List of IPL projects approved at 2017 IPL-GPC in Paris

IPL No.	Project Leader	Country	IPL Project Proposal
IPL-218	Ping Lu	China	Landslide Rapid Mapping from Remote Sensing
IPL-219	Zeljiko Arbanas	Croatia	Rockfall Hazard Identification and Rockfall Protection in The Coastal Zone of Croatia
IPL-220	Martin Krkač	Croatia	Kostanjek Landslide Monitoring Project (Zagreb, Croatia)
IPL-221	Federico Raspi Silvia Bianchini Andrea Ciampalini	Italy	PS continuous streaming for landslide monitoring and mapping
IPL-222	Claudio Margottini	Italy	Landslide risk analysis and mitigation in the ancient rock-cut city of Vardzia (Georgia)
IPL-223	Igwe Ogbonnaya	Nigeria	Landslides in Africa: Understanding catastrophic failures and effective preventive measures in vulnerable regions of the continent
IPL-224	Alexander Strom	Russia	Combination of radar and optical remote sensing for hazard assessment of the potentially river-damming landslides: the cases of the Vakhsh and the and Brakhmaputra Rivers
IPL-225	Matjaz Mikos	Slovenia	Recognition of potentially hazardous torrential fans using geomorphometric methods and simulating fan formation.
IPL-226	Mateja Jemec Auflič	Slovenia	Studying landslide movements from source areas to zone of deposition using a deterministic approach
IPL-227	K. M. Weerasinghe	Sri Lanka	Development of a Web Based Landslide Information System for the Landslides in Sri Lanka
IPL-228	Sabid Zekan	Bosnia and Herzegovina	BLISM (Bosnian Landslide Investigation and Stabilization Method)

Date of Submission	

IPL Project Proposal Form 2017

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: (2 lines maximum)
   Landslide Rapid Mapping from Remote Sensing

2. Main Project Fields
   Select the suitable topics. If no suitable one, you may add new field.
   (1) Technology Development
   Landslide Inventory Mapping
   (2) Targeted Landslides: Mechanisms and Impacts
   A. Catastrophic Landslides
   (3) Capacity Building
   A. Enhancing Human and Institutional Capacities
   (4) Mitigation, Preparedness and Recovery
   B. Preparedness

3. Name of Project leader
   Affiliation: (office and position) Ping Lu, Associate Professor, Tongji University
   Contact: (postal address, fax, phone, email)
   Address: College of Surveying and Geo-Informatics, Tongji University, Shanghai, China
   Fax: +86 21 65981085
   Tel: +86 21 65983911
   Email: luping@tongji.edu.cn
   Core members of the Project
   Names/Affiliations: (4 individuals maximum)
   Tongji University

4. Objectives: (5 lines maximum; what you expect to accomplish?)
   The main objective of this project is to propose an appropriate method that can be directly applied to rapid responses and emergency managements of landslide hazards by developing more reliable and automated methods for inventory mapping from remote sensing imageries.

5. Background Justification: (10 lines maximum)
   In recent years, with the availability of very high resolution (VHR) remote sensing images (spaceborne, airborne, and terrestrial), landslides can be mapped more accurately, completely, and rapidly than ever

before. Numerous semi-automated or automated approaches have been developed for landslide inventory mapping over the past few years. However, their applicability needs to be further verified in different situations, and there is no single method and no single type of remote sensing data practical enough for all types of landslide inventory mapping. In addition, it is currently still difficult to find an appropriate method that can be directly applied to rapid responses and emergency managements of natural hazards. Therefore, there is a need to propose more reliable and automated landslide inventory mapping methods.

6. Study Area: (2 lines maximum; where will the project be conducted/applied?)
   The project will particularly focus on Hong Kong where destructive landslides are prevalent in urbanized areas.

7. Project Duration: (1 line maximum)
   Three years.

8. Resources necessary for the Project and their mobilization
   Personnel, Facilities, and Budgets
   Dr. Ping Lu, the associate professor in Tongji University, will lead the research team. The fundamental facilities will include remote sensing images, software and workstations. The budget for three years will be around 60,000 USD.

9. Project Description: (30 lines maximum)
   Landslide inventory mapping is an increasingly important research topic in remote sensing and natural hazards. In recent years, the use of multi-temporal remote sensing images makes it possible to map landslides semi-automatically. This project will focus on developing semi-automated approaches for reliable and accurate landslide inventory mapping. Specifically, it consists of two principal methods: 1) the change detection-based thresholding and level set evolution, and 2) a change detection-based Markov random field method. The effectiveness and advantages of the proposed methods will be corroborated by a series of experiments. These methods will be tested, but not limited in a total land area of approximately 40 km^2 in Hong Kong. Compared with the existing LM methods, particular focuses will be given to the following attractive characteristics: 1) to take into account both the spectral and spatial contextual information of landslides; 2) to ensure a great level of automation and 3) to use little parameter tuning and improve the generic methods.

10. Work Plan/Expected Results: (20 lines maximum; work phases and milestones)
    1st year: Field investigation, remote sensing datasets collection.
    2nd year: Methodology development of level set evolution and Markov random field.
    3rd year: Result validation and accuracy assessment.

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

    1st year: Field report and processed remote sensing data.

    2nd year: Technical report of methodology: level set evolution and Markov random field.

    3rd year: landside inventory map and project report.

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

    Stakeholders such as public department and relevant companies, as well as local inhabitants in Hong Kong, will be the project beneficiaries.

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

Note: Please fill and submit this form by 1 September 2017 to ICL secretariat <secretariat@iclhq.org> and ICL network <ICL-network@iclhq.org>

Date of Submission	01 September 2017

IPL Project Proposal Form 2017

1. Project Title: Rockfall Hazard Identification and Rockfall Protection in The Coastal Zone of Croatia
2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(1) Technology Development

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

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides, **B. Landslides Threatening Heritage Sites**

(3) Capacity Building

A. Enhancing Human and Institutional Capacities

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation, C. Recovery

3. Name of Project leader: Professor Željko Arbanas

Affiliation: University of Rijeka, Faculty of Civil Engineering; Head of Geotechnical Chair

Contact: Radmile Matejčić 3, 5100 Rijeka; fax +385 51 265998; phone +385 51 265936; email zeljko.arbanas@gradri.uniri.hr

Core members of the Project:

Snježana Mihalić Arbanas, professor, University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering; snjezana.mihalic@rgn.hr

Vedran Jagodnik, assistant professor, University of Rijeka, Faculty of Civil Engineering, Croatia; vedran.jagodnik@gradri.uniri.hr

Sanja Dugonjić Jovančević, assistant professor, University of Rijeka, Faculty of Civil Engineering, Croatia; sanja.dugonjic@gradri.uniri.hr

Marin Sečanj, assistant, University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering; marin.secanj@rgn.hr

4. Objectives: Study of triggering conditions and rockfall mechanisms and run out paths and processes in carbonate rocks and at along the contacts of carbonate rocks and flysch formations in Croatia; Modeling of typical historical and recent rockfalls in Croatia: back analyses; Identification of conditions that influence and cause rockfalls in carbonate rocks and at along the contact of carbonate rocks and flysch formations in Croatia; Recommendations for rockfall hazard identification and rockfall protection in the coastal zone of Croatia.

5. Background Justification: The geological setting of the coastal part of Croatia is mostly carbonate rock mass and flysch rock mass complex. In both carbonate rock mass and flysch rock mass complex rockfall phenomena are frequent while the rock features are remarkably different. The rockfalls on steep

slopes in carbonate rock mass are predominately small with the volumes from some cm^3 to some hundreds of m^3 and are mostly caused by lithology, existing joint systems, and climate conditions (heating, cooling, ice, water in discontinuity system). The rockfalls along the flysch–carbonates contacts are usually larger with the volumes of some hundreds to some hundreds thousands m^3, and very often have been developed in rock slides and rock avalanches. The main causal factors are lithology, existing joint systems, and climate conditions, but also gravitational processes, weathering, erosion and ground water. The rockfall phenomena in Croatia were never systematically investigated.

6. Study Area: Coastal zone of Croatia, City of Omiš, Vinodol Valley, Rječina Valley, North Istria
7. Project Duration: 4 years
8. Resources necessary for the Project and their mobilization

Personnel: Four (4) senior researchers, eight (8) young researchers (Postdocs, PhD students); Facilities: Geotechnical laboratory, GIS software, landslide stability analyses software (LS Rapid, GeoSlope, Rocscience Slide), rockfall simulation software (Rockfall, RocPro3D); Budget: 65.000 US$

9. Project Description: The existing numerous rockfalls in Croatia endangered infrastructure facilities and settlements and towns in the past. There are a lot of still active well known hazardous rockfall phenomena sites that still endanger human lives and structures such as rockfalls above the Town of Omiš in Dalmatia and Grohovo Village near the City of Rijeka; the Raspadalica Cliff above the railway route in Istria, the Stupica location near the road in Dalmatia, the rockfalls below the Trsat Fortress (Rijeka) and Rota Castle (in Istria) cultural heritage sites etc. The main task of the Project is investigation of noted sites (as pilot Project sites) in detail and find regularities in the process that would be accepted as a behavior pattern for these types of rockfalls. In the 1st phase the filed investigation will be provided to obtain high resolution digital terrain models (HR DTM) using terrestrial and airborne LiDAR and photogrammetric structure from motion (SfM) techniques. The field engineering-geological mapping will be conducted. In the 2nd phase pilot sites rockfall models will be developed based on HR DTM and SfM 3D point cloud data, automatic/semi-automatic recognition and extraction of discontinuity sets and field mapping data. In the 3rd phase the spatial back analysis of rockfall sites will be conducted and further rockfall hazard will be identified. Based on identify hazard, recommendations for rockfall susceptibility and hazard map guides would be prepared. In the 4th phase the application of different rockfall protecting measures will be examined for different types of rockfall features. The last 5th phase is foreseen for project results dissemination to the local authorities and other stakeholders (road and railways maintain companies) and publication at conferences and in journals.

10. Work Plan/Expected Results:

1st phase: Data collection, FIELD INVESTIGATION AND SURVEY. Milestone: Field data base establishment.

2nd phase: NUMERICAL MODELING. Milestone: Establishing of typical rockfall models.

3rd phase: SPATIAL ANALYSES. Milestone: Rockfall susceptibility and hazard maps for the pilot areas of historical and recent rockfalls in Croatia. Recommendations for rockfall susceptibility and hazard map guides preparation.

4th phase: ROCKFALL PROTECTION MEASURES APPLICATION. Milestone: Assessment of the most effective rockfall protection measures and construction application. Recommendations for rockfall protection measures application guides preparation.

5th phase: RESULTS PRESENTATION. Milestone: presentation of results to the local authorities and stakeholders in the study area.

11. Deliverables/Time Frame:

1st phase: Field data base establishment. Time duration: 12 months.

2nd phase: Numerical modeling. Time duration: 12 months.

3rd phase: Rockfall susceptibility and hazard maps for the pilot areas of historical and recent rockfalls in Croatia. Time duration: 12 months.

4th phase: Assessment of the most effective rockfall protection measures and construction application. Time duration: 6 months.

5th phase: Results presentation. Time duration: 6 months.

12. Project Beneficiaries: Society, through implementations of Project's results in physical planning and urban areas protection. Local authorities, through better understanding of conditions of land use planning. Companies those maintain facilities (highways, roads, railways, etc.) and constructions in urban areas through identifying of rockfall hazard on existing and new facilities. Scientists, through new scientific knowledge of rockfall behavior.

13. References:

Arbanas Ž, Grošić M, Udovič D, Mihalić S (2012) Rockfall hazard analyses and rockfall protection along the Adriatic coast of Croatia. Journal of Civil Engineering and Architecture 6(3): 344-355.

Gigli G, Morelli S, Fornera S, Casagli N (2014) Terrestrial laser scanner and geomechanical surveys for the rapid evaluation of rock fall susceptibility scenarios. Landslides 11: 1-14.

Lan H, Martin, CD, Zhou, C, Lim CH (2010) Rockfall hazard analysis using LiDAR and spatial modeling. Geomorphology 118: 213-223.

Li L, Lan H (2015) Probabilistic modeling of rockfall trajectories: a review. Bulletin of Engineering Geology and Environment 74(4): 1-13.

Mihalić Arbanas S, Sečanj M, Bernat Gazibara, S, Krkač M, Begić H, Džindo A, Zekan S, Arbanas Ž (2017) Landslides in the Dinarides and Pannonian Basin—from the largest historical and recent landslides in Croatia to catastrophic landslides caused by Cyclone Tamara (2014) in Bosnia and Herzegovina. Landslides 14: 1-16.

Sečanj M, Mihalić Arbanas S, Kordić B, Krkač M, Bernat Gazibara S (2017) Identification of Rock Fall Prone Areas on the Steep Slopes Above the Town of Omiš, Croatia. Proc. Of 4th World Landslide Forum "Advancing Culture of Living with Landslides", Vol. 5, M Mikoš et al. (eds). Springer, Heidelberg, pp. 481-489.

Volkwein A, Schellenberg K, Labiouse V, Agliardi F, Berger F, Bourrier F, Dorren LKA, Gerber W, Jaboyedoff M (2011) Rockfall caracterisation and structural protection – a review. Natural Hazard and Earth System Sciences 11: 2617-2651.

Date of Submission	7th August 7, 2017

IPL Project Proposal Form 2017

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: *KOSTANJEK LANDSLIDE MONITORING PROJECT (Zagreb, Croatia)*

2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(1) Technology Development

A. Monitoring and Early Warning,

B. Hazard Mapping, Vulnerability and Risk Assessment

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides,

B. Landslides Threatening Heritage Sites

(3) Capacity Building

A. Enhancing Human and Institutional Capacities

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation, C. Recovery

3. Name of Project leader:

Martin KRKAČ

Affiliation:

Assistant Professor

University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering

Contact:

Pierottijeva 6, HR-10000 Zagreb, Croatia

mkrkac@rgn.hr

Core members of the Project

Names/Affiliations: (4 individuals maximum)

- **Snježana Mihalić Arbanas, Full Professor,** University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering
- **Sanja Bernat Gazibara, Research Assistant,** University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering
- **Marin Sečanj, Assistant,** University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering
- **Željko Arbanas, Full Professor,** University of Rijeka, Faculty of Civil Engineering

4. Objectives: (5 lines maximum; what you expect to accomplish?)

The project aim is to develop a procedure for prediction of the Kostanjek landslide movement in order to mitigate the landslide risks. Establishment of the procedure for prediction of the landslide movement consists of two objectives. First objective is development of the phenomenological (statistical) model for prediction of landslide movement and the second objective is automatization of the landslide prediction process through the development of customized software.

5. Background Justification: (10 lines maximum)

In cases of deep-seated and large landslides, costs of remediation are often unsustainable and the stabilization of slopes often cannot be achieved. In areas where deep seated and large landslides occur in urban area, prediction of landslide movements is sometimes the only risk prevention measure that has a practical benefit in the avoidance, or at least minimization, of adverse impacts on humans, property and the environment. The Kostanjek landslide is urban, deep seated landslide, which endanger approximately 290 buildings placed inside landslide borders. Kostanjek landslide is located in the City of Zagreb, covering an area of approximate 1 km^2. Prediction of the Kostanjek landslide movement is an important step that enables prescriptions of adequate emergency management measures, necessary for public safety. Additional benefit of the project is opportunity for the research community to test instrumentation and monitoring technologies, to develop landslide movement prediction models, early warning systems and to better understand the mechanics of slow-moving masses.

6. Study Area: Kostanjek landslide, located in the urbanized area of the City of Zagreb, Croatia.

7. Project Duration: (1 line maximum): 2 years

8. Resources necessary for the Project and their mobilization, Personnel, Facilities, and Budgets

Resources necessary for the Project are available at the University of Zagreb (Faculty of Mining, Geology and Petroleum Engineering) and City of Zagreb (City Office of emergency management).

9. Project Description: (30 lines maximum)

The IPL project is an extension of bilateral scientific Japanese-Croatian SATREPS FY2008 project ‘Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia’ that lasted from 2009 to 2014. During this project a monitoring system on the Kostanjek landslide has been established for the purpose of an early warning system (EWS). Landslide monitoring activities began in 2011 with continuous monitoring of landslide movement, groundwater level and precipitation.

Next phase in Kostanjek landslide research (the aim of the IPL project) is development of a procedure for an EWS, necessary for emergency management. EWS procedure consists of development of various prediction models and customized software for automatic prediction of landslide movement. Prediction models within the framework of the project are statistical models based on methods such as random forests or multiple linear regression. In order to obtain prediction model it is necessary to establish the complex relationships between precipitations, groundwater level and landslide movement from the continuous monitoring data for the period between 2012 and 2018. Complex relationships between landslide movement and triggers will be established with different training models using various parameters obtained from time series of monitoring landslide movement, groundwater level and precipitation data. After definition of appropriate parameters, statistical models should be tested for different periods. The most accurate models will be selected for the landslide movement prediction and EWS.

After definition of appropriate models, automatic procedure for prediction should be established. Automatic procedure consist of customized software which allows daily automatic input of monitoring data, filtering of data, calculation of parameters necessary for landslide movement prediction and prediction of landslide movement for different periods. Software should allow automatic update of models with new measured data allowing more accurate predictions. Predictions of landslide movement should provide useful information in periods of landslide reactivation and can serve as a decision making tool for emergency management offices in City of Zagreb.

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

The project encompasses several stages. First phase include preliminary analyses of the data collected in the period from 2012 to 2018. The GNSS, groundwater level and precipitation data time series should be examined and filtered in order to remove false data from further analyses. In second phase various prediction parameters, such as antecedent precipitation or groundwater level change rate, should be calculated. Third phase include development of several landslide trigger-movement models with statistical methods such as random forests and multiple linear regression. In model development the most important prediction parameters will be examined. Fourth phase include testing of developed models by comparison of prediction results with measured data, for different periods. The model with best prediction result will be selected as a model for prediction of the Kostanjek landslide movement. The last phase of the project is development of customized software which includes visualization of monitoring data in real time, calculation of prediction parameters and prediction of landside movement with selected statistical model. The prediction model should be updated on a daily basis, as new data are receiving from the monitoring site, enabling greater accuracy predictions.

Results of landslide movement prediction should provide information to City of Zagreb authorities related to emergency management. To make prediction information useful, it is necessary to establish different threshold values, for different levels of preparedness. According to selected threshold values, emergency management offices in cooperation with scientists should prepare and define efficient emergency measures in case of risky landslide movements.

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

The project starts in January 2018 and will end in January 2020. Phase of preliminary analyses will end up until June 2018. Phases of parameter selection, development and testing of statistical models for prediction of landslide movement will end up until the end of 2018. During the 2019 customized software for prediction of landslide movement will be developed. After development, the software will be tested at least two months before the end of project and probably 10 months after the project. During the software testing phase members of Zagreb city emergency offices will be acquainted with the software and in the same time they will, together with scientist, prepare and define efficient emergency measures in case of landslide movements.

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

The main beneficiary will be emergency management offices and the civil protection of the City of Zagreb, as well as residents endangered by the Kostanjek landslide. The research will promote innovation in the field of landslide monitoring and prediction. The beneficiaries of the research will also be the professionals and scientists involved in geological and geotechnical engineering who are in charge of landslide research and high education.

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

KRKAČ M, MIHALIĆ ARBANAS S, ARBANAS Ž, BERNAT S, ŠPEHAR K (2014) The Kostanjek Landslide in the City of Zagreb: Forecasting and Protective Monitoring. In: Lollino G et al. (eds) Proceedings of the XII IAEG Congress 'Engineering Geology for Society and Territory', Vol. 5 'Urban Geology, Sustainable Planning and Landscape Exploitation'. Heidelberg: Springer, pp. 715-719

KRKAČ M, MIHALIĆ ARBANAS S, ARBANAS Ž, BERNAT S, ŠPEHAR K, WATANABE N, OSAMU N, SASSA K, MARUI H, FURUYA G, WANG C, RUBINIĆ J, MATSUNAMI K (2014) Review of Monitoring Parameters of the Kostanjek Landslide (Zagreb, Croatia). In: Sassa K et al. (eds) Proceedings of the 3rd World Landslide Forum, Landslide Science for a Safer Geoenvironment: Volume 2: Methods of Landslide Studies. Cham: Springer, pp. 637-645

KRKAČ M, MIHALIĆ ARBANAS S, OSAMU N, ARBANAS Ž, ŠPEHAR K (2014) The Kostanjek landslide - Monitoring system development and sensor network. In: Mihalić Arbanas S and Arbanas Ž (eds) Landslide and Flood Hazard Assessment, Proceedings of the 1st Regional Symposium on Landslides in the Adriatic-Balkan Region. Croatian Landslide Grup, Zagreb, pp. 27-32

KRKAČ M, ŠPOLJARIĆ D, BERNAT S, MIHALIĆ ARBANAS S (2016) Method for prediction of landslide movements based on random forests. Landslides 1-14, doi 10.1007/s10346-016-0761-z

MIHALIĆ ARBANAS S, KRKAČ M, BERNAT S (2016) Application of advanced technologies in landslide research in the area of the City of Zagreb (Croatia, Europe). Geologia Croatica 69(2): 231-243, doi: 10.4154/gc.2016.18

Note: Please fill and submit this form by 1 September 2017 to ICL secretariat <secretariat@iclhq.org> and ICL network <ICL-network@iclhq.org>

Date of Submission	04/08/2017

IPL Project Proposal Form 2017

1. Project Title:

   PS continuous streaming for landslide monitoring and mapping

2. Main Project Fields:

   (1) Technology Development

   A. Monitoring and Early Warning,

3. Name of Project leaders:

Federico Raspini, Silvia Bianchini, Andrea Ciampalini

Affiliation: Earth Sciences Department of the University of Firenze (DST-UNIFI)

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Mobile: +39 3398929831 E-mail: federico.raspini@ unifi.it

Core members of the Project:

Nicola Casagli, Full Professor, DST-UNIFI

Veronica Tofani, Researcher, DST-UNIFI

Lorenzo Solari, PhD student, DST-UNIFI

Matteo del Soldato, Researcher assistant, DST-UNIFI

4. Objectives:

   The main objective of this project is to perform the transition from historical analysis of radar satellite image archives to real time monitoring of ground deformation at regional scale using radar satellite scenes. To accomplish this objective the short revisiting time and regularity of acquisitions of Sentinel-1 constellation of SAR (Synthetic Aperture Radar) satellite sensors will be exploited.

5. Background Justification:

   Before the launch of the Sentinel-1 mission, the long revisiting time and the limited access to SAR data of orbiting satellites were the most serious limits for the extensive use of satellite SAR information as monitoring tool. So far, SAR data have been used only to map past ground displacement and to reconstruct the deformation history of the observed scene. This type of elaboration creates static maps, as they simple provide a synoptic, retrospective view of the main areas affected by ground motion. The launch of Sentinel-1 mission opened a new opportunity for InSAR (Interferometric SAR) applications: Sentinel-1 provides, on a regional scale, real-time deformation monitoring tools and response for geological processes. Sentinel-1 mission is composed of a constellation of two twin satellites, Sentinel-1A and Sentinel-1B. Launched in April 2014 and in April 2016 respectively, they share the same orbital plane and ensure a unique revisiting time of 6 days optimized for SAR interferometry applications. Sentinel-1 SAR products are freely accessible, providing the scientific community with consistent archives of openly available data, suitable for monitoring applications relying on the processing of long series of SAR images.

6. Study Area:

   The study area will be the Tuscany Region (Central Italy), specifically selected due to its peculiar geological setting prone to ground instability phenomena. Its territory, mainly hilly (66.5%) with mountainous areas (25.1%) and few plains (8.4%) results to be a very landslide-prone area.

7. Project Duration:

   The duration of the project is two years.

8. Resources necessary for the Project and their mobilization:

   The Geohazards research group, which is established at Earth Sciences Department of the University of Firenze it is one of the largest centers for scientific and technological services on geohazard in Italy, currently composed by more than 50 full-time employees. The group counts 5 professors, 4 researchers, 4 technicians, 18 post-doc fellows, 11 PhD students and several collaborators. The group has the necessary personnel, research infrastructure, field instrumentation, vehicles and administrative support essential for carrying out effective research in the framework of the proposed project, with a wide range of dedicated laboratory facilities supplying the most advanced technical support required for the many fields covered. The total budget of the group in 2016 related to international, European and national funding projects is about 2 Million of Euros. The required budget will be covered by DST-UNIFI for the research part. A contribution by ICL-IPL project budget might be required for dissemination purposes concerning the project results.

9. Project Description:

   For the initial implementation of the continuous monitoring of the Tuscan Region, the existing archives of the Sentinel-1A will be acquired and then processed by means of a multi-interferometric (MT-InSAR) approach, specifically designed to analyze long series of SAR scenes. For both ascending and descending geometries, reference ground deformation maps are thus generated, providing a synoptic, retrospective view of the main areas affected by ground motion. To accomplish the transition from historical analysis to real time monitoring program at regional scale based on Sentinel-1 images, a processing plan for both ascending and descending geometry will be set. Once a new Sentinel-1 image is available, it is automatically downloaded and added to the existing archive. The new data stack is then entirely reprocessed to generate new ground deformation maps and updated displacement time series (TS). A series of subsequent updating is created every six days using Sentinel-1A and Sentinel-1B images. Following the creation of updated ground deformation maps, displacement TS of each measurement point for both ascending and descending geometry will be systematically and automatically analyzed to identify, in the last part of the TS (i.e., in the last 150 days), any change in the deformation pattern. When this change occurred a breaking point (Tb) is identified and defined. The average deformation rates before and after the breaking point are recalculated; when their difference $|\Delta V|$ is higher than 10 mm/yr the points are highlighted as anomalous points. Changes in the deformation pattern are analyzed and interpreted, update by update, assigning them a driving triggering factor. To properly use, interpret and exploit the deformation TS and trend variation two important parameters have to be take into consideration:

   i) the spatial consistency: a single, scattered point with a change in the deformation pattern offers no reliable information on the probability of movement. Only a group of neighbor points (i.e., cluster), sharing the similar TS trend variation and behaviour can be considered representative of a change in the kinematics of a given phenomenon (activation, acceleration, deceleration, etc.);

ii) the temporal persistency: only anomalies repeated in at least two updates are considered representative of an occurring change in the deformation TS. On the contrary, "ghost anomalies", i.e., anomalies identified only in one single update, are discarded from further interpretation because likely related to errors in the data processing (e.g., uncompensated orbital phase ramps, phase unwrapping errors, atmospheric artifacts, thermal effects on targets). It also worth recalling that TS are a zero-redundancy product, i.e., they contain one deformation measure per each SAR acquisition and for this reason, they are particularly sensitive to the phase noise.

10. Work Plan/Expected Results:

The project includes two Work Packages (WP):

WP1- Multi-interferometric analysis of archive of Sentinel-1 - which includes the analysis of historical archive of Sentinel-1 and the continuous elaboration of Sentinel-1 images for landslide monitoring and mapping with associated trend variation analysis (Month 1-12).

WP2 - Analysis and interpretation of results derived from continuous elaboration of Sentinel-1 images- which includes the "radar-interpretation" activity, devoted to assign a geomorphological meaning to the scattered point-wise ground displacements measurements and to obtain an accurate analysis of the phenomenon (i.e. typology, spatial extension, causes). Due to the intrinsic characteristics of multi-interferometric techniques (e.g., the possibility to measure only the LOS component of ground movement and the scattered distribution of measurement points), the interpretation of the TS changes (i.e., anomalous points) requires a proper strategy of analysis based on traditional geomorphological thematic information (i.e. topographic, geomorphologic, geological and land use maps), optical images (both aerial and satellite data) and in situ data investigations. The necessary input data for the study area will be downloaded from the web portal of the Tuscany Region (http://www.regione.toscana.it/-/geoscopio) (Month 3-12).

This monitoring system is designed to capture any changes in the deformation pattern occurring within the territory of the Tuscany Region, such as precursor movements related to major events (i.e., accelerations recorded before landslide failures). Advances in satellite technology, processing algorithms and computing power are now enabling scientists to expand the application fields of satellite SAR acquisition, providing a new tool to systematically track the evolution of landslide-induced ground deformation and for early warning purpose.

11. Deliverables/Time Frame:

Information on persistent anomalies affecting elements at risk will be routinely delivered every 12 days to the Regional authorities in charge of the geohazard management practices, in the form of monitoring bulletin and implemented in a web-service. Field investigations will be performed in these areas at potential risk and, if necessary, they will be targets for detailed analysis with high resolution sensors (e.g., COSMO-SkyMed) to create a virtual constellation, where different satellite data sources are used in synergy to create a more effective and robust Earth observation system. Moreover, a geodatabase of the anomalous points identified will be created and constantly updated. The database will be populated with anomalous points and relevant attributes (i.e., location coordinates, municipality, Province, cause, persistency, spatial consistency, land use, slope, etc.). **A written report will be delivered at the** end of the project (i.e., month 12).

12. Project Beneficiaries

The main end user of **this project is the Tuscany Region. Potential beneficiaries include** Civil Protection Authorities, River basin Authorities, local authorities and any other entities in charge of management of risk posed by landslide.

Note: Please fill and submit this form by 1 September 2017 to ICL secretariat <secretariat@iclhq.org> and ICL network <ICL-network@iclhq.org>

Date of Submission	01/September 2017

IPL Project Proposal Form 2017

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: (2 lines maximum)

   Landslide risk analysis and mitigation in the ancient rock-cut city of Vardzia (Georgia)

2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(1) Technology Development

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

(2) Targeted Landslides: Mechanisms and Impacts

B. Landslides Threatening Heritage Sites

(3) Capacity Building

A. Enhancing Human and Institutional Capacities

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation

3. Name of Project leader: **Claudio Margottini (*Scientific Coordinator*)**

Affiliation: **Scientific and Technological Attaché Embassy of Italy in Egypt - UNESCO Chair at Florence University (Italy) Prevention and sustainable management of geo-hydrological hazards adj. Professor and Founder**

Contact: 15, Abdel Rahman Fahmy Str., Garden City Il Cairo, Egypt Tel.+20 (0)2 27943194 – 227943195 Fax:+20 (0)2 27940657 mobile: +20 (0) 101 2601076 E-mail: claudio.margottini@gmail.com

Dr. Daniele Spizzichino (ISPRA project manager)

Affiliation: (office and position)

ISPRA - The Italian National Institute for Environmental Protection and Research – Researcher (Rome office)

and Contact: (postal address and email)

Via Vitaliano Brancati 60, 00144 Rome, daniele.spizzichino@isprambiente.it

Core members of the Project: Names/Affiliations: (4 individuals maximum)

- **Dr. Nikoloz Antidze (General Coordination) Director General of the National Agency for Cultural Heritage Preservation of Georgia. Tbilisi, Georgia.**
- **Dr. Mikheil Elashvili Professor (Contribution to monitoring system implementation and analysis) School of Natural Sciences and Engineering, Ilia State University Tbilisi, Georgia.**
- **Prof. Nicola Casagli – (Contribution to Engineering Geology, thermographic survey and kinematic analysis). UNESCO Chair at Florence University (Italy) Prevention and sustainable management of geo-hydrological hazards.**

- **Prof. Daniela Boldini – (Contribution to geotechnical characterization, stability model and mitigation measures design). Department of Civil, Chemical, Environmental, and Materials Engineering. University of Bologna.**

4. Objectives: (5 lines maximum; what you expect to accomplish?)

   The project will:

   - **Geological, geomorphological and geomechanical characterization of the entire monastery (laboratory and field survey);**
   - **Identify potential unstable area in the rock cut city by means of field geotechnical techniques;**
   - **Stability model implementation for the entire rock slope and suggestion for mitigation measures;**
   - **Implementation of long term monitoring system (GBR, meteo station, seismic)**
   - **Improve knowledge of local authorities for the identification of potential unstable areas, monitoring of the site, design and implementation of landslide mitigation works/strategies.**

5. Study Area: (2 lines maximum; where will the project be conducted/applied?)

   Rock cut city of Vardzia Monastery (Georgia)

6. Project Duration: (1 line maximum)

   September 2017 – September 2019 (possibility of extension for another one year)

   Personnel involved: about 10 experts in the field of Rock mechanic, Engineering geology, monitoring management, ICT, management of Cultural Heritages.

   Facilities: Monitoring network composed by Ground Based Radar, seismic accelerometers, meteorological sensors; ICT laboratories.

   Budget: operational budget (monitoring, mitigation, etc.) is provided by the National Agency for Cultural Heritage Preservation of Georgia; personnel cost is covered by involved institutions.

7. Project Description: (30 lines maximum)

The rock-cut city of Vardzia is a cave monastery site in South-western Georgia, excavated inside the Erusheti mountain on the left bank of the Mtkhvari river. The caves stretch along the cliff for about 800 m and up to 50 m inside the rock slope. Most of the site was carved inside the volcanic and pyroclastic rock layers located at an elevation of 1300 m above the sea level. The earthquake that struck the Samstkhe region in 1283 AD destroyed about two thirds of the city cave, exposing most of the rooms to the exterior. Recently, as a part of a National Heritage Reserve, the site was submitted for a prospective inclusion into the UNESCO World Heritage List. However, the site has been affected by frequent instability phenomena along the entire volcanic cliff that, because of their rapid evolution, are deemed dangerous to the visitors that daily crowd the site to discover its beauties. In consideration of this high risk, the National Agency for Cultural Heritage Preservation of Georgia (NACHPG) promoted, with the support of Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), based in Italy, an assessment of the landslide hazard for the entire area: this project included in situ surveys, terrestrial laser scanner acquisitions and elaborations, rock mechanics characterization, geo-structural and kinematic analysis and a real time monitoring based

on Ground Based Radar interferometry, meteo-climatic, seismic network and real time photo-camera, for the identification of deformation paths for the most hazardous areas. Vardzia is an excellent example of a cultural landscape in which human activities and natural processes are strictly connected. Often, lithology (e.g., soft rock easy to excavate), geomorphological processes (e.g. landsliding, erosion and weathering), beautiful and impressive landscapes and inaccessibility (settlement easier to defend and protect) have been the main elements in the history of humanity concerning the choice for the realization of towns, monuments, religious structures, and defence works. This is one of the main cultural heritage sites of Georgia, attracting thousands of tourists every year. It is essential to preserve the site to guarantee a safe access for the visitors

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

The main activities of the Vardzia project include a multidisciplinary survey and monitoring of Vardzia rock cut complex, that implies the following:

1. General coordination and cooperation with National experts;

a. State of art in the field of Geology, Rock mechanic, hydrology and hydrogeology (from other project partners)

b. State of art in the field of cliff monitoring (past and existing)

c. Analysis and elaboration of all data coming from different working groups;

2. Detail reports for practical design

a. Final elaboration on Thermal Infrared Analysis of the cliff

b. Implementation of rock laboratory tests

3. General design of mitigation works

a. General mitigation plan of the site

b. Operational design in selected unstable portion of the cliff;

4. Maintenance of the site

a. Operational plan for maintenance of the mitigation works

b. Analysis and elaboration of all data coming from different working groups;

5. General framework for safety of field-workers and field support

a. Field support to local companies in drilling and mitigation works;

6. Final report

7. Workshops with local experts

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

   Three report/deliverables must be produced every years in order to verify the progress of the works.

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

   The project is directly addressed to support the local authority and more in detail the National Agency for Cultural Heritage Preservation of Georgia. Another beneficiary will be for sure the Ilia University of Tiblisi that will be supported for the implementation and interpretation of all the date coming from the monitoring system.

11. References (Optional): (6 lines maximum; i.e. relevant publications)

Note: Please fill and submit this form by 1 September 2017 to ICL secretariat <secretariat@iclhq.org> and ICL network <ICL-network@iclhq.org>

Date of Submission	1st Sepember 2017

IPL Project Proposal Form 2017

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: **Landslides in Africa: Understanding catastrophic failures and effective preventive measures in vulnerable regions of the continent**
2. Main Project Fields

   Select the suitable topics. If no suitable one, you may add new field.

   (1) Technology Development

   A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment
3. Name of Project leader OGBONNAYA IGWE

Affiliation: UNIVERSITY OF NIGERIA, NSUKKA

Contact: DEPARTMENT OF GEOLOGY, UNIVERSITY OF NIGERIA, NSUKKA. Ogbonnaya.igwe@unn.edu.ng; igwejames@hotmail.com

Core members of the Project Ogbonnaya Igwe; ikenna Okonkwo; Okechukwu nnebedum; Ifeanyi Oha

Names/University of Nigeria, Nsukka

4. Objectives: to integrate new methods in solving the increasing trend of catastrophic landslides in Africa

Background Justification: **Catastrophic landslides are increasing in Africa. The recent Sierra Leone and DR Congo landslides in August 2017 have claimed over 600 lives according to reports. Experts predict that any more catastrophic landslides will still happen if the increasing rainfall trends and urbanization activities remain unabated. We think that unless some drastic measures are taken even Conakry, the capital of Guinea may experience similar slope movements in future.** Our sustained IPL projects in the past eight years in West Africa have yielded new methods of dealing with old problems of landslides in the region. The new methods include the use of high resolution satellite images, state-of-the- art structural analysis, quality geophysical procedures, improved geological and geomorphological investigations, and high level field surveys. Our results have shown that the integration of these methods yield better landslide prevention and mitigation.

5. Study Area: Nigeria, Cameroon, Sierra Leone, DR Congo, Uganda, Guinea, Mali, Ghana and Benin Republic
6. Project Duration: 5 years
7. Resources necessary for the Project and their mobilization

   Personnel, Facilities, and Budgets: The task ahead is quite tough. We intend to build a comprehensive synergy across major Universities and Research Institutes across Africa. We have already started in this direction and we hope to achieve our goal by the first and second quarter of 2018. Dong this and securing all the data we need to produce landslide susceptibility map for Africa would cost at least $ 200, 000 USD. However we would like to start with as little as $ 5, 000 USD. Our Department is a Centre of Excellence in landslide research so we are confident we would be able to achieve our objective of research.

8. Project Description: **Global warming and climate-driven changes have brought increased rains in several parts of Africa. Many of the slopes in the continent are distressed. They have been predisposed to failure by severe weathering, tectonic activities and the mounting pressure of urbanization. When the increasing amount of rainfall act as trigger the result is expected to be catastrophic. Sierra Leone, DR Congo, Uganda and Nigeria have witnessed recent landslide catastrophes. In a poor continent where poor urban planning, destabilization of slopes during farming or construction activities are the norm, an effective landslide preventive measure is highly desirable. It is also widely known that because of economic challenges in Africa poorer people live at the foot of the most vulnerable hills. We hope to produce a landslide susceptibility of Africa at the end of the project.**
9. Work Plan/Expected Results: We intend to integrate extensive field work with satellite imagery, laboratory analysis and geophysical study to understand the catastrophic landslides, and evolve an effective preventive measure. Our Research Group collaborated with Reuters in the recent Sierra Leone landslides. We in intend to build on similar collaborations as our work progress. We hope to carry out rigorous investigation of landslide susceptibility in Nigeria, DR Congo, Sierra Leone, Guinea, Uganda, and other mountainous regions in the continent. We will also collect samples for laboratory analysis. Finally we would be able to publish the first landslide susceptibility map for Africa.
10. Deliverables/Time Frame: We will discover effective, low-cost preventive measures for Africa, produce the first landslide susceptibility map for the continent, and ensure adequate housing plan in some vulnerable areas. These would take at least 5 years.
11. Project Beneficiaries: Africa and some others who may use our results
12. References (Optional):

1. Our collaboration with Reuters may be accessed on: http://www.reuters.com/article/us-leone-mudslide-africa/cities-across-africa-face-threat-of-landslides-like-sierra-leone-idUSKCN1AY115
2. Igwe O, Onwuka S, Oha I, Nnebedum O (2016) WCoE/IPL projects in West Africa: application of Landsat ETM+ and ASTER GDEM data in evaluating factors associated with long runout landslides in Benue hills, North-central Nigeria. Landslides DOI 10.1007/s10346-016-0703-9
3. Igwe O (2015) The study of the factors controlling rainfall-induced landslides at a failure-prone catchment area in Enugu, Southeastern Nigeria using remote sensing data. Landslides DOI 10.1007/s10346-015-0627-9
4. Igwe O (2015) Predisposing factors and the mechanisms of rainfall-induced slope movements in Ugwueme South-East Nigeria. Bulletin of Engineering Geology and the Environment DOI 10.1007/s10064-015-0767-0
5. Igwe O, Mode W, Nnebedum O, Okonkwo I, Oha I (2015) The mechanism and characteristics of a complex rock-debris avalanche at the Nigeria-Cameroon border, West Africa. Geomorphology 234: 1-10

Date of Submission	August 1, 2017

IPL Project Proposal Form 2017

(MAXIMUM: 3 PAGES IN LENGTH)

1. **Project Title**: Combination of radar and optical remote sensing for hazard assessment of the potentially river-damming landslides: the cases of the Vakhsh and the and Brakhmaputra Rivers
2. **Main Project Fields**

(1) Technology Development

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

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides

(4) Mitigation, Preparedness and Recovery

A. Preparedness

3. **Name of Project leader**

Affiliation: Geodynamics Research Center – branch of JSC "Hydroproject Institute". Chief expert.

Contact: Volokolamskoe Shosse 2, 125993, Moscow, Russia; +7 910 455 34 05; strom.alexandr@yandex.ru

Core members of the Project (Names/Affiliations): (4 individuals maximum)

- Prof. Andrea Manconi, ETH Zürich, Dept. of Earth Sciences
- Mr. Nurilo Abdulloev, JSC "Rogun Hydraulic Power Plant", Tajikstan, head of the engineering monitoring department.
- Prof. Yueping Yin, China Geological Survey

4. **Objectives**: To perform identification and some quantitative characterization of sites in the Vakhsh and Brakhmaputra River basins, far upstream from the sites where high dams with large reservoirs are constructed or planned, where large-scale bedrock landslides could originate causing rivers damming and subsequent catastrophic outburst floods that would pose a significant threat to dams, popolaton and infrastructure. (5 lines maximum; what you expect to accomplish?)
5. **Background Justification**: Large-scale landslides are one of the most threatening natural phenomena for hydraulic schemes in mountainous regions. Besides affecting slopes directly at the dams' abutments they can collapse in reservoirs casing tsunami-like waves as it occurred in 1963 at Vajont, highlighting the importance of the potentially unstable slopes identification not only directly at the dam sites but also in the reservoir areas. However, adverse consequences might result from river channel blockage upstream from the reservoir since catastrophic breach of such blockage could produce outburst flood which discharge would be far larger than the design values. Such potentially hazardous sites were identified in the Vakhsh and the Brakhmaputra River basins, upstream of the dam sites which are constructed now or planned in future. All of them are located in high altitude hardly attainable areas and combination of various remote sensing methods is the most efficient way to get information about these sites allowing grounded decision on necessary prevention or mitigation measures.

6. **Study Area:** Vakhsh River basin in Northern Pamir mountains (Tajikistan) upstream from the Rogun dam site (Obi-Khingou, Surkhob and Muksu River valleys); Brakhmaputra (Siang, Tsangpo) River basin upstream from the proposed dam sites (Yigong River valley).
7. **Project Duration**: 3 years (2018-2020)
8. **Resources necessary for the Project and their mobilization**: Hydroproject Institute (ICL member) and ETH have qualified personnel with long-term experience in the analysis of optical and radar images. Necessary instruments and software for various types of the remote sensing data analyses, including INSAR are available. High quality modern optical data for the study regions are available at such resources as Google Earth, SAS Planet, ArcGIS Earth. Aerial photographs of 1956 and KFA-1000 space images made in late 70s for some parts of the Vakhsh River basin upstream from the Rogun dam site are available in Hydroproject Institute. Corona declassified space images obtained in 70s for the Barakhmaputra River basin will be purchased from the USGS. Project participants have software that will be used for data processing.
9. **Project Description**:

Project will start from comparative analysis of the georeferenced space and aerial images of the suspicious sites that have been preselected in both regions. Images obtained decades ago will be compared with modern that will provide preliminary, qualitative assessment of the activity of slope deformations at the sites in question. Maps of these sites showing various geomorphic indications of slope processes will be compiled.

Next step of the Project implementation will be the analysis of the available radar data by use of the INSAR technology. It will provide quantitative data on the rates of most recent deformations at these sites that will be compared with data revealed from the analysis of optical images.

Project participants will perform field reconnaissance of the sites demonstrating active slope deformations to collect structural and geotechnical information necessary for slope stability analysis.

Combined analysis of all data collected will be performed to estimate possibility of large-scale slope failures in both basins and to assess height, shape and stability of the blockages that might originate here. Volume of water that could accumulate upstream and be released after dams breach will be estimated and scenarios of possible outburst floods will be elaborated. Depending on the results of risk analysis recommendations on optimal protection/mitigation measures well be provided for local authorities (necessity of monitoring and selection of optimal combination of monitoring methods; development of the early warning system(s) and their structure; possible technical measures).

10. **Work Plan/Expected Results**:

2018.

1 - Search and selection of optical and radar images of the study regions suitable for carrying out planned investigations.

2 - Landslide mapping (search of past rockslides and of the evidence of the ongoing slope

deformations) in the pre-selected parts of Vakhsh and Brakhmaputra River basins based on the geomorphic and landscape identification criteria.

3 - INSAR analysis aimed to identify slopes with ongoing slope deformations.

4 - compilation of the landslide susceptibility maps based on joint analysis of optical and radar data.

2019.

5 - Selection of the most critical sites that of Vakhsh and Brakhmaputra River basins require more detailed analysis.

6 - Comprehensive study of the selected sites based on combination of various techniques of the analysis of the remote sensing data.

7 - Field visits of some sites that will be possible.

8 - Preparation of research paper(s).

2020.

9 - Analysis of possible adverse effects that might be caused by slope failures in river basins upstream of the dam sites.

10 - Elaboration of recommendations on protection/mitigation measures (necessity of monitoring and selection of optimal combination of monitoring methods; early warning system(s) and their structure; possible technical measures).

11. **Deliverables/Time Frame**:

After completion of the first stage of he Project implementation (end of 2018) maps of the potentially hazardous sites in the study river basins will be compiled based on the analysis of both optical images and INSAR;

After completion of the second stage (end of 2019) most hazardous sites or sites with potentially most adverse effects will be selected and described and quantitative data on their present day state (slopes motion rates) will be provided. We expect submission of one or two research papers at the end of this stage.

At the end of the project (2020) recommendations on possible protection/mitigation measures to avoid most adverse effects of slope instabilities in the study river basins will be elaborated and provided to local authorities. Research papers could be submitted at the end of Project.

12. **Project Beneficiaries**: Owners and designers of the hydraulic projects in the study river basins in Tajikistan, China and India; Emergency agencies responsible for peoples' safety at the local, regional and state levels; young researchers from Tajikistan and China that will participate in the Project and will be trained in modern techniques of the remote sensing data analyses.

13. **References**:

Strom, A.L. 2010. Landslide dams in Central Asia region. Landslides – Journal of the Japan Landslide Society 47(6), 309-324.

Strom, A. 2013. Geological Prerequisites for Landslide Dams' Disaster Assessment and Mitigation in Central Asia. In: Wang F, Miyajima M, Li T, Fathani TF (eds). Progress of Geo-Disaster Mitigation Technology in Asia, Springer-Verlag Berlin Heidelberg. (ISBN 978-3-642-29106-7), 17-53.

Strom, A., Zhirkevich, A. 2013. “Remote” landslide-related hazards and their consideration for the hydraulic schemes design. In: Genevois, R., Prestinnizi, A, (eds). Proc. Int. conference on Vajont – 1963-2013. Italian Journal of Engineering Geology and Environment, Book series No 6. 295-303.

Date of Submission	July 11, 2017

IPL Project Proposal Form 2017

1. Project Title: Recognition of potentially hazardous torrential fans using geomorphometric methods and simulating fan formation.
2. Main Project Fields: (1) Technology Development: B. Hazard Mapping, Vulnerability and Risk Assessment.
3. Name of Project leader: Professor Matjaž Mikoš, dr. sc. techn. ETH.

Affiliation: University of Ljubljana, Faculty of Civil and Geodetic Engineering, Dean.

Contact: UL FGG, Jamova c. 2, SI-1000 Ljubljana, Slovenia, Mobile: +38641761186, E-mail: matjaz.mikos@fgg.uni-lj.si

Core members of the Project: Tomaž Podobnikar, PhD (UL FGG), Jošt Sodnik, MSc (UL FGG), Matej Maček, PhD (UL FGG), Mateja Jemec-Auflič, PhD (Geological Survey of Slovenia – GeoZS).

4. Objectives: The main goal of the research project is the automatic determination and classification of torrential fans, with an emphasis on their potential for the development of debris flows in their catchment areas. The basic hypothesis is that by using a high-resolution DEM, and the characteristic spatial variables (indicators), it is possible to distinguish between torrential fans caused by debris flows and the alluvial fans where debris flows are not expected and where only fluvial torrential processes take place.
5. Background Justification: According to their formation, we distinguish between the debris flows resulting from torrential outburst (torrential debris flows) and those that are developed from landslides (slope debris flows). Fans are layers of coarse and poorly sorted debris (rocks, stones, gravel, or sand) at places where debris-flow torrents or rivers exited from narrow valleys into a broader or another valley. A fan's conical shape is formed due to a rapid decrease in flow velocity and, consequently, due to lower transport power to continuously transferring debris material.
6. Study Area: selected torrential fans in Slovenia to develop the model and the Sava Dolinka River valley in NW Slovenia to test the validity of the model.
7. Project Duration: 3 years (May 1, 2017 – April 30, 2020).
8. Resources necessary for the Project and their mobilization: The total project budget is 300.000 EUR, approved in 2017 by Slovenian Research Agency, covering materials and personnel costs for 57.15 man-months (principal researchers from UL FGG, research collaboration with GeoZS).
9. Project Description: The main goal of the research project is the automatic determination and classification of fans, with an emphasis on their potential for the development of debris flows in their catchment areas. The basic hypothesis is that by using a high-resolution DEM or DSM, and the characteristic spatial variables (indicators), it is possible to distinguish between the fans caused by debris flows and the alluvial fans where debris flows are not expected and where only common torrential processes take place. Moreover, it is assumed that with such an approach the potentially

dangerous fans can be distinguished from the more stable ones. In connection with the latter, it is also assumed that we can identify potential areas of landslide occurrence.

Fans are common features in mountainous areas. Unstable slopes of valleys are often covered with fans. Their geomorphological shape mostly depends on their poorly distributed material. This, together with other factors, defines the angle of inclination of the deposited material. Fan areas (debris, scree) are frequently overgrown, which can increase the inclination of the fans and thus their instability. Less active, often populated fans in lower-lying valleys have slightly different properties than those located high in the mountains. It is expected that by using remote sensing tools, and specifically image processing and geomorphometry tools (while using terrain and surface models), it is possible to classify different types of fans, especially due to our good experience with their determination on Mars (Podobnikar & Székely, 2015), where our knowledge of field conditions is obviously very limited.

The automatic identification of fans as well as classification of their shapes using the geomorphometric analysis is a step further from the procedures such as the Melton number, which is calculated based on the characteristics of the catchment area. This approach includes the development of several innovative methods of using DEMs as well as remote sensing techniques. Despite the fact that the classical (manual) determination of surface characteristics will remain important in the future, adequately collected and prepared databases consisting of high-quality spatial data allow for the highest possible degree of fast and automated techniques for numerical spatial analyses. We will compare the classically (manually) mapped fans with those determined automatically, and thus evaluate the quality and usefulness of this methodology. Such comparison is a rarity, but essential to establish the credibility of the emerging automated geomorphometry field.

10. Work Plan/Expected Results: The project will be organized around the following work packages:

WP I Project management: Task (1) Interim reports and a final report; Task (2) Addressing practical issues arising from the project.

WP II Spatial data acquisition and pre-processing: Task (1) DEM and DSM acquisition, quality control, gross and systematic error removal, improving quality; Task (2) Obtaining other information about the fans (based on fieldwork, geological maps, etc.); Task (3) Data homogenization.

WP III Geomorphometric analysis for fan determination: Task (1) Classic geomorphological fan mapping in selected areas, and field sedimentological inventory to define the fan's genesis; selection of key geomorphological characteristics of certain fan types; Task (2) Processing variables (factors) for geomorphometric analysis; Task (3) Analysis/modelling with spatial data, rheological information, and other relevant descriptive information; Task (4) Comparison of the classical and developed methodology results.

WP IV Applying the mathematical model to simulate triggering and movement of debris flows: Task (1) Application of 2D debris-flow models (Flo2D, LS-RAPID); Task (2) Analysis using the new research method (greater Viscometer CONTEC) on soil samples; Task (3) A comparison of both groups of analysis and sensitivity analysis; Task (4) Comparison of geomorphometric analysis and simulations of the formation of fans.

WP V Dissemination: (1) Methods of the research work; (2) Results of the research work.

Year	2017			2018				2019				2020
Quarter	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**
WP I: Management												
WP II: Spatial data acquisition and pre-processing												
WP III: Geomorphometric analysis for fan determination												
WP IV: Mathematical model to simulate triggering and												
WP V: Dissemination												

Table. Gannt chart of the project.

11. Deliverables/Time Frame: The automatic identification of fans as well as classification of their shapes using the geomorphometric analysis is a step further from the procedures such as the Melton number, which is calculated based on the characteristics of the catchment area. This approach includes the development of several innovative methods of using DTMs as well as remote sensing techniques. Despite the fact that the classical (manual) detection of surface characteristics will remain important in the future, adequately collected and prepared databases consisting of high-quality spatial data allow for the highest possible degree of fast and automated techniques for numerical spatial analyses. We will compare the classically (manually) mapped fans with those determined automatically, and thus evaluate the quality and usefulness of this methodology. Such comparison is a rarity, but essential to establish the credibility of the emerging automated geomorphometry field.
12. Project Beneficiaries: The proposed methodology should be tested in other test sites with known debris-flow historical records, and then applied as a tool for debris-flow hazard assessment and mitigation on a national or regional level (large scale) together with debris-flow susceptibility models.
13. References:

Millaresis, G. C., Argialas, D. P. (2000). Extraction and Delineation of Alluvial Fans from Digital Elevation Models and Landsat Thematic Mapper Images. Photogrammetric Engineering & Remote Sensing, 66(9), 1093-1101.

Podobnikar, T., Székely, B. (2015). Towards the automated geomorphometric extraction of talus slopes in Martian landscapes. Planetary and Space Science, 105, 148–158.

Sodnik, J., Mikoš, M. (2006). Estimation of magnitudes of debris flows in selected torrential watersheds in Slovenia. Acta geographica Slovenica 46/1, 93-123.

Sodnik, J., Vrečko, A., Podobnikar, T., Mikoš, M. (2012). Digital terrain models and mathematical modelling of debris flows. Geodetski vestnik; 2012; 56(4), 826-837.

Zhang, H., Lü, Y. (2014). Geomorphometric Features of the Alluvial Fans around the Chaka-Qinghai Lake in the Northeastern Tibetan Plateau. Journal of Earth Science, 25(1), 109–116.

Date of Submission	28 August 2017

IPL Project Proposal Form 2017

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: Studying landslide movements from source areas to zone of deposition using a deterministic approach
2. Main Project Fields: (1) Technology Development: B. Hazard Mapping, Vulnerability and Risk Assessment
3. Name of Project leader: dr. Mateja Jemec Auflič
   Affiliation: Geological information Centre, Geological Survey of Slovenia
   Contact: Dimičeva ulica 14, SI-1000 Ljubljana, Slovenia, Mobile: +38631717099, E-mail: mateja.jemec@geo-zs.si
   Core members of the Project: Tina Peternel, PhD (GeoZS), Jernej Jež, PhD (GeoZS), Mitja Janža, PhD (GeoZS), Prof. dr. Matjaž Mikoš (UL FGG)
4. Objectives: The main objective of this project is an interdisciplinary approach aimed at developing a methodology for risk assessment of landslides and debris flows, which will include landslide origin (source areas) modelling, assessment of deposition volume, determination of rheological characteristics of the material, and modeling of the runout distance and the zone of deposition.
5. Background Justification: This research project is focused on landslides investigations and conditions required for mobilization into debris flow. The landslide and debris flow origin (source areas) was determined by previous studies using spatiotemporal factors while rainfall, velocity, volume of deposit, sliding/flow path, and deposition area are more difficult to predict and manage and were not yet considered in studying the dynamics of the landslide. Therefore, in order to determine movement and hazard assessment regarding potential mobilization of the landslide mass into a rapid debris flow, the following key parameters will be studied: geological structure, slope inclination (relief), geomechanical characteristics of the soil, catchment area of surface water and groundwater, and rainfall threshold above which landslide failure is initiated.
6. Study Area: Studying landslide movements from their source areas to the zone of deposition will be performed in two selected pilot areas: at the Stože landslide and at the Potoška planina landslide.
7. Project Duration: 3 years (May 1, 2017 – April 30, 2020).
8. Resources necessary for the Project and their mobilization: The total project budget is 300.000 EUR, approved in 2017 by Slovenian Research Agency, covering materials and personnel costs for 57.15 man-months (principal researchers from GeoZS, research collaboration with UL FGG).
9. Project Description: The proposed research project is aimed at studying landslide movements from their source areas to the zone of deposition using a deterministic approach. Shallow landslides, soil slips and low speed movements may cause failure of structures but are not usually dangerous for humans. While a highspeed, long-runout and wide-spreading landslides may cause a greater disaster

since they occur more suddenly, without showing any prior signs of cracks. Therefore only a small possibility exists for a timely evacuation. Thus the significance of landslide dynamics from their origin to the deposition areas is becoming crucial to reduce human loss from landslides and assess landslide hazard. In doing so, the following questions are pursued: where can landslides occur (place of origin), when (rheological properties of material, rainfall), how extensive can they be (magnitude), and where can landslides act (place of action)? Therefore, in order to determine movement and hazard assessment regarding potential mobilization of the landslide mass into a rapid debris flow, the following key parameters will be studied: geological structure, slope inclination (relief), geomechanical characteristics of the soil, catchment area of surface water and groundwater, and rainfall threshold above which landslide failure is initiated. The existing landslide susceptibility map will be upgraded for the wider catchment of Potoška planina and Stože landslides in a detailed scale which will be directly applicable in spatial planning, planning of prevention measures, and mitigation measures. Developed hydrogeological models for both study cases will enable spatially distributed and transient modelling of processes of the hydrological cycle. At the same time integration into slope stability model will significantly improve the accuracy of landslide prediction models. The results of modeling and the rheological characteristics of the sampled soils will enable the prediction of the landslide source area, its spreading and possible mobilization into debris flow and 3D visualisation of potential landslide areas at different scales. These objectives will be achieved through extensive fieldwork in order to capture the data needed to improve the reliability of the modeling results.

10. Work Plan/Expected Results: The structure of the proposed IPL project consists of 5 Work Packages: (1) Geological, geomorphological, geophysical, geotechnical and hydrogeological investigations in pilot areas; (2) Rheological investigations of materials in pilot areas; (3) Analytical and model-based prediction of landslide movements; (4) 3D maps of landslide hazards; (5) Project management and reports. A detailed plan for the implementation of individual Work Packages of the project and the timetable for the 3 years is shown in Table 1.

TIME SCALE		YEAR 1	YEAR 2	YEAR 3
WP1	**Geological, geophysical, geotechnical and hydrogeological investigations in pilot areas**			
1.1	Geological mapping of the Stože landslide and the wider Koroška Bela catchment	* * * * * * * *		
1.2	Shallow excavation and boreholes	* * * * *		
1.3	Lithological and geomechanical characteristics of material	* * *		
1.4	Geophysical measurements	* * *	* *	
1.5	Hydrogeological measurementse (infiltration, groundwater table)	* * * *		
WP2	**Rheological investigations of materials in pilot areas**			
2.1	Rheological characteristics of the material	* *	* * *	
WP3	**Analytical and model-based prediction of landslide movements**			
3.1	Geological maps of Stože landslide and wider Koroška Bela catchment	* *	* * *	
3.2	Landslide source area identification using Lidar-derived DEMs		* * * * *	
3.3	Hydrological modelling		* * * * *	
3.4	Modelling of landslide initiation, movement and spreading (LS-RAPID)		* * * * * *	*
3.5	Modelling landslide volume (Flo-2D)			* * * * * *
WP4	**3D maps of landslide hazards**			
4.1	Conceptual model for hazard maps			* * *
4.2	3D landslide hazard maps in different scales			* * *
WP5	**Reports**			
5.1	Intermediate annual reports	* *	* *	
5.2	Final report			* * *

Table 1: Grant chart of the project

11. Deliverables/Time Frame: WP1 is the most comprehensive, consisting of geological, geomorphological, geophysical, geotechnical and hydrogeological research done on the field of pilot areas. The field work described in WP1 will mostly take in the first year of the project, and to a lesser extent in the last year when field verification of the developed models will be performed. The gained field data and samples will be used for input data for further research, as outlined in WP 2. Analytical and model-based prediction of landslide movements from the origin point to the deposit areas, using a deterministic approach, will start in the second year of the project once data from the field works and laboratory will be available. In WP 4 the results of modelling of landslide movements from the origin point to the deposit areas, will be shown as 3D maps. This will serve as the basis for spatial planning and hazard assessment for the Stože landslide (Log pod Mangartom) and the Koroška Bela catchment (Potoška planina). The activities outlined in WP 5 will take place during the whole time of the project.
12. Project Beneficiaries: The results concerning the volume and deposition modelling presented in the form of thematic maps will provide an effective tool for the work of Civil Protection when dealing with landslides, improving the existing or creating a new Early Warning System (EWS) and creating risk assessments of unpredicted natural disasters. They could also be used in spatial planning and proper placement of infrastructures in relation to potential risks due to landslides and debris flows.
13. References (Optional):

- Jež, J., Mikoš, M., Trajanova, M., Kumelj, Š., Budkovič, T., Bavec, M. (2008) Koroška Bela alluvial fan - the result of the catastrophic slope events (Karavanke Mountains, NW Slovenia. Geologija 51 (2): 219–227
- Peternel, T., Kumelj, Š., Oštir, K., Komac, M. (2017) Monitoring the Potoška planina landslide (NW Slovenia) using UAV photogrammetry and tachymetric measurements. Landslides, 14/1, 395-406
- Mikoš, M., Fazarinc, R., Majes, B. (2007) Delineation of risk area in Log pod Mangartom due to debris flow from the Stože landslide. Acta geographica Slovenica 47(2): 171–198
- Sassa, K., Nagai, O., Solidum, R., Yamazaki, Y., Ohta, H. (2010) An integrated model simulating the initiation and motion of earthquake and rain induced rapid landslides and its application to the 2006 Leyte landslide. Landslides 7:219-236

Note: Please fill and submit this form by 1 September 2017 to ICL secretariat <secretariat@iclhq.org> and ICL network <ICL-network@iclhq.org>

Date of Submission	01st September 2017

IPL New Project Proposal Form 2017

1. Project Title: **Development of a Web Based Landslide Information System for the Landslides in Sri Lanka**

2. Main Project Fields - 1. Technology Development (database and hazard assessment)

3. Name of Project leader :

Ms. K. M. Weerasinghe - B. Sc. (Civil Engineering), M. Sc. (Geotechnical Engineering)

Affiliation: **Civil Engineer**

Contact: **Centre for Research & Development (CRD), Central Engineering Consultancy Bureau (CECB), No. 11, Jawatta Road, Colombo 05, Sri Lanka;**
Fax: +94 112 598215; Tel: +94 112 505688; e-mail: kmweera@yahoo.com

Core members of the Project

Ms. J. M. K. Herath – B. Sc. (Geology Special), M. Sc. (Water Resources Management)

Mr. K. B. Attapattu – B.Sc (Town and Country Planning)

Mr. A. A. Virajh Dias – B.Sc(Civil Eng); CEng, PG.Dip; MASCE,MIESL

4. Objectives:

The objective of this research is to develop a web based database on landslides for Sri Lanka by collecting information through online tools such as 'Google alert' (https:/www.google.com/alerts), other available databases (www.desinventar.lk) and field verification, and organizing the data in an user friendly manner.

5. Background Justification:

Individuals and institutions continuously carry out various studies on landslides, and collect landslide information at their own desired levels. Most of the collected information are kept in possession of the collectors and seldom shared among other users. Due to the very fact, an institution or an individual who requires landslide related information for decision making or for further research often face difficulties, as the information which can be obtained are limited. The Des Inventar database published by the Disaster Management Center of Sri Lanka (www.desinventar.lk) is the only online disaster database available in the country, and carries information only on the damages caused by different hazards. In the referred database also, information related to landslides have not been updated after the year 2011. This situation has impelled the necessity of developing an online comprehensive landslide database which is accessible to anybody who is in need of either technical or non-technical information on landslides.

6. Study Area:

Mountainous area of Sri Lanka covering the Central, Sabaragamuwa, Uva, Western and Southern administrative provinces.

7. Project Duration: Three years (September 2017 –August 2020)
8. Resources necessary for the Project and their mobilization

Item	Description of Personnel and Facilities	Cost USD	Mode of Contribution
1	Database server and associated peripherals	200.00	By CECB
2	Field data collection	2,500.00	By CECB
3	Dissemination of Information	3,000.00	Research grant
	Total USD	**5,700.00**	
	Total grantee contribution (USD)	2,700.00	By CECB
	Total expected through funding (USD)	3,000.00	Through a grant

9. Project Description:

The project proponent (CECB), World Center of Excellence on landslide disaster reduction for 2014-2017 and 2017 – 2020, has studied several landslides which have been occurred in Sri Lanka and carries a certain amount of information which are needed to be organized into a comprehensive database. Harnessing the information carried by the Des Inventar database shall be carried out next and as it lacks technical information such as the dimensions of landslide, the average slope gradient, land use, geological and geotechnical information at the failure surface etc. adding those missing technical information by searching through past reports, and/or through field investigations are to be done. In the meantime, additional information can be continuously collected through the online tools such as Google Alert and field data verifications.

Since the database carries information collected through various sources, expressing the accuracy levels shall be done by developing an appropriate legend and/or color codes as applicable.

Ability for performing statistical analyses from the users' end shall be incorporated and the processed information shall be illustrated via graphs and/or maps. The possibility of downloading data in tabular and graphic form shall also be incorporated and finally a user friendly, web based comprehensive landslide information system shall be developed.

10. Work Plan/Expected Results:

September 2017-February 2018:

(a) Scrutinizing already available information and designing backend database architecture on a Mysql server, (b) Continuing collection of data, if new landslides occur, and (c) Field data verification

March 2018- August 2018:

(a) Harnessing Des Inventar database for information available on past landslides, (b) Field data verification on past landslides, where possible, (c) Continuing collection of data, if new landslides occur, (d) Continuing designing backend database architecture, (e)

Commence designing of user interfaces and front end architecture using PHP.

September 2018-February 2019:

(a) Continuing harnessing Des Inventar database for information available on past landslides, (b) collecting information carried by published reports on past landslides, (c) Field data verification on past landslides, where possible, (d) Continuing collection of data, if new landslides occur, and (e) Continuing designing of front end architecture using PHP, Java etc.

March 2019- August 2019:

(a) Continuing collection of information carried by published reports, (b) Field data verification on past landslides, where possible, (c) Continuing collection of data, if new landslides occur, (d) Development of appropriate legend for representing different accuracy levels, and (e) Development of tools for data analyses at the users' end.

September 2019-February 2020:

(a) Continuing collection of data, if new landslides occur, (b) Continuing development of tools for data analyses at the users' end, and (c) Performing unit testing, sub system testing and integration testing.

March 2020- August 2020:

Continuing collection of data, if new landslides occur, (b) Launching the Beta version of the comprehensive landslide information system, and (c) Performing performance testing and acceptance testing.

11. Deliverables/Time Frame:

February 2018:	Mysql database on landslide information available at CECB
August 2018:	Preliminary user interface for retrieving landslide information
February 2019:	Improved user interface for retrieving landslide information
August 2019:	Improved user interface with basic tools for data analyses at the users' end, Enriched database with appropriate legend for representing different accuracy levels
February 2020:	Launching beta version of the landslide information system
August 2020:	Launching final version of the comprehensive landslide information system

12. Project Beneficiaries:

The landslide professionals, academics, researchers, planners and people residing in landslide prone areas in Sri Lanka are the beneficiaries of this project.

13. References

Devoli G., Strauch W., Chávez G., Høeg K., (2007), A landslide database for Nicaragua: a tool for landslide-hazard management, Journal on Landslides (Springer).

Des Inventar Disaster Information System, https:/www.desinventar.lk.

Innocenzi, E., Greggio, L., Frattini P and Amicis M.de.,(2017), A Web-based Inventory of Landslides Occurred in Italy in the Period of 2012-2015, In: Advancing Culture of Living with Landslides, Vol 2, 1127 -1133.

Weerasinghe, K.M., (2014),Utilization of Inferred Landslide Hazard Information as a Web Based Decision Making Tool for Landslide Disaster Risk Reduction and Early Warning, In: Landslide Science for a Safer Environment, Vol. 3, 319 - 332.

Date of Submission	11.09.2017.

IPL Project Proposal Form 2017

1. Project Title:

BLISM (Bosnian Landslide Investigation and Stabilization Method)

2. Main Project Fields

(3) Capacity Building

A. Enhancing Human and Institutional Capacities

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation, C. Recovery

3. Name of Project leader: ***Sabid Zekan***

Affiliation: ***Univ. professor, University of Tuzla - Faculty of Mining, Geology and Civil Engineering***

Contact: ***Univerzitetska 2, 75000 Tuzla, Bosnia and Herzegovina,***

fax: ++ 387 35 320-570, tel: ++ 387 61 562-277, e-mail: sabid.zekan@untz.ba

Core members of the Project

– ***Univ. prof. Mato Uljarević, University of Banja-Luka, Faculty of Architecture, Civil Engineering and Geodesy***

– ***Univ. Prof. Azra Špago, University of "Džemal Bijedić" Mostar, Faculty of Civil Engineering***

– ***Univ. Prof. Dženari Ćerimagić, University of Sarajevo, Faculty of Civil Engineering***

– ***Univ. prof. Maja Prskalo, University of Mostar, Faculty of Civil Engineering***

4. Objectives:

"Bosnian Landslide Investigation and Stabilization Method" has to establish the basic elements for more economical and efficient stabilization of landslides and to ensure that the sufficient degree of safety has been applied in the slopes. BLISM must be the set of simple principles, understandable to the wide audience, that result from research and knowledge on landslides.

5. Background Justification:

The landslides that occurred in the period from 2010 to 2016 caused few casualties and severe damages to housing facilities and infrastructure. The state of Bosnia and Herzegovina invests very little in landslides stabilization.

The legal regulations for landslides investigation and stabilization are not articulated nowadays. There is no methodology to be followed by investors, researchers, designers and contractors, and there is no state's strategy for governing semi-stable slopes processes.

6. Study Area:

Project will be conducted to area of Bosnia and Herzegovina, but would be applicable to all of the world.

7. Project Duration:

   Project has been lasting from idea after 2014 up today, and will be lasting in future without time limiting

8. Resources necessary for the Project and their mobilization

   It has been enrolled 5 universities from Bosnia and Herzegovina. Just, we have staff capacity. In general there is now financial support for the project. Last year, we have started with first preparatory phase of the project. Government have supported the project with small amount of money approx 1.500,00 USD. This year, 2017, we have continued to make connection with public institutions which will be enrolled to the project. New laboratory and field equipment would be necessary to done main phases of the project. It means, that project would be disseminated to region or internationally and get new title as option:

   - INTERNATIONAL LANDSLIDE INVESTIGATION AND STABILIZATION METHOD (ILISM)

9. Project Description:

BLISM is the methodology recognizable by investors, researchers, designers and contractors and provide an effective system of control in slope processes, investigation and stabilization of unstable slopes in order to ensure safety of people and property with as less as possible financial expenditures. The BLISM should be divided in several categories that are to be developed in detail:

- Slope and urban-planning processes' management;

- Pre-investigation and investigation activities on semi-stable and unstable slopes;

- Stabilization and post stabilization activities.

<u>The management of the slope and urban-planning processes</u> should be narrowly related to the definition of the term: stable – semi-stable - unstable. The following basic elements of the methodology for the control of the slope processes are suggested:

- systematization of slope processes;

- assessment of economic interest in the slope process;

- assessment of safety interest in the slope process;

- quantitatively defined terms: stable, semi-stable and unstable;

- stress-strain investigation of the slope in the pre-sliding phase;

- kinematics and sliding dynamics;

- water-permeability and water-containing of soil - rock (quantitative evaluation);

- draining and reduction in pores pressures.

<u>Pre-investigation and investigation activities</u> that may be classified into the following categories:

- Investigation of interaction: structure-unstable slope;

- Definition of the stress-strain status of landslide in the pre-sliding, sliding and post sliding phases;

- Definition of the kinematic parameters during landslide's movement,

- The scope of field investigation and procedures, as an alternative to the laboratory tests;

- Compliance of laboratory and field investigation tests, scope and type of investigation;

- Advantages and disadvantages of drilling sets and core quality;

- The role of geophysical investigation methods;

- Duration of the investigation and the season;

- The amount of investigation activities;

- Phase procedures in investigation;

- The gradual nature of geospatial investigation from global to local.

Stabilization and post-stabilization activities

- The possibility of soil strengthening instead of structures supporting;

- Development in the production of new materials that are to be used for stabilization;

- Establishing the term: Interest towards risk;

- Defining the possibility of stabilization in phases;

- Reactivation of landslide and legal procedure to establish responsibility;

- Post-stabilization observation and monitoring of landslides and semi-stable slopes.

10. Work Plan/Expected Results:

    1st year: Development of 1st phase: *slope and urban-planning processes*

    2nd-3rd year: Development of 2nd phase: *Pre-investigation and investigation activities*

4th year: Development of 3rd phase: *Stabilization and post stabilization activities*

5th year: Finalization of BLISM

6th an unlimited time: Improvement and distribution of BLISM internationally

11. Deliverables/Time Frame:

    Results of the project will produce next:

    - more safety and cheaper management of semi-stable and unstable slopes

    - better understanding between investors, investigators, designers and construction companies

    - improvement of urban planning on slopes, especially semi-stable slopes

12. Project Beneficiaries:

    All people-institutions conducted to slopes management such as: municipalities, institutes, universities, construction companies, government agencies, urban planning sectors.

13. References (Optional):

- S. Zekan at all, (2015), Bosansko-hercegovačka metodologija za istraživanje i stabilzaciju klizišta (BLISM), Proceedings: GEO-EXPO 2017, Zenica, BiH