SURPRISE

SUPER-RESOLVED COMPRESSIVE INSTRUMENT IN THE VISIBLE AND MEDIUM INFRARED FOR EARTH OBSERVATION APPLICATIONS

Project Updates after 12 months (January – December 2020)

SURPRISE Factsheet

Title: SURPRISE - SUper-Resolved comPRessive InStrument in the visible and medium infrared for Earth observation applications

Grant agreement ID: 870390

Start date: 01 January 2020 **End date**: 31 December 2022

Funded under: Call H2020-SPACE-2019 / Topic LC-SPACE-14-TEC-2018-2019 - Earth observation technologies (*RIA - Research and Innovation action*)

Overall budget / EU contribution: € 2 988 795

Coordinator: "Nello Carrara" Institute of Applied Physics (IFAC) - National Research Council - Italy

Partners: Swiss Centre for Electronics and Micro-techniques (CSEM) – Switzerland; Politecnico di Torino (POLITO) – Italy; ACRI-ST S.A.S- France; SAITEC Srl- Italy; RESOLVO Srl – Italy; Fraunhofer Institute for Photonic Microsystems (IPMS) – Germany; LEONARDO S.P.A - Italy

1. SURPRISE at 12 months

1.1. Overview

The first twelve months of SURPRISE were busy, despite restrictions caused by the COVID-19 emergency. Project activities started from a preliminary performance assessment of the SURPRISE system, using it to investigate which Earth Observation (EO) applications could most benefit from our disruptive demonstrator.

The SURPRISE project will use a Spatial Light Modulator (SLM) to implement a Super-resolved Compressive Sensing (CS) instrument. In this first period, partners investigated different SLM technologies and identified COTS available on the market. They carried out studies on SLM diffraction effects in the Medium Infrared (MWIR) spectral range and their impact on expected performance of the SURPRISE demonstrator.

Partners also started the design of the demonstrator and its sub-systems, which has recently achieved its final version. Alongside this, they began looking at user requirements for EO applications and at the definition of the architecture of a possible SURPRISE-like payload from a geostationary platform.

The SURPRISE consortium has been delighted to involve its User Community Panel members in all stages of project development. Throughout the year, our members have participated in two full consortium meetings and in a webinar organised with national Space Offices.

1.2. Details, findings and innovations

Work began with analysis of SLM functioning in the SURPRISE Demonstrator, as a basis of the optical design. CNR-IFAC, together with CSEM, SAITEC, Fraunhofer IPMS and LEONARDO, worked on defining the architecture of the demonstrator with its sub-systems and on identifying suitable components for its implementation. CNR-IFAC and IPMS carried out analysis of SLM functioning, covering simulations of diffraction effects. Results coming from simulations allowed partners to evaluate the impact of diffraction effects on demonstrator performance. Diffraction analysis has been developed in the MWIR spectral range by varying several parameters, such as: SLM micromirror pitch, deflection mode, tilt angle. On the basis of this analysis, a specific COTS SLM was selected for implementation of the SURPRISE Demonstrator. This will work in two distinct spectral ranges: VIS-NIR (multispectral) and MWIR (2 channels).

CNR-IFAC performed the optical design of the laboratory demonstrator by using ZEMAX optical CAD. Simulations have been performed for the estimation of the signal reaching VIS-NIR and MIR detectors. In parallel, CSEM carried out the reworking of the COTS SLM, to make it suitable for operation in the MWIR spectral range. They also defined the architecture of the Master Unit, providing control and synchronisation of the sensors and the actuators, and data storage. SAITEC has been developing the target scanning system and OGSE for the demonstrator.

Fraunhofer IPMS has been working on the design of a custom SLM for space applications. Criteria related to mirror deflection (angle), pitch (size), deflection mode and wavelength range were analysed, together with space-environment compatible solutions.

Work began on the Compressive Sensing (CS) algorithms at POLITO labs, with an analysis of sparsity on selected images for different scenarios and a literature review in the use of deep learning for CS reconstruction (image reconstruction algorithms). Two algorithms were selected, one using no deep-learning baseline and the other employing a deep learning baseline. The standard CS algorithms and deep learning ones will be tailored to SURPRISE applications taking into account how laboratory demonstrator will acquire a multispectral image.

ACRI-ST studied five possible geostationary missions that were selected and analysed based on the SURPRISE concept. Investigation addresses evaluation of possible flexibility in setting integration time and spatial resolution. This analysis is based on the preliminary performance indicators of a SURPRISE-like payload to determine applicable mission concepts. In parallel, LEONARDO is further studying and developing the architecture of a SURPRISE-like payload from geostationary platform.

Resolvo led exploitation activities, which run in parallel to technical ones. The aim is to evaluate the exploitation potential of the SURPRISE demonstrator as a whole and of its key technologies. The first stage of this was a full stakeholder mapping exercise. As a result, Resolvo organised a webinar (September 2020) with partners and their national Space offices, identified as a key stakeholder in all SURPRISE countries.

2. Next Steps

In June 2021, SURPRISE will reach its mid-term and the Consortium will meet up virtually, with the EC Project Officer and participants from the User Community Panel.

At technical level, the next steps are the procurement of the components and the construction of sub-systems needed for the implementation of the SURPRISE demonstrator, its modelling and test of the reconstruction algorithms. Partners will continue to study the development of a space-oriented SLM and relevant electronics, while environmental testing and validation of the SLM electronics will start. The reworked COTS SLM will be also tested and characterised spectrally.

Work on algorithms continues with the definition of an approach for robustness to uncertainty in the sensing matrix and introduction of super-resolution and of optical system characteristics.

Working groups within the consortium will continue to collaborate, through virtual meetings. These groups work on roadmap analysis, on SLM modelling and development, SURPRISE-like payload configurations and relevant impact on EO applications.

We are expecting new publications, one challenge workshop with the UCP members (March 2021) and one exploitation workshop to discuss the business model for the SURPRISE demonstrator and its technologies (May 2021).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870390.