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Safety Management of Infrastructures through an Organizational Approach: preliminary results

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Abstract. The safety of the road infrastructures is a very relevant topic within the governance of a territory characterized by several structural systems built some decades ago. In fact, since these structural systems are affected by not negligible safety problems, the governance actors are called to define appropriate plans and interventions to reduce undesirable social impacts. It derives that the actors, i.e., public or private stakeholders, are responsible of both the administrative and economic procedures. The present study discusses this topic by means of some preliminary suggestions and results in relation to the safety management of the infrastructures from an organizational perspective through two models. In fact, the study highlights the stakeholders domain as the virtual place where the organizational principles should guide all the processes. In detail, as for a group of Italian infrastructures in Rome, the author suggest to adopt the monitoring by means of satellites for a territorial analysis. This technology-based data can lead to the elaboration of alert maps as well as risk analyses useful to upgrade the organizational features within the management and governance procedures.

Keywords: Organizational Features, Infrastructure Safety, DInSAR.

1 Introduction

The safety of the infrastructures is a very relevant topic within the governance of a territory characterized by a large number of structural systems built some decades ago. In fact, since these structural systems are affected by not negligible safety problems, the governance actors are called to define appropriate plans and interventions to reduce undesirable social impacts, as commented in [1-5].

It derives that infrastructure safety is an important issue that involves numerous actors such as authorities, central and local actors (i.e., private or public stakeholders), who are responsible of both the administrative and economic procedures [6-7], in addition to the researchers and technology experts.

In fact, all plans and strategies provided by these actors obviously affect the safety of the infrastructures. Moreover, as marked in [8-10], the execution and design standards represent very important aspects when planning activities are delineated in a territory subjected to extreme natural events. These aspects, often missing [11], are essential in the planning with the purpose to reduce the risk improving the resilience.

In studies [12-13], public policies have been proposed to ensure protection from natural events as well as risk-based plans combined with the use of the GIS (Geographical Information System) technique have been commented in [14-15]. The studies [16-17] describe the proposals of managerial approaches, inspired by organizational issues, for safety and security of road infrastructures.

Public and private actors have elaborated some strategies, defined as Bridge Management Systems, through the use of the Structural Health Monitoring (SHM) techniques [18-19], such as, the one by means of satellites, i.e., the Differential Interferometry Synthetic Aperture Radar (DInSAR) [20-21].

The present study aims at discussing this topic by means of some preliminary suggestions and results in relation to the safety management of the infrastructures from an organizational perspective. In fact, the study highlights the stakeholders domain as the virtual place where two organizational models should guide all the processes. In particular, two competing models can be useful in this case. Firstly, there is the centralized model based on a command-and-control approach. This is supported by a strict use of bureaucratic coordination rules and works well under two main conditions: 1) a limited number of agents to coordinate and 2) a low degree of alert.

Secondly, a flexible model [22] where centralized decisions go hands to hands with those decentralized based on a "loosely coupled" approach. Coordination rules turn into forms of partnership together with a significant leeway at the local level [23] particularly suitable under conditions of 1) high alert and 2) greater numbers of actors involved.

In detail, as for a group of Italian infrastructures in Rome, the authors suggest to adopt the monitoring through satellites for a territorial analysis to be supported through the organizational models.

This remote sensing activity is a very powerful monitoring technique to observe the infrastructure responses to some natural events (e.g., earthquakes, landslides, subsidence phenomena, temperature variations, degradation processes and seasonal phenomena) at territorial scale.

These technology-based data can lead to the elaboration of alert maps as well as risk analyses useful to upgrade the organizational issues in the management and governance procedures.

2 The DInSAR technique useful to an organizational approach within the safety management of the infrastructures

The DInSAR technique [24-25] is based on the use of data from a satellite constellation (e.g., the Italian COSMOSkyMed) to achieve measurements in terms of both velocities and displacements on the topographic surface. These measurements obviously depend on time due to the occurrence of many natural or anthropic events.

The DInSAR technique exploits, in its basic form, the phase difference of (at least) two complex-valued SAR images, acquired by different sensors along so called Lower Earth Orbits (LEO), between 500 - 800 km, following polar (ascending and descending - with opposite ground looking directions) orbits to ensure a global coverage. As for the SAR sensors, they may be different mainly for maximum measurable displacement, band, acquisition period, revisiting time, line of sight and resolution [24]. All these factors can influence the quality of final data.

These data, referred to a territorial context where the infrastructures are built, can be properly elaborated to achieve alert thresholds as well as perform risk analyses. Successively, the results can be detailed in the GIS environment leading to the definition of territorial maps illustrative of the infrastructures safety.

These satellite-based maps can be adopted as common data to all actors and, therefore, are useful to define an organizational framework (Figure 1) in the management and governance processes of infrastructures safety. In fact, the stakeholders are easily recognized and involved in the institutional processes.

The domain of the stakeholders should englobe all the analytical and management processes. This domain should be seen as the virtual place where the organizational principles should guide all the processes.

In this way, a synergic behavior between the different institutions, public actors and the various administration levels can be increased according to the guidelines described in the previous section. Specifically, the displacement maps will address for the suitability of the two models by considering the number of actors involved as well as the degree of alert.

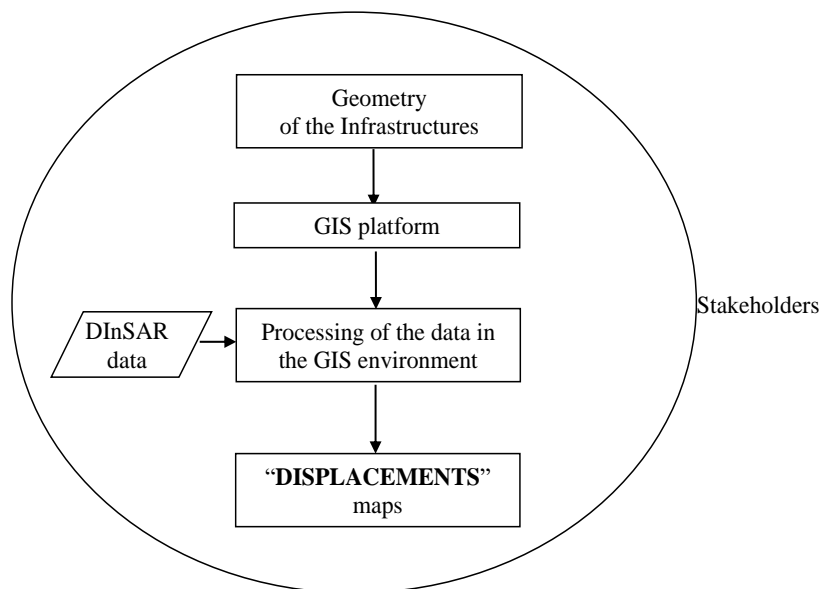


Fig. 1. Organizational framework.

3 Italian infrastructures in Rome

Referring to some Italian road infrastructures in Rome, in compliance with the research project [26], this section illustrates some preliminary results achieved from the elaboration of the DInSAR data.

Table 1. Infrastructures in addition to the corresponding stakeholders.

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

Figure 1 depicts a thematic map in the GIS environment showing the physical boundaries of Rome Municipality in addition to the infrastructures extrapolated for the present analysis.

Table 1 reports the corresponding stakeholders: “Strada dei Parchi S.p.A.”, “ASPI - AutoStrade Per l’Italia”, “ANAS S.p.A.”, Municipality and Province.

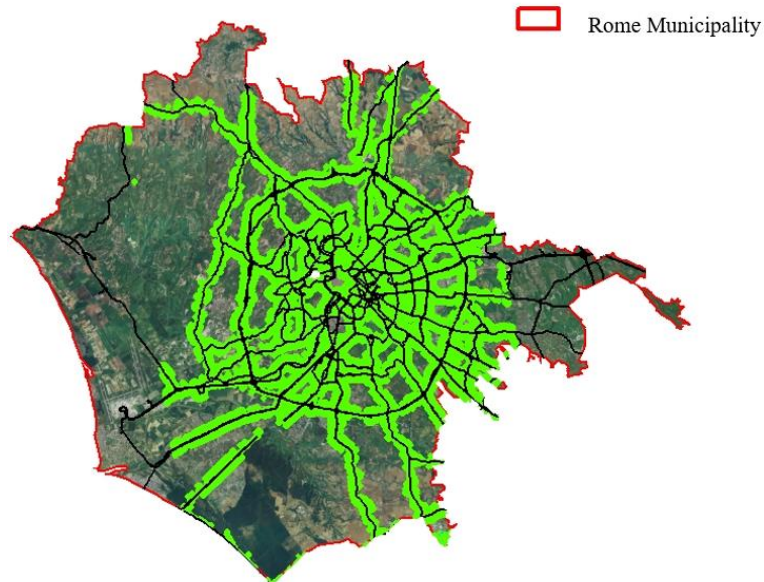


Fig. 2. The infrastructures with the points monitored over time.

After that, we have properly managed the DInSAR data, regarding the SAR sensor images (COSMO-SkyMED) along the ascending orbit within a timeframe of the last eight years. Selecting 0.6 as reference value for the coherence [27], we have monitored more than six millions of points, as illustrated always in Figure 1.

With the purpose to carry out the computation in terms of the displacements, all the infrastructures have been divided by means of “cells” with dimensions equal to 50x50m [24,28]. Next, the horizontal displacements have been calculated, as suggested by [24,28], and are shown in Figure 2.

These preliminary results indicate that some infrastructures are affected by potential damages due to high values of the horizontal displacements. Precisely, some infrastructures, managed, respectively, by “ANAS S.p.A.”, “Autostrade per l’Italia - ASPI”, Province and Municipality (Figures 1 and 2) present severe alerts as regards the horizontal displacements. In this case, there is not a prevailing model that can be applied.

On one hand, any infrastructures can be referred to different authorities both when considered the hierarchical level and the nature (private vs public). On the other one, there is a similar risk that does not suggest a model inspired to flexibility as decisions should come with similar timeframes and thus are hard to be coordinated through common guidelines. A possible solution could refer to a hybrid model where both some features of the top-down model and the flexible one can be applied. We are thinking to a command chain among public authorities and the use of more flexible solutions when private authority is involved.

This propose should be better implemented considering a certain rigidity of the competences and of the rules, particularly for the public field. However, it could be useful for two reasons: 1) theoretical model needs reality to be adjusted, and a hybrid model better catches the complexity of the infrastructure system 2) one must carefully consider the trade-off between the rigidity of systems and the efficiency of the solution purposed.

It is important to specify that further and more detailed analyses need to be performed to assess the safety conditions of the infrastructures especially when severe damages are fearsome.

Although these results are preliminary, they represent a useful contribution for territorial analyses. In fact, they demonstrate the actual way to relate the infrastructures and the stakeholders for a more appropriate and sustainable planning in terms of structural safety at a territorial scale.

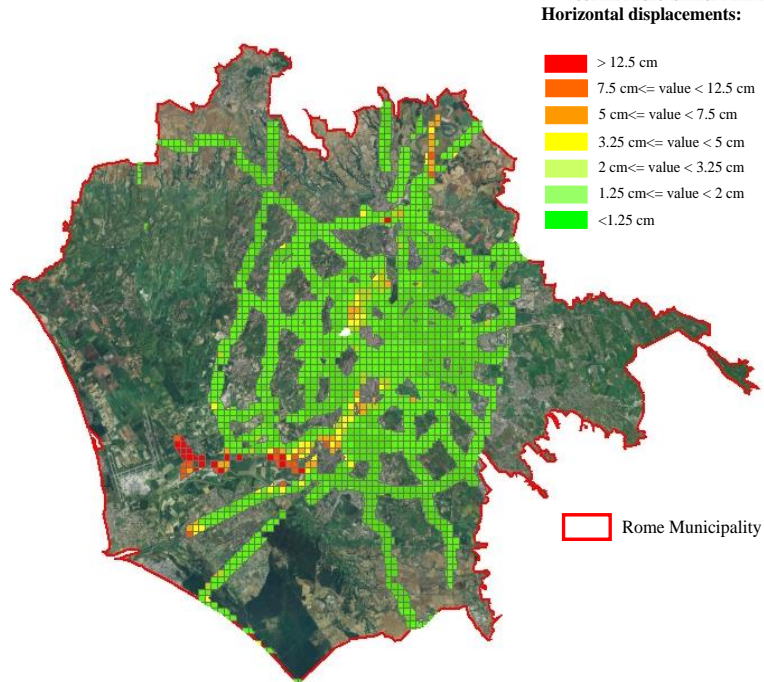


Fig. 3. Horizontal displacements.

4 Conclusions

The study discusses some preliminary suggestions and results in relation to the safety management of the infrastructures from an organizational perspective.

A preliminary framework is illustrated in order to put in evidence the role of the stakeholders to be coordinated according to two main models. In fact, the domain of the actors represents the virtual place where the organizational rules should guide all the processes, where the institutional and administrative processes should be synergic and systemic in relation to the safety of the infrastructures.

Furthermore, some technical instruments (i.e., satellite data and GIS) are discussed for their features useful to the organizational aims at a territorial scale.

In detail, as for a group of Italian infrastructures in Rome, the results, derived from the use of the monitoring through satellites, demonstrate their effectiveness for a territorial analysis from an organizational perspective.

The preliminary results indicate that some infrastructures are affected by potential damages due to high values of the horizontal displacements. Precisely, some infrastructures, managed, respectively, by “ANAS S.p.A.”, “Autostrade per l’Italia - ASPI”, Municipality and Province present severe alerts as regards the horizontal displacements.

These technology-based data can lead to the elaboration of alert maps as well as risk analyses useful to upgrade the organizational features within the management and governance processes. These latter ones are not flexible enough to justify

different models of coordination that are not respectful of hierarchy. This is particularly true in case of public stakeholders.

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