HIGH-COMPACTED FM-CW SAR FOR BOARDING IN SMALL UAVS

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1. INTRODUCTION

Different geophysical and biophysical parameters have been extensively monitored with SAR sensors. Digital elevation models, damage assessment, subsidence maps, harvest monitoring, forestry clear cut mapping, deforestation, burn mapping and others were obtained by SAR systems boarded in different airborne and space-borne [1-5] platforms, but some drawbacks must be considered for these platforms: long revisiting time, low flexibility and difficult deployment. In contrast Unmanned Aerial Vehicles (UAV) partly sidesteps these problems: UAV can be remotely piloted, they could be programmed to be operated continuously by many hours, UAV systems have the possibility to take off and land in short runways, and its maintenance is simpler and more cost-effective than for manned aircrafts. All these characteristics are achieved without any loose of benefits, and they have allowed SAR sensors on UAVs to be used for several applications on earth observation, reconnaissance, monitoring, etc..

In this paper a compact, lightweight, airborne SAR sensor to be fitted in an UAV is presented. The system is based on previous experience in developing GB-SAR sensors [6-7] for subsidence and landslide monitoring. Different results using single polarimetric and interferometric measurements will be presented that show its capability to extract substantial information from geophysical parameters. These results can be obtained with similar performances of systems boarded in more complex platforms.

2. SYSTEM CHARACTERISTICS

The development of a SAR sensor to be boarded inside a UAV imposes strong constrains in compactness, weight, power consumption, flexibility and robustness. Taking into account these constraints an experimental, short to medium range C-Band SAR with single pass interferometric measurement capability has been developed. Strong constrains of light weight and stand alone operability were imposed during the design and development of the sensor, but resolution and performance were not compromised.

The sensor has four main blocks: Chirp Generator, Transmitter, Receiver and Data Acquisition System (DAQ). FM-CW modulation is used to reduce power requirements; the SAR transmits up to 2 W from a solid state power amplifier. The Chirp Generator is based on a digital direct synthesizer chipset with a PLL at L-band as local oscillator (LO), the signal is multiplied by four to generate the 5.3 GHz signal. The modular configuration of the system enables the future use of different frequency bands (migration to X and K band), and exploits the possibility for commercial applications with “off the shelf” components. Change to different frequency bands can be done with interchangeable active frequency multiplication modules and different front end. The SAR is enclosed inside a box of dimensions 15 x 25 x 9 cm and its weight is only 2.5 kg.

The UAV platform, shown in Fig. 1, is based on a radio controlled aircraft that was specifically designed and built in RS Lab to match the proposed requirements. The aircraft is 2 m length with 2.5 m of wingspan. It can fly at altitudes up to 500 m and speed between 15 - 45 m/s, it has 45 min autonomy boarding a payload of 5 Kg. GPS-INS systems must be incorporated for position and attitude record that will be used for motion compensation. The integration of an autopilot is planned to facilitate repeated pass interferometry.

3. EXPERIMENTAL RESULTS

The validation of the system was made placing the sensor in a mobile platform to check the system performance. The system was carried in a car with one transmitting antenna and two receiving antennas, one per each receiver. A test was performed near the bridge of Ripoll river in Ripollet, Barcelona. Results of the test are shown in Fig. 2. In this image two strong reflective targets are well distinguished (at distances approx. of 150m far from de baseline). One corresponds to an active PARC that was placed in the scene as a reference point and the other is a column of the bridge. The distances were determined by GPS waypoints and local maps to check the targets. The SLC (single look complex) image has been obtained with a Back Projection focusing Algorithm, but other algorithms are going to be verified.

It is observed that velocity and attitude are critical in the focusing process: errors in the determination of the attitude and velocity of the platform will be translated in a bad focused image. Attitude information from Inertial Motion Sensors must be recorded, and together with velocity and altitude they would determine the flight trajectory information to perform the Motion Compensation (MoCo) for precise image formation.

Fig. 1 Aircraft built and developed in the RS Lab

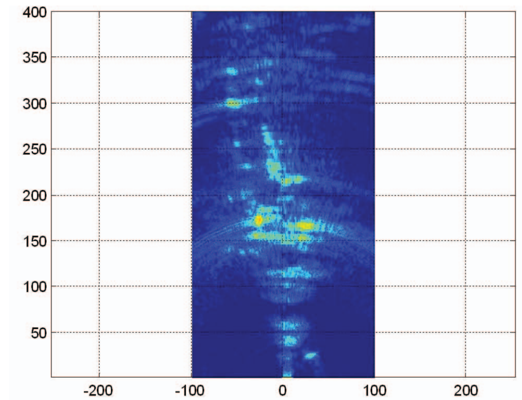

Fig. 2 SAR image (400 x 200 m) showing high bright spots from PARC and bridge columns

4. CONCLUSIONS

The results of the tests in a mobile platform and in the UAV will be presented. Single pass interferometric images will be shown. Inertial motion sensors information will be analyzed to increase resolution in the positioning and attitude determination for motion compensation. Advanced techniques for the retrieval of residual MoCo errors will be applied to improve the focusing of the image [8]. Finally, conclusions will be extracted and discussed.

5. REFERENCES

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