

Geodetic and Geotechnical Combined Monitoring Concept

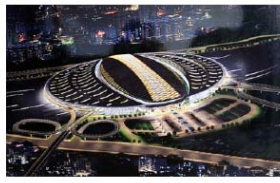
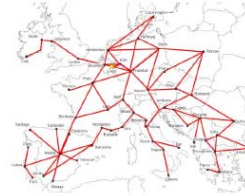
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Structural and environmental behaviors understanding: a new challenge



Structural and environmental behaviors understanding: a new challenge



The necessity of Risk Management

- ▀ Much consideration in preventive risk management and mitigation
 - ▀ Direct and indirect impact

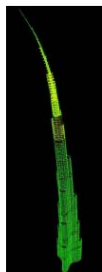


Direct and Indirect Impact



Monitoring systems new critical role

- ▼ Monitoring is becoming essential to protect the huge investment needed for
 - ▲ Building up infrastructures
 - ▲ Mitigate the risk of failure on the population
 - ▲ Protect the environment
 - ▲ Guarantee a sustainable economy



Monitoring systems and Risk Management

- ✔ Risk Management is today a good governance attitude
- ✔ Monitoring systems will then play a critical role to keep infrastructures on service and to gain better understanding of potential risks linked with natural hazards or structural problems.
- ✔ The essence of a monitoring system is to provide on time accurate and reliable data to evaluate correctly the parameters connected with risks.
 - ▲ deformation model
 - ▲ Predict failures
 - ▲ Warning and early warning
 - ▲ Time to react and mitigate the risk



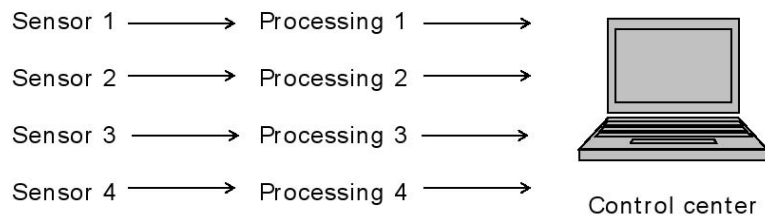
Monitoring world and monitoring success

- ✔ There are different Monitoring sensors and techniques.
- ✔ Geodetic sensors, Geotechnical sensors, Meteorological sensors, Radar sensors, Fiber sensors, Laser sensors, Remote sensing....
- ✔ To be successful in delivering sensitive informations:
 - ▲ Proper design of the right sensors
 - ✔ Right sensors
 - ✔ Right locations
 - ▲ Reliable transmission system
 - ▲ Robust power supply
 - ▲ Millimeter accuracy is mandatory.

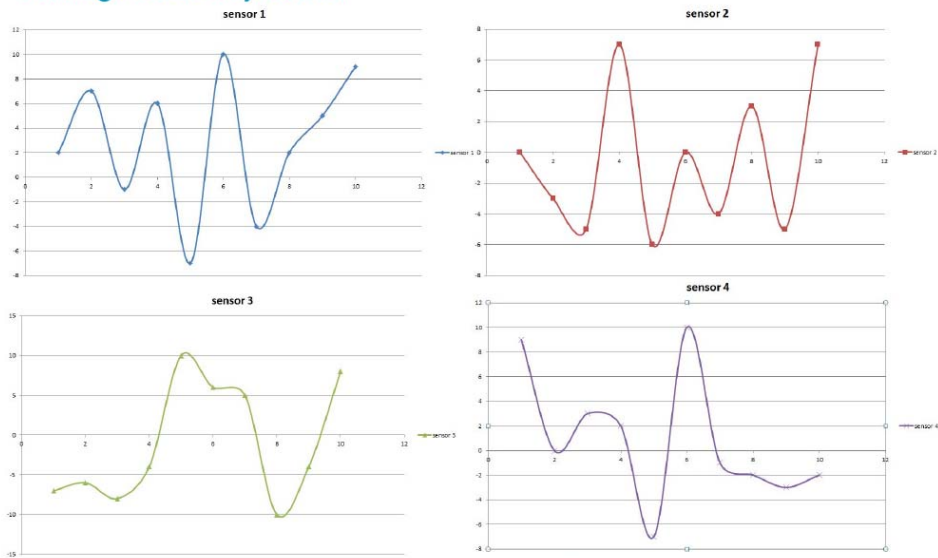


Integrated system

- Traditionally integrated systems are system able to display data from different sensors on the same diagram.

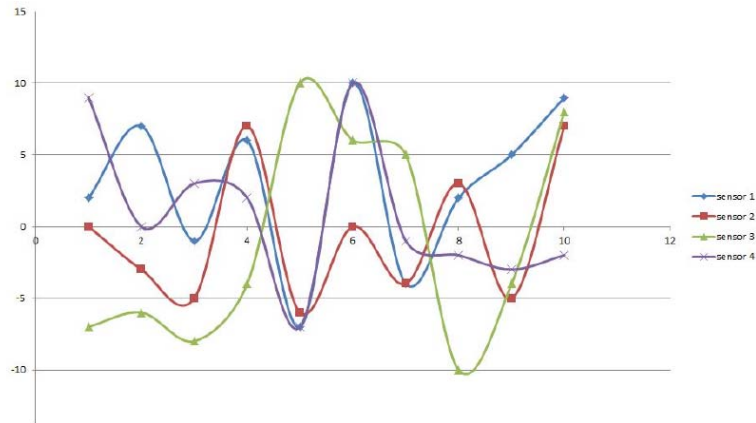


Integrated system



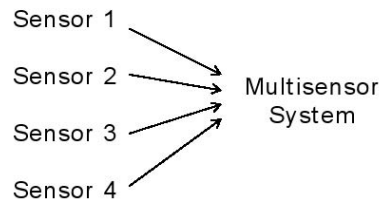
Integrated System Advantages

- ✔ Compare results
- ✔ Redundancy



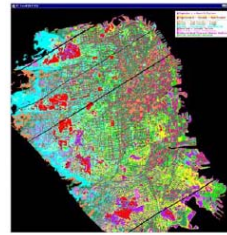
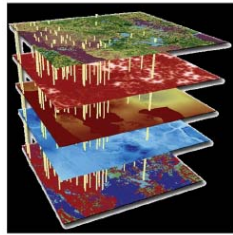
A new guideline – System integration and Data Fusion

- ✔ To consider different sensors sources of different information from the same site, and merge all the data to provide the best answer to responsible needs.



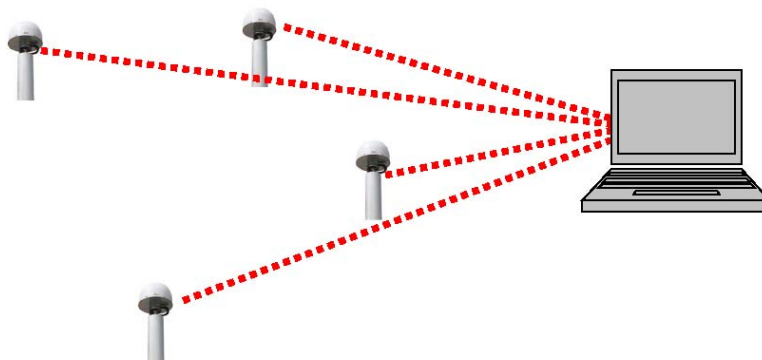
A new guideline – System integration and Data Fusion

- ▼ Use every single component or information to achieve the higher level of synergy and as a part of system with a task – to manage the risk.
- ▼ 2 main strategies:
 - ▲ System physical integration
 - ▲ Data Fusion (mutual offsetting method)

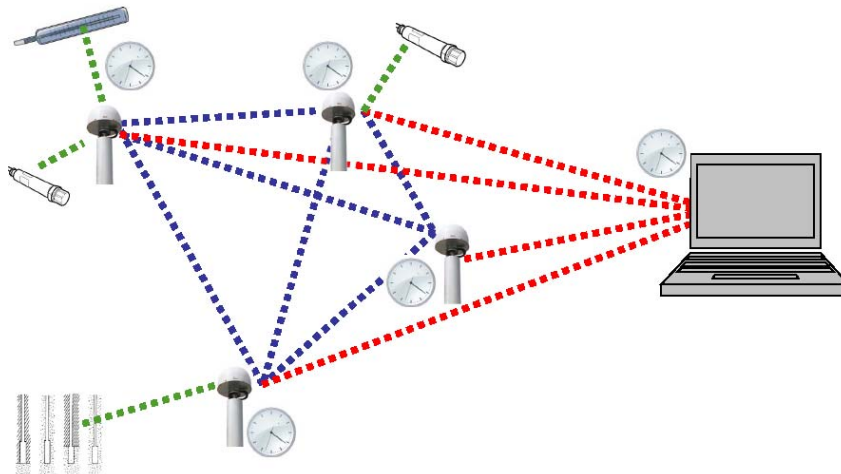


Physical Integration

- ▼ Take advantages from different hardware devices to create much robust and efficient system architecture at an affordable cost.



Physical Integration



Physical Integration

Other ideas:

- ✔ Sharing resources as power supply back up
- ✔ Solar panels smart switch
- ✔ On site memory sharing

With the following main advantages:

- ✔ Less Maintenance
- ✔ Less Complexity
- ✔ Save Money



Data Fusion

- Data fusion is about considering a data model to process different raw data together in order to obtain the best result



Data Fusion

- Data fusion is about considering more than a single source of data per point to generate unbiased input to a deformation model.
- «Mutual offset» is the key to this process.
 - thermal effect or inclination affecting a GNSS antenna support,
 - water pore pressure variations affecting the stability of a station pillar,
 - absolute deflections provided by a GNSS antenna + receiver versus the response of a vertical pendulum sensor

There are many algorithms and data fusion techniques:

- Least square adjustment
- Fuzzy logic
- Neural network
-

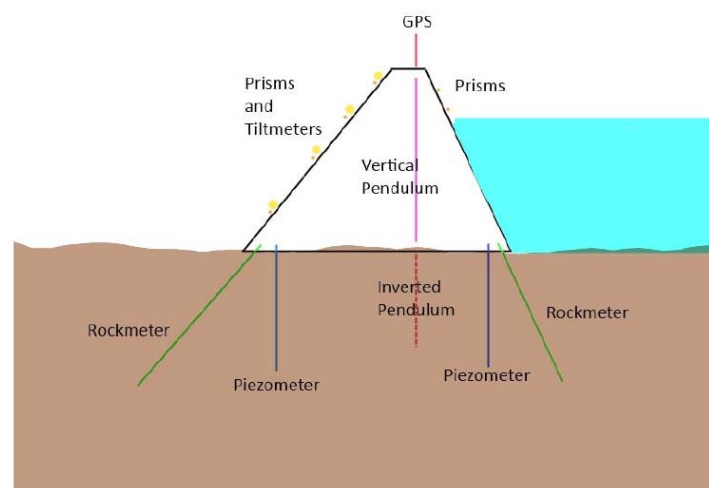


Data Fusion

- ▼ In case of dam safety operations, a line of piezometer is often considered as one of the most important monitoring segment. As the performances of a borehole piezometer is affected by settlement's effects:
 - a reflector collocated and sighted by an Automatic Total Station or a GNSS antenna will provide just the necessary information to take into account during the data analysis.
- ▼ Generally for a structural monitoring project, geotechnical sensors are placed to deliver physical information from inside a structure and around while geodetic sensors are monitoring the geometry of a structure from outside.



Data Fusion



Case of study: Grohovo Landslide 3D Early warning system

- ▀ Research Project of the University of Rijeka for 3D Fully automated Early Warning System.
- ▀ Data fusion with Geotechnical Sensors and Meteorological Sensors.
- ▀ Independent power supply
 - ▀ 90% of the system is powered by distributed Solar Pannels
- ▀ Communication system integration on field
 - ▀ Triple WiFi and UMTS communication networks



Grohovo Landslide



Grohovo Landslide

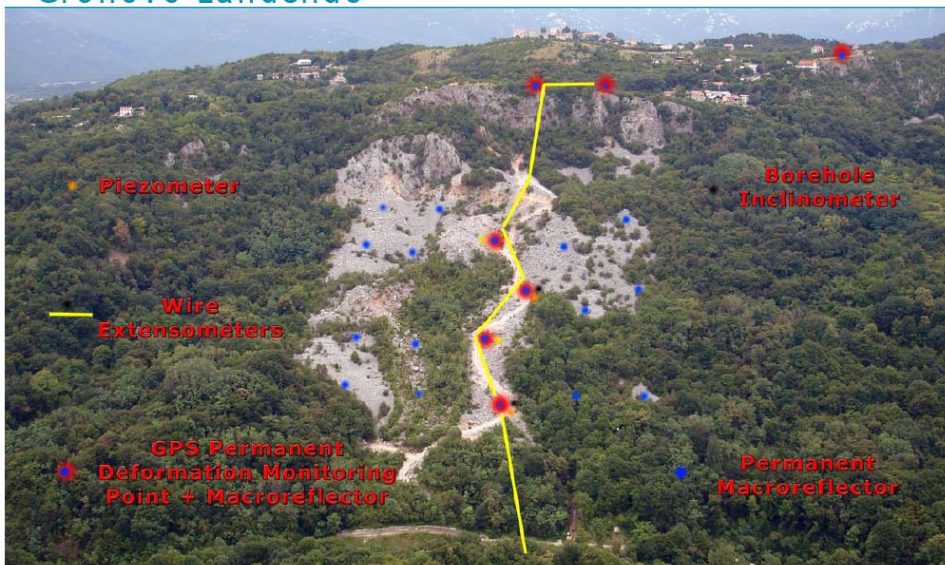


FIG WORKING WEEK 2012
May 6-10, 2012
Rome, Italy

Grohovo Landslide (Rijeka, Croatia)



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Conclusions

- ▀ Authorities and responsible of population, vital infrastructures and environmental protection must be informed that if a monitoring system is beneficial to provide information's that will help them in their tasks to assume their responsibilities, attention must be paid on the design and expertise is needed to effectively engage actions that at the end will result in mitigating the effects of natural disasters or the impact of engineering structures failures.
- ▀ Traditionally geodetic and geotechnical sensors were installed independently and often without any effort or attention that would have been of the great interest during the analysis.



Conclusions

- ▀ We do hope that this paper will open more experiences, investigations and reports demonstrating that the concept the authors are promoting will provide significant benefits compared to the actual situation.
- ▀ Monitoring is a serious matter that forces the professionals to innovate and every time to refine and to improve their proposals.
- ▀ Multi-sensors, integration and analysis are every time also a task that needs a multi-disciplinary approach. The technology has reached a mature level than combining sensors just makes sense. Offsetting geodetic and geotechnical sensors however will most probably also stimulate the industry to consider new developments.



Conclusions

Thank you for your attention.



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