Date of Submission	30/03/2019

IPL Project (IPL - 196) Annual Report Form 2018

1 January 2018 to 31 December 2018

1. Project Number (approved year) and Title,

IPL-196 (2015) **Development and applications of a multi-sensors drone for geohazards monitoring and mapping**

2. Main Project Fields
   (1) Technology Development
      A. Monitoring and Early Warning,
   (4) Mitigation, Preparedness and Recovery
      C. Recovery

3. Name of Project leader
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   Core members of the Project: Names/Affiliations: (4 individuals maximum)
   Nicola Casagli, Full Professor, DST-UNIFI
   Guglielmo Rossi, Research assistant, DST-UNIFI
   Filippo Catani, Associate Professor, DST-UNIFI
   Luca Tanteri, Research assistant, DST-UNIFI

4. Objectives: The objective of the proposed project is to test the applicability of a multi-sensors drone for the mapping and monitoring of geohazards. In particular the project has two specific objectives: i) development of the drone, sensors, safety and automation and ii) application of the drone as a platform of integrated sensors (multispectral sensor, visible light camera, infrared camera and LIDAR) for the mapping and monitoring of geohazards.

5. Study Area:

   Several test cases in Italy where different applications of the drone have been tested and evaluated.

6. Project Duration: 3 years

7. Report

1) Progress in the project:

During the second year of the project the activities carried out are related to the two work packages foreseen in the project proposal. In particular:

WP1: Development of the multicopter drone, sensors, safety and automation.

The drone fleet has been enhanced by adding a series of lightweight drone prototypes called Saturn Mini to the Saturn M2 prototype (22 kg maximum take-off weight). Saturn Mini is a drone hexacopter of class VL (Very Light - takeoff weight <4 kg), with a 55 cm frame entirely printed in 3D with FFD (Fused Filament Deposition) technique. The development of a 3D-molded plastic frame suitable for flight has allowed to reduce drone production and repair costs while maintaining high performance. The Saturn mini can reach 90 km/h, climb and descent speeds over 6 m/s while maintaining a maximum range of 30 minutes of flight.

In order to improve the quality of the measured data, new stabilization and image taking devices have been designed, implemented and developed. As for the sensors, a compact 20 Mpixel Canon camera was implemented for extended photogrammetric surveys and the SaturnCam-Z, a camera with a 20.4 Mpixel Sony sensor with 30X optical zoom.

Furthermore, a new laser scanner sensor has been acquired, the VUX-1UAV sensor, produced by Riegl. Airborne laser scanning is a fast, accurate and efficient method for acquiring large-scale 3D data, such as vegetated and non-vegetated terrain, rock faces, wooded and urban areas, monuments, archaeological areas, industrial plants, etc. The sensor in question can be integrated on any type of aircraft platform and has a maximum range of 920 m with an accuracy of 10 mm. Its maximum operating height can reach 350 m. The sensor also includes an IMU/GNSS system for compensation of platform movements during acquisition.

WP2: Application of the multi-sensors drone for rapid mapping, 3D surface reconstruction, monitoring.

During this year the applications of the multi-sensor drone have been several. In particular here after we focus on the results of the survey of the Marano landslides. The aero-photogrammetric survey concerned an area located within the Municipality of Gaggio Montano (Province of Bologna), Italy.

The landslide phenomenon has a length of about 650 meters and develops on a hillside between 400 and 260 meters above sea level. The operations of aerial photogrammetric survey have allowed to

completely cover the area occupied by the landslide phenomenon, for an area of total extension equal to 0.14 km^2.

On 16 March 2018, the aerial photogrammetric survey of the area affected by landslides was resumed. The survey was aimed at the three-dimensional reconstruction of the surface geometry of the landslide area and of the neighboring portions, through the photogrammetric processing of optical images acquired by drone and the elaboration of point clouds and three-dimensional polygonal models.

The survey was carried out using the Saturn X21 drone (Saturn Mini class), made and patented by DST-UNIFI, equipped with a Canon digital camera, with a resolution of 16.1 Mpix (maximum image resolution: 4608x3456 pixels). The camera was calibrated before the start of the survey, in order to accurately set the optical parameters, which are useful during image processing using dedicated software. A GPS (Global Positioning System) detection campaign was carried out on the ground, using a Leica 1200 GPS with RTK correction via Italpos service, aimed at measuring the coordinates of no. 16 control points (Ground Control Points, GCPs), used for the geo-referencing of the three-dimensional model obtained in the aerial photogrammetric survey phase and for the evaluation of the accuracy of the resulting data.

The photogrammetric processing was performed with Agisoft Photoscan Professional 1.4 (http://www.agisoft.com/) Structure-from-Motion software in order to obtain three-dimensional representations of the visible surfaces in "point cloud" format (point cloud) , 3D polygonal models of the surveyed surfaces (Mesh), digital terrain (DTM) and surface (DSM) models, as well as a high definition mosaic orthophoto (Figure 1).

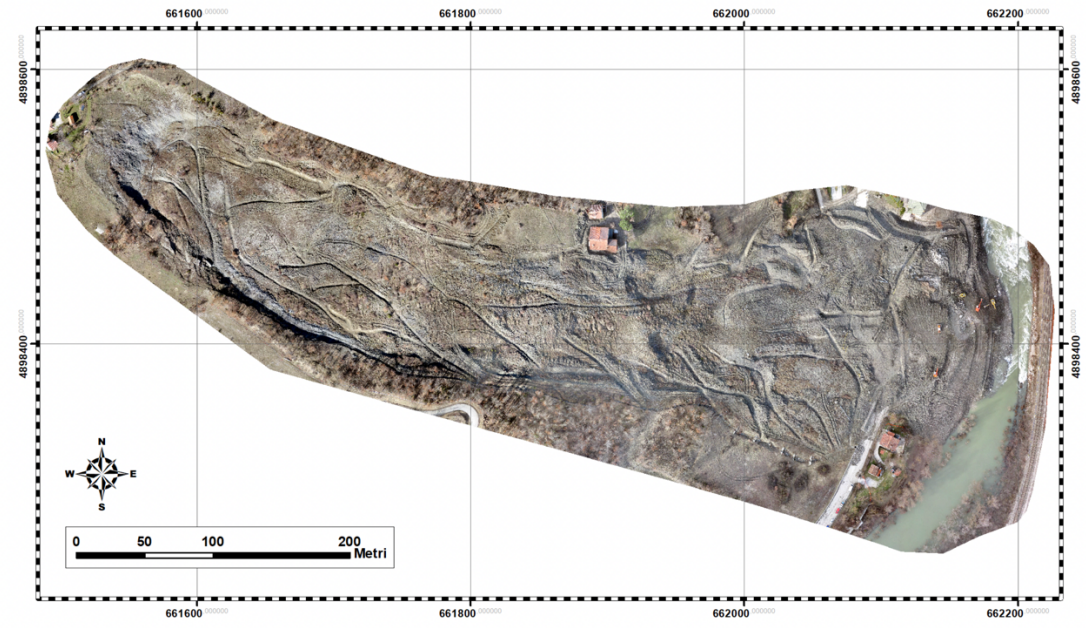

Figure 1: Digital ortophoto of the Marano landslide.

2) Planned future activities or Statement of completion of the Project

At the end of 2018 the IPL project n°196 is terminated.

3) Beneficiaries of Project for Science, Education and/or Society

The beneficiaries of this project are several: Civil Protection offices and institution, Research institutes, Universities, Public administrations, International organizations.

4) Results:

Rossi, G., Tanteri, L., Tofani, V., Vannocci, P., Moretti, S., and Casagli, N. (2017) Multitemporal UAV survey for mass movement detection and monitoring. Proceedings of the 4th World Landslide Forum, Lubiana, 29 May- 2 June 2017.

Casagli N., Frodella W., Morelli S., Tofani V., Ciampalini A., Intrieri E., Raspini F., Rossi G., Tanteri L. Lu P. (2017) Spaceborne, UAV And Ground-Based Remote Sensing Techniques For Landslide Mapping, Monitoring and Early Warning. Geoenviromental disasters. 4:9.

Rossi, G., Tanteri, L., Tofani, V., Vannocci, P., Moretti, S., and Casagli, N. (2018) Multitemporal UAV surveys for landslide mapping and characterization. Landslides. Volume 15, Issue 5, pp 1045–1052.