Date of Submission	

IPL Project Proposal Form 2020

1. **Project Title**: (2 lines maximum): ***"Landslide monitoring with cost-effective GNSS devices and development of a new equipment (LZER0) for real-time applications"***
2. **Main Project Fields**

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

(1) Technology Development

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

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides, X 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**: David Zuliani

Affiliation: (office and position) OGS, Technologist

Contact: (postal address, fax, phone, email): Via Treviso 55, 33100 Udine Italy, +39 0432522474, +39 0432 522433

Core members of the Project: National Institute of Oceanography and Applied Geophysics, OGS (Italy)

Names/Affiliations: (4 individuals maximum) Marco Severin (Solutop Sas); Mirko Antonini (Spaceexec); Antonella Peresan (OGS - ICL deputy board member)

4. **Objectives**: (5 lines maximum; what you expect to accomplish?): Development of GNSS cost effective technology to monitor landslide surface movements. Application of the developed tools and methods as services for both post-processed (with 1 hour sampling rate) and real-time (1s of sampling rate) monitoring.
5. **Background Justification**: (10 lines maximum) Cost effective instruments can achieve a centimeter accuracy, which is sufficient to detect the most relevant landslide slips, and has reduced costs compared to those needed for dual-frequency device. Currently two networks, composed by these newly developed devices, are used by OGS to provide a landslide surface movement tracking service to the Tolmezzo municipality (Cazzaso landslide) and to the Friuli Venezia Giulia Regional Civil Protection (Brugnera Landslide), needed for monitoring/alert and emergency management.
6. **Study Area**: (2 lines maximum; where will the project be conducted/applied?) Two monitored sites: Cazzaso landslide (Tolmezzo, Udine Province) and Brugnera Landslide (Pordenone Province), both located in the Friuli Venezia Giulia Region (Northeastern Italy).

7. **Project Duration**: (1 line maximum): Two years (project ongoing since 2015)
8. **Resources** necessary for the Project and their mobilization

   Personnel: 4 persons (1 technologist and 3 technicians)

   Facilities: 19 low cost GNSS equipment's, 1 dual frequency GNSS equipment, 4 GPRS modems, 5 UMTS routers, 1 seismometer, 1 rain gauge, 2 servers

   Budgets: **267.000 €**

Project Description: (30 lines maximum) OGS since 2015 has adopted GNSS cost effective technology to monitor landslide surface movements. Currently two networks made with those devices are used by OGS to provide a movement tracking service for Cazzaso landslide and Brugnera landslide (Zuliani et al. 2019).

Cazzaso village is located near the Tolmezzo municipality (Friuli Venezia Giulia Region, Northeastern Italy). The landslide is located in an earthquake prone zone, at about 30 km northeast of the 1976 Friuli earthquake of magntude ML=6.5. The seismicity in the area is routinely monitored by the OGS-CRS seismometric network since 1977 (Peresan and Gentili, 2018 and references therein). Cazzaso Landslide monitoring system is made of 10 single frequency GNSS receivers and one dual frequency receiver, beside the GNSS displacements. Rainfall measurements are also available from a local rain gauge and an additional GNSS receiver able to track real time movements (with a sampling rate of 1s) is installed to test real time performances All the GNSS data is collected and elaborated by OGS and made available to the municipality and to the Civil Protection by means of a client software with a minimum delay of 1 hour (displacement solutions are available once at hour, every 6, 12 and 24 hours as well).

Brugnera municipality is located in the western part of the Friuli Venezia Giulia plain, near the Livenza river. One of the Brugnera main routes coasts the river and it suffers from sagging and failures that have led the Municipality to remove a nearby park lot and a house in order to reduce the weight in that area. OGS has been involved since 2018 to monitor that with two cost effective GNSS device. The system realized by OGS is similar to the one used for Cazzaso but with real time services available on both point of measures. All the information collected and elaborated by OGS are made available to the Regional Civil Protection. The monitoring networks with hourly displacement availability (Displayce) has been provided by the Yetitmoves company. OGS coordinated part of the development to improve the performances and services of the system. Moreover OGS has developed its own real time GNSS cost-effective device (Zuliani et al. 2017) with the support of the SoluTOP company; this device, called LZER0, is currently part of both Cazzaso (1 instrument) and Brugnera (2 instruments) landslide monitoring networks.

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

   Cazzaso landslide work phases and milestones:

   - Phase 1: installation of the 1st dual frequency equipment to verify feasibility of the project and GNSS signal in the Cazzaso village
   - Phase 2: installation of the 1st core of GNSS low cost equipment's (6 stations + modems + server) on the Cazzaso Landslide and verification of the monitoring performances with 1 hour of sampling rate
   - Phase 3: installation of 3 new low cost devices to extend the monitoring service. Installation of the 1st real-time (1s of sampling rate) low cost GNSS equipment developed by OGS in

collaboration with SoluTOP. This last device has been coupled with a 3 components seismometer to verify landslide seismic induced signals.

- Phase 4: maintenance of the network and development of GNSS low cost devices and monitoring techniques. A rain gauge has been reactivated in order to correlate landslide movements detected by GNSS devices and rain activity.

Brugnera landslide work phases and milestones:

- Phase 1: installation of GNSS low cost equipment's (5 stations + modems + server) on the Brugnera Landslide and verification of the monitoring performances with 1 hour of sampling rate and 1s of sampling rate.
- Phase 2: development of a system aiming to provide both post-processed displacements (1 hour of delay) and real-time displacements (with 1s of sampling rate) and verification of the system robustness.

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

Cazzaso landslide Deliverables/Time Frame:

- D1: a complete and robust landslide monitoring system based on low cost GNSS technology. The monitoring system is supported by further sensors such rain gauges and seismometers in order to correlate different signals with displacements detected by GNSS equipment's.

Brugnera landslide Deliverables/Time Frame:

- D2: a complete and robust landslide monitoring system based on low cost GNSS technology. The monitoring system is able to produce both post-processed displacements and real time displacements in order to provide a better comparison of the two solutions and put the basis for an early warning system.

11. **Project Beneficiaries**: (5 lines maximum; who directly benefits from the work?)
    - Cazzaso Landslide: Tolmezzo Municipality and Civil Protection of Friuli Venezia Giulia Region
    - Brugnera Landslide: Brugnera Municpality and Civil Protection of Friuli Venezia Giulia Region
12. **References** (Optional): (6 lines maximum; i.e. relevant publications)

- D. Zuliani, P. Fabris, M. Bertoni, E. Del Negro, M. Severin (**2019**). "Moonitoraggio Frane e GNSS Cost-effective. Solicited presentation. Convegno tra geologia e geofisica 2019, XVI Workshop di Geofisica. Rovereto (TN), 5-6 December 2019, DOI: 10.13140/RG.2.2.10196.63361;
- D. Zuliani, C. Ponton (**2017**). "Organizzazione e gestione di un progetto per lo sviluppo di un prototipo GNSS cost-effective per applicazioni topografiche e monitoraggio strutturale. LZER0". Thesis, Master in Management of Research, Innovation and Technology. Master Universitario di II livello, MIT IV edizione, Polytechnic of Milan, DOI: 10.13140/RG.2.2.22750.05447;
- D. Zuliani, M. Bertoni, C. Ponton, P. Fabris, M. Severin, G. Ferin, G. Rossi (**2017**). "GNSS single-frequency devices at OGS: LZER0 a cost-effective prototype". GNGTS General Assembly 14-16 November 2017, Trieste, Italy, poster, DOI: 10.13140/RG.2.2.32319.61605;
- A. Peresan, S. Gentili (2018)."Seismic clusters analysis in Northeastern Italy by the nearest-neighbor approach". Phys. of the Earth and Plan. Int., 274 (2018), 87–104. DOI: 10.1016/j.pepi.2017.11.007.