

Landslides Early Warning Systems. Risk Scenarios and intervention model

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The University of Calabria has developed an integrated early warning system (LEWIS) in order to mitigate the landslide risks along motorways. The project developed original components (risk scenarios, monitoring sensors, networks, mathematical models, data acquisition and processing centers, traffic control centers) and their integration.

Three systems have been realized in different test sites. They include monitoring and telecommunication networks, processing and control activities (through simulation models, Acquisition and Data Processing Centers, namely CAED, Traffic and Control Centers, namely CCC

Overall, the three systems include more than 200 sensors, like inclinometers, pressure cells, piezometers, weather sensors, tensiometers and TDR, L-band radar, X-band radar, point sensors, Ground-Based Interferometer, Pois system, Smamid system, Mums system. Sushi and Geotop simulation models give nowcasting of landslides.

All systems are able to continuously transmit the recorded data to the CAED, that transmits processed information to the CCC, which is devoted to Management of the Roads.

The Intervention model consists of the following elements:

- Event scenarios
- Risk scenarios
- Levels of criticality
- Levels of alert

Event scenarios describe the properties of expected phenomena in terms of dimension, velocity, involved material and occurrence probability.

The properties useful for event scenarios are the following (subdivided in classes):

- Velocity (5 classes from slow to extremely rapid)
- Surface (5 classes from very small to very large)
- Scarp (5 classes from very small to very large)
- Volume (5 classes from extremely small to large)
- Thickness (5 classes from very shallow to very deep)
- Magnitude (3 classes: low, moderate, high), which combines the previous information
- Involved material (mud, debris, earth, rock, mixture of components)
- Occurrence probability (zero, low, moderate, high, very high, equal to 1)

Risk scenarios consists of the following three classes:

- A. Mud and/or debris movements that could induce a friction reduction and facilitate slips
- B. Road subsidence induced by landslides that could drag or drop vehicles
- C. Falls of significant volumes and/or boulders that could crush or cover vehicles and constitute an obstacle for others vehicles.

For each previous risk scenario, six sub-scenarios can be identified on the basis of the potentially involved infrastructures, carriageways and lanes (a. hydraulic infrastructures and/or barriers, b. only emergency lane, c. lane, d. fast lane, e. fast lane of the opposite carriageway, f. lane of the opposite carriageway).

Thus, all possible risk scenarios are 18.

The CAED receives the following information:

- Measurements from sensors
- Model outputs

and, for each of them, identifies four states:

- state 0 = no variation
- state 1 = small variation
- state 2 = moderate variation
- state 3 = high variation.

Then the CAED receives, continuously, information about the state (0, 1, 2, 3) of sensors and models running for

the specific highway section. Because of these states, CAED decides the appropriate level of criticality. Based on the information provided by CAED, and on its own independent evaluations, the CCC issues the appropriate warning notices (Surveillance, Alert, Alarm and Warning) and makes decisions about the consequent actions.