

### 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

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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<sup>3</sup> to some hundreds of m<sup>3</sup> 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<sup>3</sup>, 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 1<sup>st</sup> phase the field 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 2<sup>nd</sup> 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 3<sup>rd</sup> 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 4<sup>th</sup> phase the application of different rockfall protecting measures will be examined for different types of rockfall features. The last 5<sup>th</sup> 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:

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

2<sup>nd</sup> phase: NUMERICAL MODELING. Milestone: Establishing of typical rockfall models.

3<sup>rd</sup> 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.

4<sup>th</sup> 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.

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

11. Deliverables/Time Frame:

1<sup>st</sup> phase: Field data base establishment. Time duration: 12 months.

2<sup>nd</sup> phase: Numerical modeling. Time duration: 12 months.

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

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

5<sup>th</sup> 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:

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