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.
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   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.

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