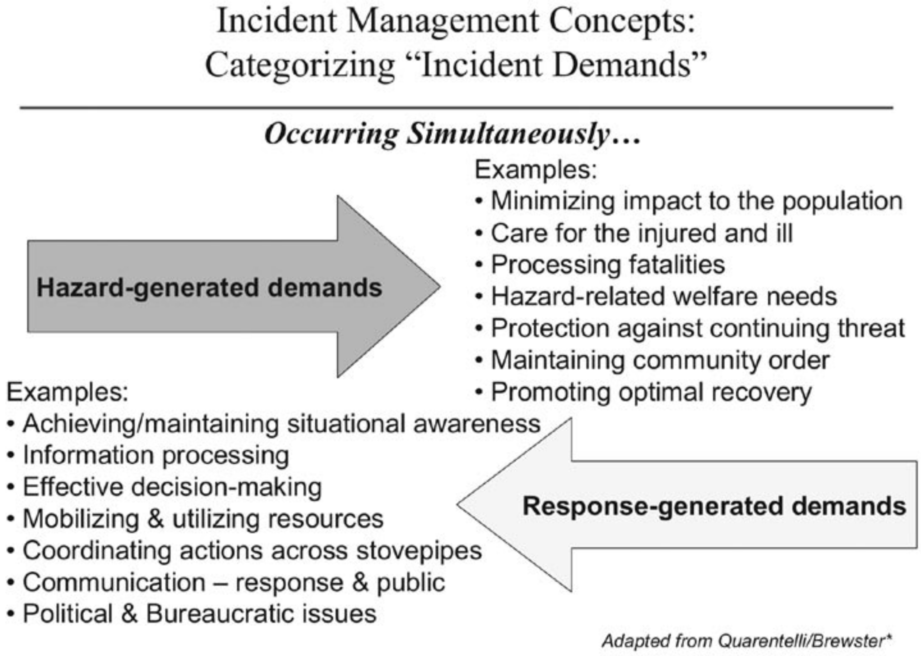

Figure 2: Hazard Generated and Response Generated Demands

creation of a response involving hundreds of organizations leads to response generated needs for the control and coordination of the massive efforts. The relationship of hazard and disaster caused demands are shown in Figure 2, based on Quarantellli (2005)

Multi government, multi organizational response coordination and collaboration is based on the assumption that shared situational awareness will be attained and maintained. The concept of shared situational awareness and common operating picture originates from an aviation safety and combat domain. Transferring these concepts to a complex, heterogeneous emergency management structure will be exceedingly difficult. When evaluating the role of shared situational awareness it must be recognized that not all actors involved in the response and mitigation to an extreme event will require the same information. When attempting to consolidate information to obtain a shared situational awareness there is a very real possibility that information that is relevant to one or more parties will be inadvertently omitted (Jefferson and Harrald, 2007).

Emergency response decision making obviously impacts future states of the system and hence future decisions. Decision making occurs in a series, one decision leads to the next. For example, if a decision is made to evacuate an area, more decisions will need to made. Where will people be evacuated too? How will they get there? What supplies will be needed? And the decisions continue. The information needed for subsequent decision will change as well as the parties included in the decision making process. Hence part of situational awareness in a distributed environment is knowing what other organizations and individual actors involved in the response are doing.. This leads to three critical attributes for agile disaster management:

- the ability to monitor and detect changes in the environment,
- the ability to monitor current and planned actions, and
- the ability to customize the response to the current environment.

One way to satisfy all three attributes is through the adoption of a virtual organization built on collaboration and cooperation. "Cooperation is central to agility; people and organizational culture must adapt to foster both internal and external cooperation," (Reich, et al. 1999). However cooperation, can not be successful without the technological framework. Therefore, agility must be planned for. The agile organization required to support an emergency response effort involves the formation of a virtual "team". Each member of this team comes with their own area of expertise, organizational culture and practices, and technology-specific proficiency as well as application-specific proficiency. The technological systems that will support this virtual, agile, team need to consider the attributes of the team member during design. The system will need to combine usability from multiple perspectives with the ability to adapt to different skill levels.

The type and form of information that is presented to the team is also important. A number of factors concerning the interpretation of data need to be considered when moving decision making from (1) individuals in homogeneous groups at the same location to (2) distributed homogeneous groups and finally to (3) dispersed non-homogeneous groups.

- The disparate semantic meaning of the data collected
- The ability to ensure or even know data quality (particularly the timeliness and completeness components)
- Even when given the same data, non-homogeneous decision nodes will perceive the information differently

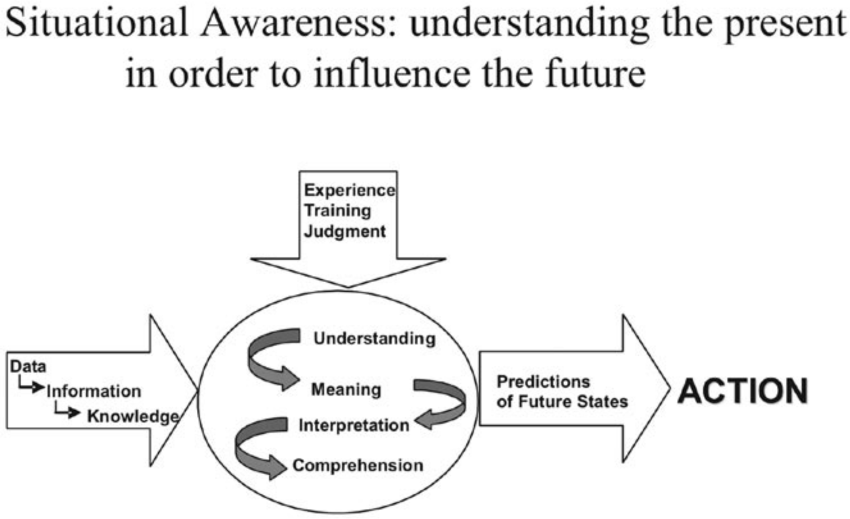

Figure 3: The Objectives of Situational Awareness

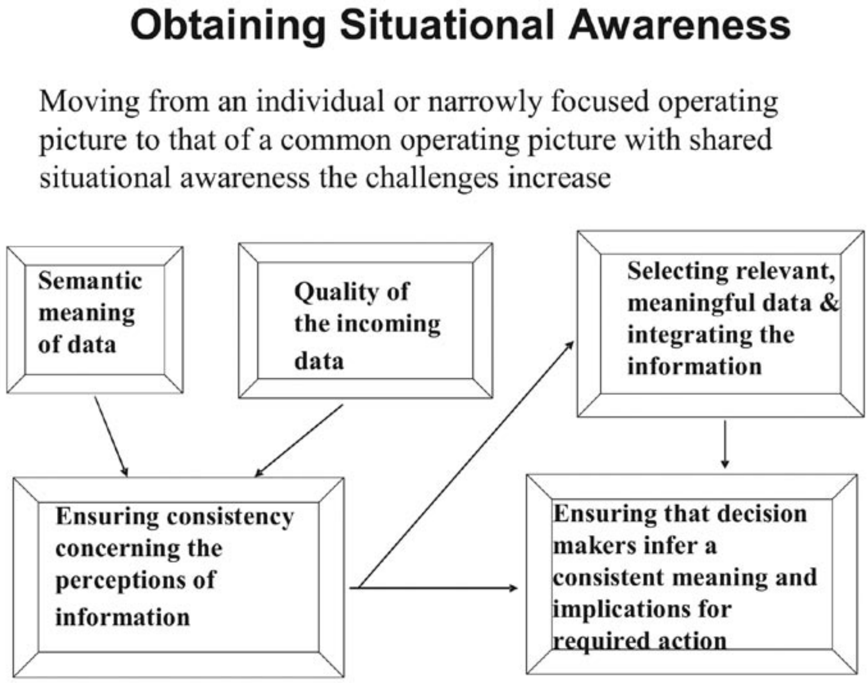

Figure 4. Requirements for Obtaining Situational Awareness

- Even when given the same data, and similar perceptions, different nodes will imply different meaning and requirements for future action

As shown in Figure 3, adapted from (Ntuen, 2005) the objective of situation awareness is to allow collaborating decision makers to assess the current system state, using available information and their own knowledge and experience, in order to make adequate decisions during the present and to develop valid future plans. In this context, distributed situational awareness implies shared ability to understand and interpret information in addition to the ability to establish common access to information. Therefore, in areas such as the US New Madrid Seismic Zone or the Adriatic Seismic Zone, the pre-disaster establishment of the ability to gather, analyze, and display data will not ensure shared situational awareness and collaborative decision making when an earthquake occurs. As shown if Figure 4, pre disaster investments must also be made to ensure the development of shared semantic standards, the ability to evaluate the quality of information, and the knowledge and experience of the decision makers .

Either scenario described above, the New Madrid Seismic Zone earthquake or the Adriatic Seismic Zone earthquake, would produce impacts across multiple governmental jurisdictions. The result would be a dynamically changing, situationally determined, geographically distributed group of decision makers expected to resolve issues, solve problems, and make collaborative decisions based on common information and awareness in a virtual eRegion. We believe that this type of situation will eventually require the replacement of the concept of physical emergency operations center and command centers where designated people gather for face-to-face meetings and for access to collaborative technology with fluid virtual EOC's where decision makers use technology to access information and each other from remote locations.

Physical emergency operations centers are human resource intensive. A 20 station, 24 hour, 7 day a week EOC will absorb the full time efforts of 60 highly skilled people. The centers can become counter productive by failing to support the flow of information to emergent decision making groups, becoming information sinks and barriers to information flow when the volume of information exceeds the capacity to analyze it. Operations centers are also physical locations that are themselves vulnerable. The New York City EOC was located in building 7 of the World Trade Center and was abandoned prior to the building's collapse. The New Orleans EOC was totally disabled during Hurricane Katrina. Information technology of the past has supported information collection and analysis at pre-determined sites (EOCs), supported predetermined organizational structures, and followed pre-designed information pathways. Information technology of the future will support agile, evolving structures and will allow for distributed awareness, analysis, and decision support in a virtual eRegion.

The virtual emergency operation center (VEOC) is composed of a team of distributed experts whose task is to achieve a specific goal in a specific time. The VEOC is composed of inter-organizational teams, many of whom have extremely different backgrounds and have not previously worked together. An important aspect of this team is that their work is not done in a "project vacuum". That is to say that besides the roles and responsibilities associated with the joint team, these members tend to have numerous other roles and responsibilities associated with their "home" organization. One distinct advantage of collaborative technology is its ability to allow individuals to work together towards a common goal while also allowing them to multi-task on other important functions.

3 Testing the Concept

The George Washington University Institute for Crisis, Disaster, and Risk Management is involved in two projects that will allow the testing of the concept of using technology to support agile disaster response in multi-jurisdictional eRegions through the creation of virtual operations centers (VEOCs). The first project is the FEMA funded New Madrid Seismic Zone Catatstrophic Preparedness project where the eRegion is a region of 8 states and 4 Federal regions. During the current first phase of the project, the University of Illinois Mid American Earthquake (MAE) Center and the GW ICDRM will develop improved loss estimation models and methods for estimating hazard generated and response generated needs. The second phase will facilitate multi state, multi region planning and exercising. During this stage, the concept of supporting distributed decision making groups using web based technologies will be investigated.

The concept of a VEOC will also be tested in a LivingLab experiment in Central Europe led by the University of Maribor, the George Washington University, and other Universities associated with ALADIN, ALpe ADria INitiative Universities' eNetwork. The objective of the LivingLab Safe and Secure eRegion is to develop a multi-disciplinary research and testing platform concentrating on identifying a domain of potential action from the users' point of view. The Living Lab will bring together researchers, developers, and users in a virtual environment. The goal will be to determine what information is needed and how can it be produced. Prototype solutions will be developed and tested in a simulated and real environment.

The LivingLab project will test the use of collaborative software in particular, IBM Rapid Response. The project will focus on :

- Creating and linking university centers
- Exploring how university centers can enhance connectivity between governments, private and public organizations, and the community
- Demonstrating how technology can assist in attaining and sustaining situational awareness in distributed network
- Generating scenarios and then evaluating different IT in terms of its ability to facilitate distributed decision making and communication
- A low risk failure environment (test technology, procedures, linkage)

4 Conclusions

Information technology will change disaster management as profoundly as it has changed other aspects of human endeavor. Technology will make organizational systems more agile and responsive and less tied to physical artifacts such as Emergency Operations Centers. Technology will enable individuals and organizations to improvise and to adapt and to track what other organizations and individuals are doing in complex, chaotic environments.

There are however major technological issues that must be resolved. Reliable and high quality video capabilities will be essential to ensuring the full communication required to ensure trust and understanding in an emergency. Decision support and information analysis and display tools will have to be highly mobile and distributed. All decision makers must have access to the same information. Security concerns will have to be identified and resolved. Finally, if all decision makers are directly interacting with the technology, the technology will have to be much more useable than the current generation of EOC technology. For example, Geographical Information System plots and images produced by satellites and other sensors are currently delivered by a technology group within an EOC. Will decision makers be able to create their own GIS and imagery products?

The organizational issues that must be resolved are, however, as significant as the technological ones. Organizations must become flatter, decentralized and less rigid. Leaders must trust decision makers on the scene and allow information to flow to where it is needed. The payoff for an achieving a technology enhanced, distributed collaborative decision making environment is, however, immense. It will allow mobilization without bureaucratization, collaboration without the creation of an expensive physical overhead. It will enable tools and procedures to work in a virtual eRegion in a single nation environment such as the US, a multi-nation developed region such as Central Europe, or for the international response to a disaster in a developing region. Most of all, the development of appropriate technology will allow the agility and flexibility to respond creatively to unexpected events and situations, saving lives and minimizing human suffering.

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CERIS-ST, the Central Europe Road Information System for Security and Tourism A Joint project of the Universities of Novi Sad, Trieste and Verona for Precise Data Acquisition on the Trans-national Road Network and the Extension to the ALADIN Group

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1 Project Description

A Road Information system is strategic for sustainable development, both for commerce and industries and for tourism. Thanks to the funding provided by the European Union (through the INTERREG Program), the Regione Friuli Venezia Giulia and the ICE-CRUI[4], about 1,200 km of roads have been already surveyed in the Balkan Adriatic Coast area.

The Universities of Rijeka, Podgorica, Tyrana, Sarajevo and Novi Sad actively took part in the project. In the meantime, working in partnership with the University of Verona[5] (from which we received helpful suggestions and contributions), we tested the application of the data gathered to tourism and territorial planning in the Verona area as well as in the Marche Region. The positive results of the work carried out convinced us to intensify the efforts and survey a wider area (the ALADIN one), aiming at covering the whole of Central Europe (which is not yet fully surveyed, though research such as this is needed here).

The first step in this project will be to better identify the technological methodology needed to acquire, store and distribute the detailed road network data used in urban planning for construction and maintenance of the road network (within the area of the Autonomous Province of Vojvodina). Resorting to satellite navigation systems will imply both the use of GALILEO - when ready – and of EGNOS (which is currently available).

This project consists of the application of instruments and methods that are currently available but are to be used in an innovative way (also in view of the European EGNOS and Galileo Systems). Therefore, it is potentially in synergy with those financed (and supervised) by the Galileo Joint Undertaking, Bruxelles. Moreover, it could be consistent with the INTERREG projects, which deal with the preservation and increase in value of cross-border cultural heritage. There is, also, a direct link between this project and the Road Cadastre prototype (already produced); a project coordinated by the Regional Government itself and concerning the roads in the four provinces of the Friuli-Venezia Giulia Region.

In addition to this, a type of survey is planned – and just begun – of regional harbour access, including piers and service roads. Applying the results of these prototypes to the road segments in the PAO areas will also be of use in order to maintain homogeneity with the Italian rules and conceive a coherent and official set to refer to. The participation of the PAO Partners is very important for adjusting, if necessary, the Italian rules for road information systems, taking under due consideration the unique conditions characterizing the PAO road network. The same revision could be necessary after surveying the harbour infrastructures (the width of the piers etc).

The project draws on previous researches carried out by Italian Universities (under the coordination of the University of Trieste); activities carried out under projects of

[4] A joint programme by the Italian Institute for Foreign Commerce and the Italian Universities Rector College.
[5] Chair of Geography of DESI (Department of Economics, Society, Institution), Faculty of Modern Languages

national relevance (PRIN) in 2000, 2001, 2002. In addition, the results were obtained in part thanks to cooperation with the University of Warmia and Masury (Poland), the University of Prague and the (ex) Austrian GPSNETZ (Differential GPS by using DARC data radio broadcasting). These results have been distributed within the Central European Initiative (CEI) WG on Satellite Navigation Systems, during several meetings in Trieste and in the CEI Countries.

The project refers to some (general) recommendations and decisions of the European Commission. In the document titled "The Transport and Energy Infrastructure in South East Europe" (Bruxelles 15th October 2001) we read the following: "Improving the transport and energy infrastructure in the region and integrating the countries of South Eastern Europe with the rest of Europe is important in order to support improved quality of life through economic growth, regional integration, social cohesion and adequate environmental conditions" (p. 5). The document then continues, saying: "Three recent planning exercises involving countries outside the EU and the region focused on are specifically relevant and have been taken into account: the decision of the Pan-European Transport Conferences, particularly those held in Crete and Helsinki, concerning the concept of Pan-European transport corridors and areas. A number of these Corridors and Areas (PETrAs) cross or concern the Balkan region: Corridors IV, V, VII, VIII, X and the Adriatic-Ionian PETrA" (p.6). In the same document: "The state of the network is very variable, although in general it shows a serious lack of periodic and current maintenance. The maintenance problem is becoming particularly acute in certain cases. In the Federal Republic of Yugoslavia it is estimated that only 30% of the roads are in a satisfactory condition. Furthermore, many roads do not comply with the requirements of European trucks. This needs special attention" (p.7). Among the principles, the same document states the following: "Priority is given to the existing infrastructure by repairing and rehabilitating it. Upgrades or new infrastructure components should be kept to a minimum" (p. 9).

Moreover, in the same document, we see the following criteria among those listed for the selection of network sections: "The network definition will take account the infrastructure planning of the UN-ECE European agreements, the E-routes for land transport to which the South East European countries agreed to" (point 1, p. 9). "The network should concentrate accessibility to only a few Adriatic ports, with the aim to support short sea shipping that requires the convergence of substantial traffic flows. These ports should be adequately linked to the land transport network and equipped for combined transport" (point 4, p. 9). "Furthermore, the ports of Rijeka, Split, Ploce, Dubrovnik, Bar and Durres should be connected to the network" (point 5, p. 11).

Describing the project now in more detail we could say that **its first segment (as designed by Zora Konjovic)** defines the data model that accurately describes the road network. The model is based on recommendations defined by the ***EuroRoadS*** project[6]. The ***EuroRoadS*** project has defined an outline for the European Directive (to be issued) governing the field of data related to the public road network. It covers the framework of the Pan-European road network data infrastructure and the implementation of the national/regional databases. This segment of the project covers:

- the information model,
- the core data,
- the data exchange model.

The second segment defines the technological background, standards and procedures for model-specified data acquisition.

- the technological background for precise data acquisition comprises remote sensing, GIS and GPS technologies;
- the standards are related to measuring equipment, communication protocols and data formats;
- the procedures are aimed at the specifications of acquisition protocols according to best practices.

The project verification will be carried out by deployment of the pilot installation.

- the first step will be the selection of certain areas in Vojvodina. The basic criterion for selection will be the presence of the various road categorise (city roads, magistral roads, regional roads, etc.). Additional criteria will concern the existence of appropriate digital maps for the region as well as the measurement infrastructure supporting the availability of data acquisition (precise GPS positioning, communication infrastructure, etc.) and remote sensing data (satellite and airborne images, etc.).
- the second step will cover the acquisition of data for the selected regions. The acquisition of the data will be carried out deploying technologies, standards and procedures defined by the Project.
- the third step will be the creation of the electronic database. The database will be created following the ***EuroRoadS*** framework. The data base will be accessible via the Internet.

The expansion of ALADIN (the ALpe ADria INitiative Universities' Network) has been already presented and is under analysis, particularly for the cost (having the SISA Project given good information on cost and feasibility). The ALADIN group covers **the following Universities:** *Graz, Rijeka, BW München, the* University of Trieste*, the* Novi Sad Business School *and* Košice.

2 Project Organisation

2.1 The University of Trieste, GEONETLAB

The Centre of Excellence for Telegeomatics, GEONETLAB, approved as a centre of Excellence and also co-financed by the Italian Ministry of University and Scientific Research, carries out research in GPS and Glonasss applied to general and thematic cartography, as well as in several applications of the geographic information systems methods (GIS), including Road GIS by means of its surveying vehicle. It

[6] http://www.euroroads.org

includes Telematics infrastructures, tools and norms, services and Operational Research for transport optimisation. The Centre is Coordinated by the principal proponent: Prof. Giorgio Manzoni (Full Professor of Topography, Faculty of Engineering, Department of Civil and Environmental Engineering, University of Trieste), under the Administrative Management of CSPA, Centro Studi e Progetti Avanzati, University of Trieste, directed by Mr. Bernardo Sannino.

2.2 The University of Novi Sad, CGITS

The University of Novi Sad, Centre for Geo-Information Technologies and Systems, Faculty of Technical Sciences, provided instruments and experience in the Geomatic field (including a GPS net), in order to carry out tele-informatic support activities during the survey operations. It will also collaborate in the dissemination and provide support in finding cartography and geodetic nets in Serbia; the University of Novi Sad also employs highly skilled software specialists (particularly in the field of Internet programming), who are relied on for setting up proper web based communication systems for the Project.

2.3 The University of Verona – DESIGEO (Dpt. of Economics, Society and Institutions, Geography Section)

DESI (an interdisciplinary department) has experience in local industrial spatial development (analyzing business strategies, their behaviors and their impact on the territory) and, recently, mainly in the following fields: Tourism and Transport Logistics. It adopts methodologies based on both the GIS/GPS and the quantitative/qualitative approaches used in social sciences. It processes data for geographic tourist itineraries (also on PDAs), focusing on landscape, agricultural and cultural heritage in the Adriatic Regions. On one hand, the work aims to get a better understanding of how tourist typologies are evolving and, on the other, at matching tourist needs (at the global level) with the localized richness of locations. In this latter area, they could benefit from the use of ICT tools and design/implement local economic policies that are sustainable and able to achieve greater competition among the various destinations in the Mediterranean countries. DESI also works at analyzing the way local/global logistics networks grow and how the role of Verona as a logistic node (with regards to a continental or world-wide situation) adjusts to changing (global) economic processes.

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- Ali Dedei, Institute for Transport Studies, Tyrana, "Albanian Road Network"
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- Giacomo Borruso, Facoltà di Architettura dell'Università di Trieste, "Cultural Heritages in Balkans and International Cooperation"
- Claudia Robiglio, University of Verona, " Gli itinerari turistico-culturali per la qualità della vita"

Contributions by the University of Trieste SISA STAFF:

- Bernardo Sannino, "Management del Progetto SISA"
- Luca S. Rizzo, "Satellite Navigation Technologies and Hypothesis of Development in Balkans"
- Giorgio Manzoni, "Road Information System for Countries across Adriatic Sea
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