

Sharing and Updating Landslide Maps Using a WebGIS System

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INTRODUCTION

The availability of updated and easy accessible regional landslide maps (scale 1:10.000) is a critical point for a good territorial planning in mountainous areas and for the careful planning of consolidation works. Although slope instability is a dynamic phenomenon continuously evolving during time, landslide maps, even digital ones, are basically static and thus prone to become quickly obsolete. Their updating is made on a long-term period and it's usually related to the exceptionally occurrence of widespread instability events.

This updating modality doesn't cover instability events, such as small new landslides or reactivation of old ones, that occurs during the year and it's cost-intensive, requiring wide and expensive aerial and field surveys. However a huge amount of data referring to slope instability is continuously gathered in a decentralised form by local authorities, either as landslide notification made by private and public subjects, or as field surveys carried out by the technicians of the same local authorities to verify the notifications received. This flow of information, if organised in a single and centralised geodatabase, could allow an updating on an almost real-time basis and in a cost-effective way, existing regional landslide maps.

To cope with these issues, the Province of Parma and the Comunità Montana Appennino Parma Est, thanks to a EU funding for Objective 2 Areas, have developed a WebGIS System (called *Difesattiva on-line*) that supplies local authorities located in mountainous areas with free and user-friendly GIS tools for sharing and continuously updating the regional landslide map, scale 1:10.000, produced by Province of Parma and Regione Emilia Romagna.

WEBGIS FRAMEWORK

The WebGIS System *Difesattiva on-line* has been developed using the ESRI software package ArcSDE 8.3, ArcIMS 4.0, ArcEDITOR 8.3 and the

Database Server Oracle 9.2. It consists of two software applications strictly integrated having two different user levels.

The first one is an ArcIMS application available on-line for registered users (i.e. local authorities) by means of an Internet browser. The application supplies tools for visualising, in a dynamic way, aerial ortophotos, topographic and thematic maps (as the landslide one) organised in a provincial geodatabase Oracle-ArcSDE stored on a server. Every registered user can display and query ortophotos and maps only for the territory falling under his own jurisdiction (fig. 1).

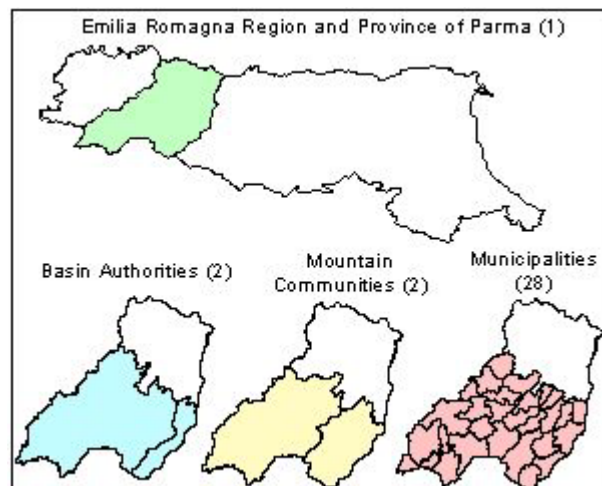


Figure 1 – Registered Users of the WebGIS System

Specific editing tools allow the user to insert, in a shared point coverage stored on the server, the slope instability notifications received. Each notification is described by a georeferenced point, representing the location of the instability event notified, and by an attribute table. The search of the area where the instability event has occurred can be done either in an analogical way by moving and changing the scale on the topographic maps displayed on the video by means of the pan and zoom tools, or in an automatic one, using a toponym researcher. The location point can then be digitised by a click of the mouse.

Once the point has been digitised, a series of forms pop up on the video for entering, in the attribute table, the alphanumeric data related to the notification. These forms are organised in five

different levels containing compulsory and optional fields. The five levels are the following:

Level 1 – Slope instability notification: The first level is used to enter data referring to the subject who reports the notification and to indicate the kind of instability event notified. The slope instability events are classified in three broad categories: landslides; erosion by water (fluvial erosion and bad lands); overflows.

Level 2 – Elements exposed to risk: At this level the user can enter elements exposed to risk by the slope instability event. For every instability event, apart from its hazard, potential worth of loss is expressed by a coefficient WL which is automatically calculated by the system. WL is the summation of the contributes of each kind of element exposed to risk.

Level 3 – Cadastral data: This thematic level includes the cadastral data of the lands where the instability event has occurred.

Level 4 – Possible financings: On this thematic level, thanks to the information included in the previous levels it is possible to estimate which public and/or private financings can be activated for the consolidation of the land affected by the instability event. The coefficient WL relative to the potential worth of loss, if calculated for each notification, can be used as a guide-line to produce lists of events in order to provide citizens with financial supports for the consolidation of their lands.

Level 5 – Survey: This form includes the date of the survey and a preliminary evaluation of the consolidation works. By the geomorphologic survey, it is possible to confirm or modify the data inserted in the database at the notification phase.

Once the alphanumeric data are saved, a symbol is assigned to the point depending on the kind of instability event recorded.

The notification layer is used to plan and coordinate field surveys among local authorities appointed for this task, in order to verify *in situ* the actual status of the notified landslides. Field surveys data, relative to the spatial extension and the geomorphologic features of the landslides verified *in situ*, can be inserted in the provincial geodatabase using the second application of the WebGIS System. This is an ArcObjects application developed for the software ArcEDITOR 8.3.

Users of this application are GIS experts, typically the same geologists who carry out the field surveys. Using the graphic interface and the powerful editing tools provided by ArcEDITOR 8.3, the application allows registered users of different local authorities to update on-line a polygonal layer of the geodatabase and to input the spatial and alphanumeric data collected during the field surveys. Alphanumeric data are entered directly into the attribute table of the polygonal layer and concern geology and geomorphology, hazard

assessment, risk and damage reporting and the first evaluations of possible consolidation works.

Any updating made by means of the ArcObjects/ArcEDITOR application are immediately displayed on the ArcIMS application, so that every user of the WebGIS System can check on a real-time basis the landslide situation of his own territory. The field survey layer represents the main reference for planning and coordinating consolidation works among public authorities having different levels of jurisdiction on the same territory (i.e.: Municipality, Province, Region, Basin Authority). It can also be used to update the regional landslide map adopted by the urban and territorial plans. This updating operation is not an automatic one. Actually it is carried out by the managing authority of the map (The Province of Parma) following the administrative procedures and the recurrence period provided by the regional urban planning law.

ACTIVITY AND RESULTS

The updating of the landslide notification layer and the field survey layer is limited to registered users. An open version of the ArcIMS application, allowing the dynamic visualisation of the ortophotos and maps composing the provincial geodatabase, is available at the following internet address:

<http://difesaattiva.provincia.parma.it/dissesto>.

At present 33 registered users can enter landslide notification using the editing tools of the ArcIMS application: 28 Municipalities; 2 Mountain Communities; 2 Basin Authorities; 1 Province. These 33 local authorities are the ones who usually receive and file landslide notifications concerning the mountainous territory of The Province of Parma. Five of them can also access the ArcObject/ArcEDITOR application developed for the updating of the field survey layer. These are the local authorities (Mountain Communities; Basin Authorities; Province) that have jurisdiction and technical staff (namely geologists) who carry out field surveys in order to verify landslide notifications.

Between 2004 and 2005, the WebGIS System was used in an experimental way. In this period 417 landslide notifications were inserted in the provincial geodatabase. On the basis of these notifications, 212 field surveys were carried out by geologists of the Comunità Montana and the Province of Parma. As a result, 257 polygons, representing new small landslides and reactivation events, were inserted in the field survey layer. This layer was then used to update the existing Provincial Landslide Map. The new version of the Map was officially approved at the beginning of 2006 by Regione Emilia Romagna and the

Province of Parma and it is now in force as a part of the Provincial Land Plan.

CONCLUSIONS

The WebGIS System developed by the Province of Parma and Comunità Montana Appennino Parma Est is a powerful tool for storing in a single, regional-scale geodatabase the spatial and alphanumeric data about landslide occurrence and slope instability events that are usually collected in a decentralised way by the various local authorities responsible of governing the territory. Thus the WebGIS System allows different users not only to share but also to update, in a systematic and timely way, landslide inventories databases.

The WebGIS System can be used by local authorities as a simple, cost-effective tool for monitoring geomorphologic risks. The record of repeated slope instability events in the same place in a significant period can give useful information about landslide reactivation frequency, hazard, state of activity and about correlations between geomorphologic events and their natural causes (precipitations, earthquakes etc.). Using the WebGIS System, local authorities, which hold the role of civil defence in emergency situations, can share and exchange information in a real-time about instability events. In a natural calamity context, the WebGIS System supports global vision of events and the setting of aid priorities based on risk evaluation.

The WebGIS System *Difesattiva on-line* can work at different territorial and administrative scale, from the provincial to the regional one. Furthermore it could be easily adapted and applied to the dynamic mapping and the monitoring of any spatial feature evolving on a weekly/monthly temporal scale, whose data are ordinarily collected by various local authorities in a decentralised manner.

BIBLIOGRAFIA

AMANTI M., CASAGLI N., CATANI F., D'OREFICE M., MOTTERAN G. – (1996) – Guida al censimento dei fenomeni franosi ed alla loro archiviazione – Presidenza del Consiglio dei Ministri, Dipartimento per i Servizi Tecnici Nazionali, Servizio Geologico – Istituto Poligrafico e Zecca dello Stato, Roma.

CANUTI P., CASAGLI N. – (1994) – *Considerazioni sulla valutazione del rischio da frana*. Atti del convegno "Fenomeni franosi e centri abitati" – Bologna 27 maggio 1994 – Regione Emilia Romagna e CNR – Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche

CRUDEN D.M. & VARNES D.J. – (1994) – *Landslides types and processes*. Landslides: Investigation and Mitigation – Transportation Research Board. National Academy of Sciences.

DALL'OLIO N., DE FRANCESCO E. – (2004) – *Difesa Attiva dell'Appennino Parmense. Sistema WebGis per la segnalazione on-line dei fenomeni di dissesto idrogeologico*. – Atti della 7^a Conferenza Italiana Utenti ESRI – 21-22 aprile 2004, Roma.

ESRI® Technical Paper – (2004) – *Developing and hosting a high-availability ArcIMS application*.

PETERS D. - (2003) - *System Design Strategies* - ESRI® White Paper .



Fig. 2 *Difesattiva on-line* - ARCIMS layout: an example of updating of the Provincial Landslide Map based on field surveys. Red triangles are instability notification verified by field surveys