Date of Submission	28/02/2015

IPL New Project Proposal Form 2015

1. **Project Title:**

   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

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Filippo Catani, Associate Professor, 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. **Background Justification:**

The multicopter drone has an increasing role in remote sensing and aerial photography. The piloting ease and the mechanical simplicity are the main reasons for drone diffusion as a hobby and for professional use. Usually multicopters have a “spider” structure with a central body and many radial arms that support the

propulsion device.

To improve the structure of the existing multicopters, the Department of Earth Sciences of the University of Firenze (DST-UNIFI) has developed a new type of chassis structure that allows to overcome some critical issues for scientific and heavy payload or long flight applications (Figure 1).

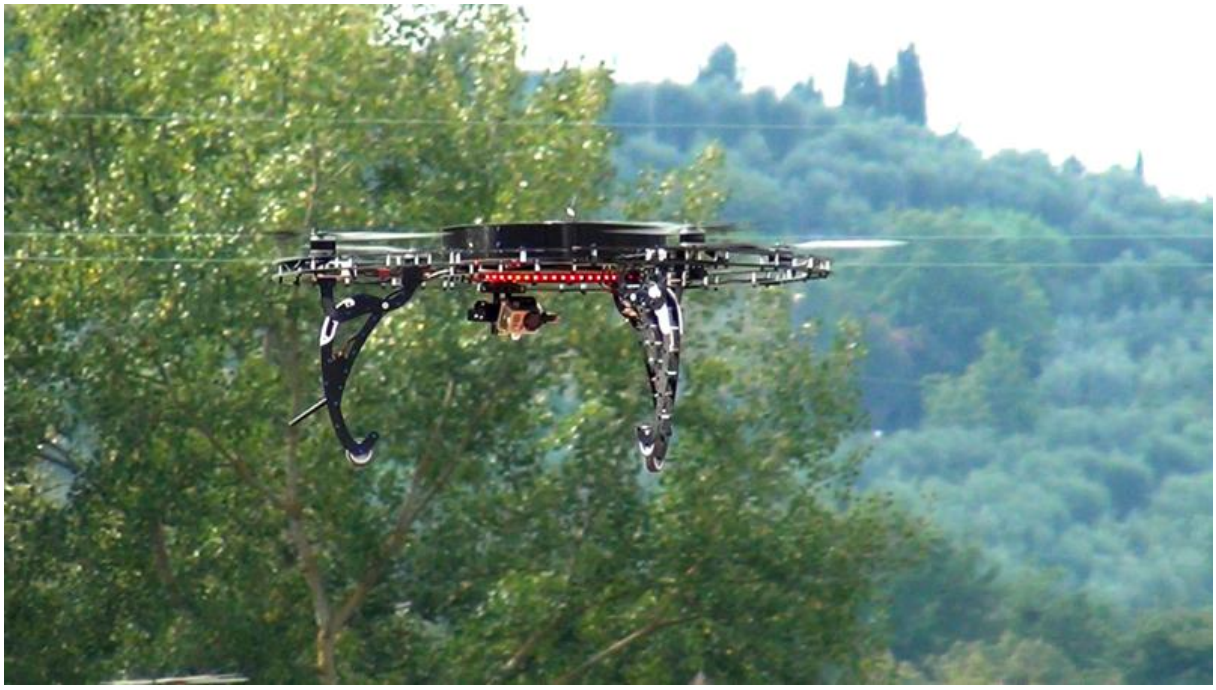

Figure 1: Multicopter drone developed by DST-UNIFI.

The new chassis is patent pending in Italy, PCT (Patent Cooperation Treaty) applied in 117 countries in the world and received its first positive report in Spring 2014. The improved structure has these main key features:

- Increased space without constraints to positioning electronics, flight system and instruments.
- The central payload area can be connected in a rigid manner or even with a flexible mount to dramatically cut down mechanical vibrations from the propulsion system.
- Maximized flexibility of propulsion configuration with a single chassis: without any modifications to the chassis it is possible to vary the number of propulsion systems (three, four, six, etc…), even during flight.
- The flexible propulsion configuration allows us to fit the need of every single mission: less engine to increase autonomy, more engine to allow for heavy payload.
- Variable propulsion geometry to keep the perfect balance with all types of payloads and to manage an emergency landing in case of a propulsion unit failure.

The DST-UNIFI drone is capable of autonomous flight, from take-off to landing, and emergency management.

The drone has onboard a complete and fully configurable acquisition system with frame grabber for scientific instruments. It is possible to plug in a multispectral camera, mini-lidar and various sensors

through the most common connections and protocols (Usb, Firewire, LAN, wifi, RS-232).

The DST-UNIFI is Center of Competence of National Civil Protection and the drone has been developed to be used and to provide data also in emergency and calamity areas. It is designed to be water resistant to fly into rain and harsh conditions.

6. Study Area:

At the beginning of the project the study area will be constituted by several test cases in Italy where the different applications of the drone will be tested and evaluated. After the testing phase the study area can be expended to European and World level.

7. Project Duration:

3 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 centres for scientific and technological services on geohazards in Italy, currently composed by 51 full-time employees. The group counts 4 professors, 3 researchers, 7 technicians, 19 post-doc fellows, 15 PhD students and 3 administratives. 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 advanced technical support required for the many fields of investigation covered. The total budget of the group in 2014 related to international, european and national funding projects is about 3 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:

The project is structured into two work packages (WP):

<u>WP1: Development of the multicopter drone, sensors, safety and automation.</u>

The development of the multicopter drone will begin from the patent pending prototype already in use at the DST-UNIFI. WP1 will be focused on research and development of the chassis and the flight model to improve flight range and transportable instruments weight limit. This is needed to employ complex and more accurate instruments over a large study area. Safety of flight is critical to avoid several damage or losses of costly instruments after a possible mechanical or electrical failure. Developing redundant safety system is a key feature of the WP especially to fly in harsh conditions. Obstacle avoiding will be implemented for added safety during normal or low altitude flight. The drone needs a ground station software designed to control and supervise the flight during mapping or reconnaissance mission of geohazards: software tools to easily plan a flight will be developed to exchange data with the most diffuse GIS platform. Scientific and multispectral instruments need electronics hardware to acquire data. The multicopter will be equipped with a mini PC that can drive, also simultaneously, different remote sensing device, like multispectral sensor, visible light camera, infrared camera and LIDAR. Specialized automated acquisition software will be developed to work side by side with the on board artificial intelligence.

The activity is subdivided into tasks:

TA1.1: Development and refinement of the drone and its safety and automation.

TA1.2: Development of specialized acquisition software for the different types of sensors.

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

This WP will deal with the application of the multicopter drone equipped with a multi-sensors platform for rapid mapping, 3D surface reconstruction and monitoring of different types of geohazards. An integrated system of sensors will be tested in order to verify their capability to rapid mapping of a different geohazards. 3D surface reconstruction with optical sensors will be carried out during multiple campaigns in order to define the entity of the volume variation in time. A special attention will be given to monitor, i.e. to measure the variations in time of some parameters, such as displacement, water content, temperature. The multi-sensors drone will be tested also in emergency situations connected to the activity of geohazards in order to evaluate its capability in disaster recovery actions. At the beginning some test sites will be selected in Italy, then the applications will be extended at international level, if applicable. The objective is also to test the drone in different conditions of geology, vegetation and climate.

Another objective of this WP is the development of devoted software for the interpretation of data coming from different sensors. Furthermore for selected test sites a comparison between the data acquired by multi-sensors platform of the drone will be compared with data coming from ground-based instrumentation.

The activity is subdivided into tasks:

TA2.1: Application of multi-sensors drone to selected case studies.

TA2.2: Development of software applications for the interpretation of the multi-sensors acquired data.

TA2.3: Validation of the multi-sensors drone acquisitions with data coming from ground-based instrumentation for selected test sites.

10. Work Plan:

Here below a time table of the project activities (WP:Work Packages, TA:tasks).

		1st year	2nd year	3th year
WP1	TA1.1			
	TA1.2			
WP2	TA2.1			
	TA2.2			
	TA2.3			

11. Deliverables/Time Frame:

The project will produce 3 deliverables, one per year, which are:

D1: Multi-copter drone, sensors and software development (T0+24)

D2: Development of software for the interpretation of data acquired by multi-sensors platforms. (T0+30)

D3: Applications of the multi-sensors drone in national and international selected test sites (T0+36).

12. Project Beneficiaries:

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

13. References:

Italian patent pending PI2013A000081

International PCT patent pending PCT/IB2014/064278