Date of Submission	18 APRIL 2019

IPL Project Proposal Form 2019

1. **Project Title:** (2 lines maximum)

   Innovation in slow-moving landslide risk assessment of roads and urban sites by combining multi-sensor multi-source monitoring data

2. **Main Project Fields**

   (1) Technology Development

   A. Monitoring and Early Warning, **B. Hazard Mapping, Vulnerability and Risk Assessment**

3. **Name of Project leader**: **Dario Peduto**, PhD

Affiliation: Associate Professor, Geotechnical Engineering Group (GEG), Dept. of Civil Engineering, University of Salerno (Italy), ICL Associate Member

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Core members of the Project

- ✓ Biljana Abolmasov, Full Professor, Department of Geotechnics, Faculty of Mining and Geology (FMG), University of Belgrade (UNIBG), Serbia.
- ✓ Uroš Đurić, Teaching Assistant, Department of Geotechnical Engineering, Faculty of Civil Engineering (FCE), University of Belgrade (UNIBG), Serbia
- ✓ Settimio Ferlisi, Associate Professor, Geotechnical Engineering Group (GEG), University of Salerno
- ✓ Diego Reale, Researcher, National Research Council, Institute for Electromagnetic Sensing of the Environment (CNR-IREA), Naples (Italy)

4. **Objectives:** (5 lines maximum)

   The project is aimed at developing and testing appropriate procedures for the use of innovative multi-temporal multi-sensor monitoring techniques jointly with multi-source field data for the landslide hazard, vulnerability and risk assessment in (slow-moving) landslide-affected areas. The proposed procedures will be double-tested in different geo-environmental contexts taking advantage of previous/ongoing studies carried out by the Project members in selected areas in both Italy and Serbia.

5. **Background Justification:** (10 lines maximum)

   Both Italy and Serbia suffer from widespread slow-moving landslides that, although not threatening human lives, recurrently cause damage to several densely populated urban areas as well as to numerous road sites with high traffic frequency and strategic importance. Accordingly, the need for easy-to-use tools that, at affordable costs, are capable of supporting decision makers in prioritizing risk mitigation measures turns out to be necessary. These tools, which should be differentiated according to the scale of analysis, require the availability of rich datasets collecting geological/geomorphological/geotechnical and monitoring data that can be extremely expensive over large areas. Consequently, the definition and implementation of integrated approaches encompassing the use of innovative non-invasive monitoring techniques for vulnerability and risk assessment

purposes turns out to be extremely useful.

6. **Study Area: (**2 lines maximum)

   Some study areas severely affected by slow-moving landslides will be selected in both countries: Calabria region and Cilento area, southern Italy; and SW Belgrade suburb (Umka landslide) in Serbia.

7. **Project Duration:** (1 line maximum)

   3 years

8. **Resources necessary for the Project and their mobilization**

   Personnel, Facilities, and Budgets

   The Project will be jointly organized by the Geotechnical Engineering Group (GEG), Department of Civil Engineering, University of Salerno (Italy) and the Faculty of Mining and Geology (FMG) and Faculty of Civil Engineering (FCE), University of Belgrade. University and staff will self-fund their activities with ongoing research projects in order to provide all necessary documentation for Project finalization. Extra co-financings for mobility of the project members will derive from Bilateral Erasmus funds for Staff/PhD student mobility exchange. Equipment for some field instrumentation and their maintenance, as well as damage surveys will be organized by both Institutions.

   The total budget requirement is € 40,000.

9. **Project Description:** (30 lines maximum)

The main aim of the present proposal is risk assessment at selected sites that are experiencing slow-moving landslide-induced displacements. Compared with devastating, abrupt displacements, subtle motion is more common and imperceptible, particularly considering its continuous long-term damaging impacts on roads and urban fabric.

Conventional geotechnical investigations and topographic surveys are limited by their spatial/temporal coverage and considerable human and financial resources. Some of the traditional approaches are invasive, and require boreholes, power sources, and other auxiliary installations. On the other hand, multi-temporal DInSAR relying on processing of repeat-pass SAR images is a well-established remote sensing technique to derive wide-area and high-precision (mm/year) deformation monitoring. The drone-based photogrammetric imaging and LiDAR technology also provide non-invasive, high-precision end-products, while overcoming some limitations of the InSAR technology (limited coverage in vegetated areas and geometric constraints related to sensor acquisition). Combining these techniques can be beneficial from many aspects, all targeted at facilitating continuous, high-certainty data acquisition for early recognition and mitigation of the landslide risks along the roads and urban areas.

In this project, empirical and numerical methods will be developed – at different scales of analysis – to analyze and forecast landslide risk. Main expected achievements are: i) mapping selected road sections and urban sites in Serbia and Italy that are in slow-moving landslide-affected areas using geological-geomorphological-geotechnical, Copernicus and Google Street view data as well as in-situ damage surveys and drone-based images used for 3D multi-temporal reconstruction; ii) classifying current damage and collecting archive data for a multi-temporal analysis; iii) hazard assessment via multi-source monitoring; iv) development of empirical and numerical methods for the vulnerability analysis and forecasting of cause (displacement) – effect (damage) relationships at selected sites; v) quantitative risk

analysis corroborated also by numerical modelling in selected at high risk areas. The project will also allow setting up a group of experts interacting with local authorities and technicians in both countries to disseminate the obtained results and bring them in the current best practice.

10. **Work Plan/Expected Results**: (20 lines maximum; work phases and milestones)

    Phase I: collection, review, harmonization of data on landslides and exposed elements in the selected study areas also considering installation of corner reflectors (GEG-UNISA and FMG-UNIBG).

    Phase II: selection and processing of SAR images from constellations operating at different bandwidths and revisiting times. This will provide multi-temporal displacement time series (GEG and IREA-CNR).

    Phase III: landslide hazard assessment based on (remote sensing and conventional) monitoring data

    Phase IV: empirical approaches to derive fragility/vulnerability functions relating displacements and damage on both roads and buildings at large scale (GEG and UNIBG).

    Phase V: for most representative buildings and road sections numerical analyses will be performed to derive numerical vulnerability functions at selected sites (GEG and UNIBG).

    Phase VI: by combining the results on hazard and vulnerability, quantitative risk analysis will be carried out. A comprehensive comparison of results from different study areas in both countries will be performed (GEG and UNIBG).

11. **Deliverables/Time Frame:** (10 lines maximum; what and when will you produce?)

    Deliverables:

    Deliverable 1. Compilation of results of Phase I and Phase II (end of 1st year)

    Deliverable 2. Compilation of results Phase III (end of month 18th)

    Deliverable 3. Proposing empirical fragility/vulnerability curves (Phase IV, end of month 24th)

    Deliverable 4. Numerical modeling on specific locations/landslide mechanism (Phase V) and quantitative risk assessment (Phase VI, end of month 30th)

    Deliverable 5. Final report: discussion, comparison of obtained results (end of 3rd year)

    Scientific papers:

    Three original papers in Landslides Journal; WLF5 - 3 papers related to: Session 2.5, 1 paper related to Session 3,2, 1 paper related to Session 5.1; several papers on local symposia and conferences.

12. **Project Beneficiaries:** (5 lines maximum; who directly benefits from the work?)

    Direct beneficiaries will be local community/municipalities affected by landslides.

    Local and regional authorities in both countries – housing sector, infrastructure authorities, Civil protection departments. Results will be disseminated to PhD students and Young Doctors attending LARAM "LAndslide Risk Assessment and Mitigation" International School, yearly organized by GEG-UNISA with the contribution of several ICL members.

13. **References**: (6 lines maximum; i.e. relevant publications)

    Đurić D., et al. (2017) Using multiresolution and multitemporal satellite data for post disaster landslide inventory in the Republic of Serbia. **Landslides** 14 (4): 1467–1482. DOI: 10.1007/s10346-017-0847-2

    Peduto D. et al. (2017) Empirical fragility and vulnerability curves for buildings exposed to slow-moving landslides at medium and large scales, **Landslides**, 14(6):1993–2007, DOI : 10.1007/s10346-017-0826-7.