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Organizational Analysis to Improve Safety Planning of Road Networks

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Abstract. The old age of existing road infrastructures has highlighted different issues related to safety management and governance of road systems in many European countries. In fact, safety problems are affecting infrastructure networks generating the need of a sustainable planning of interventions as well as management of traffic flows in a territory. In this context, the different private/public actors have an active role to minimize undesirable economic and social impacts. The present research addresses this issue by means of an organizational analysis based, first, on the identification of all the stakeholders who can define appropriate decisions following specific organizational models. Considering a road network in Rome (Italy), the study proposes the remote sensing by satellites as a useful tool for the stakeholders within a territorial investigation. Indeed, the safety issue of road networks needs complex analyses where all the elements have to be investigated together to achieve a more comprehensive understanding of the organizational issues to improve their governance.

Keywords: Organizational Analysis, Road Network, Remote Sensing.

1 Introduction

The old age of existing road infrastructures has highlighted different issues related to safety management and governance of road systems in many European countries. In fact, safety problems with different degrees are affecting infrastructure networks generating the need of a sustainable planning of interventions as well as management of traffic flows in a territory. In this context, the different private/public actors have an active role to minimize undesirable economic and social impacts [1-5].

In fact, over the years, different proposals (i.e., plans/strategies) have been defined by different actors to improve the safety and resilience of urban systems against extreme natural phenomena, as discussed in [6-11], highlighting the attention on their design and execution standards. In [12-15], the GIS (Geographical Information System) technique has been implemented for definition of risk-based plans. Moreover, Structural Health Monitoring (SHM) techniques [16-17], e.g., the remote sensing, i.e., the Differential Interferometry Synthetic Aperture Radar (DInSAR) [18-19] have been included in other management proposals. Contextually, some managerial approaches, based on organizational issues, regarding safety of road networks have been presented in [20-21].

The present research addresses the abovementioned issue by means of an organizational analysis based, first, on the identification of all the stakeholders who can define appropriate decisions following specific organizational models: coordination model useful when the actors involved are few and for a low risk; flexible model [22] grounded on a "loosely coupled" interaction necessary for high risk and when there are many actors involved [23]. Additional details may be found in [24].

Considering a road network in Rome (Italy), the study proposes the remote sensing through satellites as a useful tool for the stakeholders within a territorial investigation with respect to natural hazards (e.g., earthquake and landslide events, seasonal and subsidence phenomena, variations of temperature, deterioration processes). Indeed, the safety issue of road networks needs complex analyses where all the elements have to be investigated together to achieve a more comprehensive understanding of the organizational issues to improve their governance. The case study is useful to better explain the two organizational models.

2 The remote sensing for an organizational analysis of road networks

The DInSAR technique [25-26] employs the data of a satellite constellation (e.g., the Italian COSMOSkyMed) to derive measurements of ground movements (e.g., velocities together with derived displacements). These measure values can vary on time depending on natural/anthropic events.

The abovementioned technique is grounded on the phase difference of two or more complex-valued SAR images, obtained by several sensors along the Lower Earth Orbits (LEO), with a distance variable from 500 to 800 km, going along with polar (ascending and descending) orbits to have a global coverage.

The SAR sensors may be characterised by different properties [25] which can affect the final quality of data.

The processing of these remote sending based-data can represent the tool useful to implement a territorial investigation of the road networks with respect to their safety level. Additionally, the elaborated results can be treated in the GIS platform for their graphical representation overlapped on the of the road networks. In this way, technical maps [27] are defined and, therefore, can represent an effective instrument common to all actors to understand the organizational issues (Figure 1) for an improvement of the governance processes. In fact, all the stakeholders involved are immediately recognized

and an in-depth analysis with respect to the organizational issues can be approached (Figure 1).

By this way, it is possible an improvement in involving the different private/public actors, institutions and administration levels within the two organizational models previously mentioned. Specifically, the technical maps will support the choice between the two models as a function of the actors number together with the level of safety.

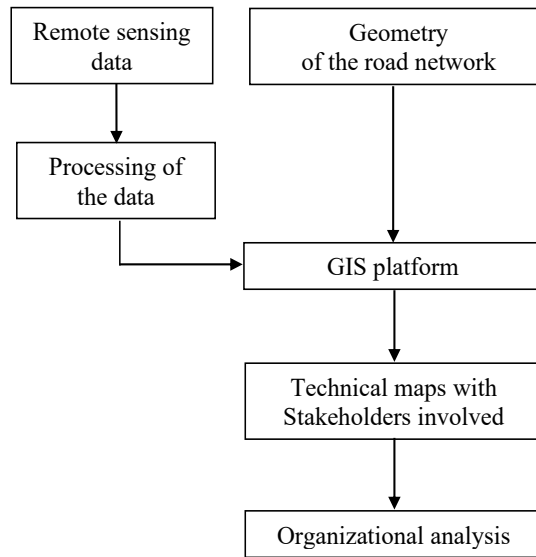


Fig. 1. Flowchart for organizational analysis.

3 A road network in Italy: case study of Rome

Referring to a case study corresponding to the road network in Rome (Italy), composed of both national and regional highways, in agreement with the research projects [28]-[29], this section deals with some results computed from the processing of the satellite data.

Table 1. Roads and stakeholders.

Roads	Stakeholders
“A1 - Autostrada del Sole”	“ASPI - AutoStrade Per l’Italia”
“A91”	“ANAS S.p.A.”
“A12 - Autostrada Azzurra”	“ASPI - AutoStrade Per l’Italia”
“Circonvallazione”	Municipality
“Grande Raccordo Anulare”	“ANAS S.p.A.”
“A24”	“Strada dei Parchi S.p.A.”
“Lungotevere”	Municipality
“SP 216 - Maremmana”	Province

In the GIS platform, Fig. 2 illustrates a map with technical information showing the road network, adopted herein for the investigation, overlapped on the Municipality boundaries of Rome.

Table 1 lists the stakeholders who can be involved within the organizational analysis if necessary: “Strada dei Parchi S.p.A.”, “ASPI - AutoStrade Per l’Italia”, “ANAS S.p.A.”, Municipality and Province.

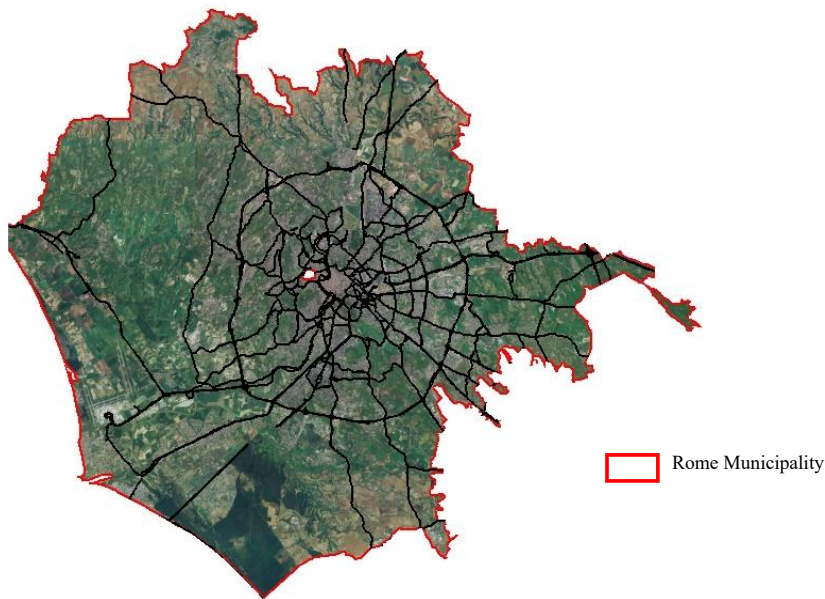


Fig. 2. The road network under investigation.

Contextually to the identification of the geometry of the road network, there is the phase of the processing of the DInSAR data, with reference to the SAR sensor images (COSMO-SkyMED) corresponding to the ascending orbit during the last 8 years.

Setting 0.6 as coherence value [30], some millions of points have been monitored, as can be deduced from Fig. 3 illustrating the average velocities.

In order to compute the technical maps having information on the displacements, all the roads of the network have been subdivided in square “cells” 50x50m [25,31]. Next, the vertical displacement values have been derived, as recommended by [25,31], and have been reported in the GIS platform (Fig. 4).

These partial results have a preliminary value but are essential to demonstrate the effectiveness of the tool. In fact, it can be deduced that that some roads of the network suffer potential damages for the high vertical displacements. It is also possible to recognize the potential stakeholders involved: by “ANAS S.p.A.”, “Autostrade per l’Italia - ASPI”, Province and Municipality (Fig. 2 and Table 1).

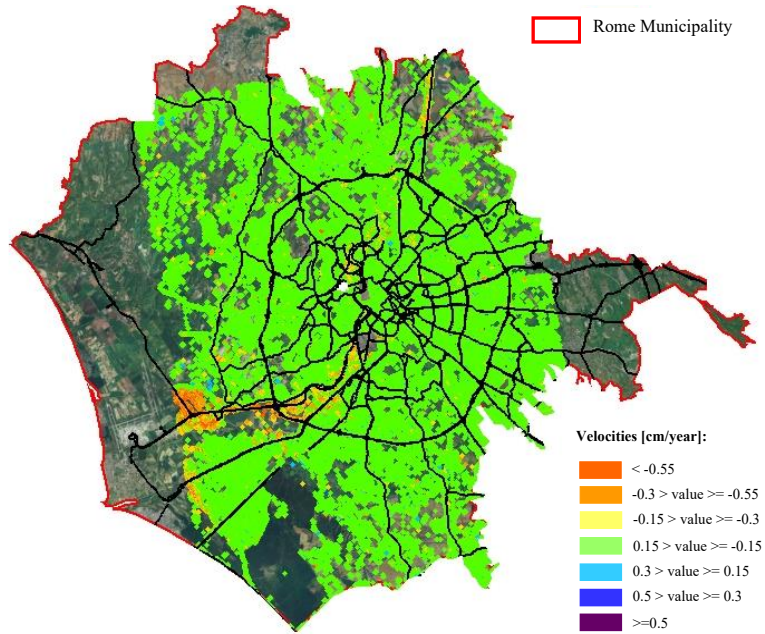


Fig. 3. Velocities corresponding to the ascending orbit.

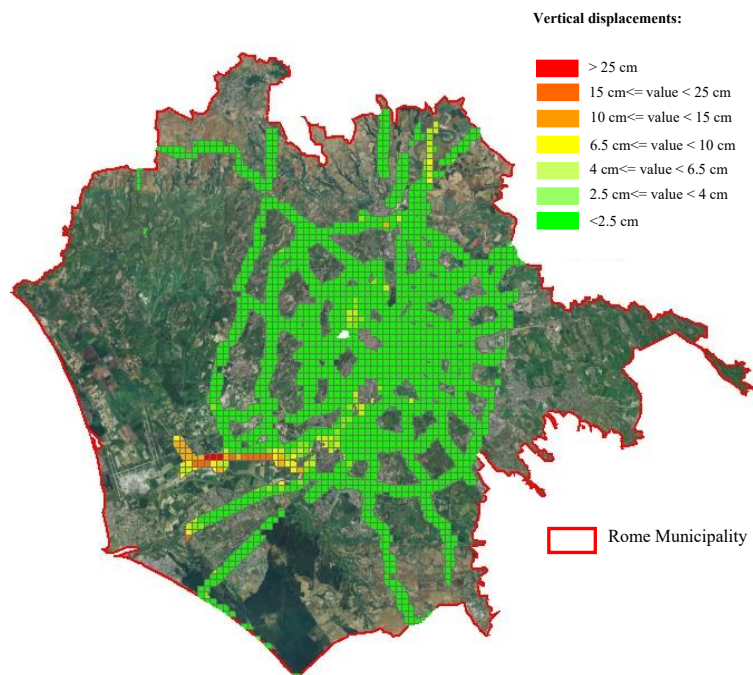


Fig. 4. Technical map showing the vertical displacements.

Considering the different potential actors involved and not very high magnitudes of the vertical displacements, the most appropriate organizational model should be the one coordinated referring to common guidelines. Instead, with reference to the specific road having high displacements values, the most appropriate organizational model should be focused on flexibility as the difficulty to coordinate the decision-making process.

It is essential to underline that more specific investigations are absolutely necessary to check the infrastructures [32-35] sustaining the roads especially when high displacements values are observed.

Although the preliminary value of this analysis, the outcomes demonstrate the effectiveness of the proposals for territorial investigations. In fact, the proposed technical maps are an effective document to relate the networks and the actors to define the most appropriate organizational model for improving the planning of interventions with respect to the safety issue at a territorial overview.

4 Conclusions

This research presents some preliminary features of organizational analysis with few preliminary results regarding the safety planning of the road networks. The analysis is aimed to emphasize the roles of the stakeholders together with the need to be managed within two organizational models. The processing of the remote sensing based-data in the GIS platform can represent the tool useful to implement a territorial investigation of the road networks with respect to their safety level. In this way, technical maps can be defined and, therefore, can represent an effective instrument common to all actors to understand the organizational issues for an improvement of the governance processes. In fact, all the stakeholders involved can be immediately recognized and an in-depth analysis with respect to the organizational issues can be approached. By this way, it is possible an improvement in involving the different private/public actors, institutions and administration levels within the organizational models by taking into account the actors number together with the level of safety.

As for the road network in Rome (Italy), the obtained results have demonstrated the effectiveness of the organizational analysis for a territorial investigation. In fact, the preliminary results highlight that higher magnitudes of the vertical displacements affect only some roads with respect to most of the roads. In addition, by means of the technical map it is possible to recognize the potential actors involved (e.g., "ANAS S.p.A.", "Autostrade per l'Italia - ASPI", Municipality and Province).

Although the preliminary value of the outcomes, the proposed technical maps are an effective way to relate the networks and the actors to define the most appropriate organizational model for improving the planning of interventions with respect to the safety issue at a territorial overview.

The proposals are also effective and, so, can be extended to other international countries as well as to road networks between different nations to improve the international governance of infrastructures.

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- ReLUIS fund projects 2019-2021 (Monitoring of reinforced Concrete Structures) – WP6 “Monitoring and satellite data”;
- ReLUIS fund projects 2022-2024 (Monitoring of reinforced Concrete Structures) – WP6 “Monitoring and satellite data”.

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