1st Croatian Conference on Earthquake Engineering
1CroCEE
22-24 March 2021 Zagreb, Croatia

DOI: https://doi.org/10.5592/CO/1CroCEE.2021.143

GEOINT in natural and technical disasters

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Abstract

This work will present a project proposal that represents the national complement of NATO-Science and Technology Organization activity SET-279 "Satellite sensor with synthetic aperture and big data technology in support of NATO operations". There is a possibility to use the acquired knowledge and experience in automatic processing of Synthetic Aperture Radar (SAR) images for civilian support tasks of the Croatian Armed Forces (CAF) in cases of natural and technical disasters (floods, earthquakes, large fires, landslides, avalanches, contamination with oil and chemicals at sea, lakes and rivers, illegal excavations and illegal logging). The use of commercial satellites with a high time resolution (6 hours) will enable the rapid production of thematic maps for the CAF Command and Operations Center and field intervention units. Algorithms developed through the SET-279 activity will be adapted to national needs. Through this activity, the operational units in charge of Geospatial Intelligence (GEOINT) and Imagery intelligence (IMINT) will be trained and qualified to independently process satellite images, according to current NATO standard operating procedures and doctrines, and to distribute them through existing command and control channels. The concept of the future system includes expert support at the inter-ministerial level; transfer of resources of the CAF (acquired images and processing of satellite images) to other ministries; e.g. application in spatial planning and environmental protection, forestry, agriculture and fishing, energy, border protection, transport, hazard estimation etc. A solid and well-defined framework will be created for scientific and development activities, definition of operational procedures and specialist training.

Key words: GEOINT, natural and technical emergencies

1 Introduction

The application of remote sensing in military operations to assist civilian structures in cases of natural and technical disasters is not in question. Remote sensing plays a significant role in hazard assessment and proposing of prevention options, in recognized environmental picture (REP) during rescue operations, and finally for disaster damage assessment. The participation of a military organization in disaster relief operations requires the adjustment of the overall operation management process. Acquiring situational awareness (SA) in the field is gaining a new importance because the only thing left for the immediate response forces is to react to the situation caused by the disaster. Disaster itself is often not one point in time and space. One catastrophic event can cause a whole chain of events that can increase the intensity of the catastrophic event and expand it in time and space. It is possible, in active cooperation with civilian institutions, to respond to events in a rational and purposeful manner, with minimal risk in conducting search and rescue operations. In doing so, gathering information about the terrain is becoming extremely important. In the first moments of conducting a search and rescue, it is difficult to set priorities in gathering information. All available and possibly useful information in the entire endangered area are collected. In doing so, satellite images are usually the basic thematic layers where localized information from other sources are added. Over time, as the Task Force Headquarters (HQ) conducting the search and rescue operation becomes more and more aware of the situation, one can speak of directing the focus of interest in gathering information. The time of collecting initial information can be significantly shortened with the developed Geospatial Intelligence (GEOINT) system.

2 Methodology

In the proposal of the organization and methodology of the work of the national GEOINT system, we start from what we already have, what has already been developed at the national and international level. The favourable circumstance is that the GEOINT doctrine is practically already used in commercial activities, especially in: transport, logistics, land use, forestry, agriculture and data analytics. Also, high-performance hardware is available today, allowing all GEOINT participants to respond in hours. The availability of satellite imagery, software, abundant and reliable data sources and layers in open access has stimulated the interest of a large number of experts. Thanks to all this, nowadays there is a large interested professional community that has gained significant experience in its work so far, and can apply for GEOINT support for crisis response operations [1]. International cooperation was also well developed, which in the last ten years has grown from bilateral and multilateral to global cooperation. On the foundations of the Committee on Earth Observation Satellites (CEOS), following the UNISPACE III conference held in 1999, the European Space Agency (ESA) and the French Center National d'Etudes Spatiales (CNES) initiated the International Charter Space and Major Disasters

(ICSMD) [2, 3]. In 2014, ESA translated the Global Monitoring for Environment and Security (GMES) system into Copernicus, which, along with the United States Geological Survey (USGS), is the largest open source of GEOINT substrates [4]. Accessing ICSMD provides professional assistance and access to a large number of satellite systems: RISAT-1, RADARSAT-1 & 2, TerraSAR-X, TanDEM-X, Pleiades, UK-DMC 2, KOMPSAT-2, Resourcesat-2, Oceansat-2, Cartosat-2, IMS-1, RapidEye, POES, GOES, SAC-C, Formosat, GeoEye, IKONOS, QuickBird, WorldView, Risat-1, RADARSAT-2, TerraSAR-X, TanDEM-X, Sentinel-1, Sentinel- 2, Sentinel-3, Sentinel 5 Precursor, UK-DMC 2, Landsat 8, SPOT 5, 6, & 7, PROBA 1, SJ-9A, GF-1, KOMPSAT-2, IRS-P5 (Cartosat-1), Canopus-V, Resource-P, POES, GOES, FY-3C, Metop, Meteosat, Meteor-M, Formosat, GeoEye and the camera mounted on the Kibo module aboard International Space Station. Besides operational systems, archival data from nonoperational satellites such as ALOS, ENVISAT, ERS, CBERS, IRS-1C, Astra 1D, IRS P4, P6, IMS-1, RADARSAT-1, SAC-C, SPOT 1-3 & 4, UK-DMC, Landsat-5 and NigeriaSat are also available. ICSMD member countries must have the technical prerequisites to download thematic maps and the professional staff to interpret them. By activating the ICSMD, the state also receives professional assistance, all free of charge during the state of emergency. The only exceptions are droughts, for which ICSMD cannot be activated. During the twenty years of its existence, until the writing of this paper, ICSMD has been activated 690 times, on average once in 11 days. The Republic of Croatia is a member of the ICSMD, but the Charter has not been activated so far despite several floods and earthquakes, not to mention severe forest fires during summer seasons.

The Republic of Croatia has a developed system of civil defence and crisis management. There are appropriate operational plans (OPLANs) of the armed forces in case of disasters, which have been verified through military exercises. Also, there is a developed system for GEOINT that can be incorporated into crisis management. CAF collaborates with Oikon Ltd. – Institute of Applied Ecology on the introduction of new Earth Observation technologies, research and development, while participating in the NATO Science and Technology Organization on activity SET-279 "Space-Based SAR and Big Data Technologies to support NATO Operations". Croatian Defence Academy has the ability to train GEOINT staff, independently or in collaboration with national academic and economic entities.

3 Capabilities and opportunities

The Republic of Croatia has developed and tested in practice the ability to act in cases of disasters, including GEOINT. Examples of such data are given in Figures 1, 2 and 3. However, from capable but uncoherent units it is necessary to create a permanent civil-military system for GEOINT. This system should constantly organize preparedness and alertness activities and carry on education and training of personnel for their own needs [5, 6]. The system will be activated during the disasters in its full capabilities

to conduct crisis cycle activities: rapid analysis, response, and recovery support [7, 8]. If necessary, ICSMD will be activated, simultaneously collecting multisensory satellite images from open sources and complementary commercial Earth Observation platforms. This approach should ensure the availability and applicability of sensor imagery regardless of the atmospheric and environmental conditions. Commercial recordings should be ordered in advance at a flat rate, in order to make the procurement cycle as fast as possible. GEOINT teams, in addition to having the ability to retrieve all relevant contemporary sources, should have developed procedures for inserting all information gathered from the field [9]. The fact that modern smartphones have a built-in Global Navigation Satellite System (GNSS) should be used to accurately locate devices and cameras with significant capabilities, and geotag the gathered information. In the near future, we can expect an increasing number of Internet of Things (IoT) devices as well as Unmanned Aerial Vehicles (UAVs) owned by individuals and various organizations. The possibility of using historical recordings to gain insight into the pre-disaster situation and to identify possible sanctuaries for survivors should also be envisaged. Well prepared, such a GEOINT system will be able to provide quality situational awareness for emergency management during the civil-military rescue operations. It is very important that GEOINT interpreters are trained in simulated real conditions, when due to speed priorities there is no time for experimentation to innovate procedures. Everything must be coordinated and everyone must know current Standard Operation Procedures (SOPs) or, in absence of them, follow the current doctrine. GEOINT interpreters must be familiar with the overall decision-making process in disaster-relief operations in order to fully tailor their products to users (operations HQ and decision-makers) and their specific information needs. GEOINT products could be useful for press and charity organizations.

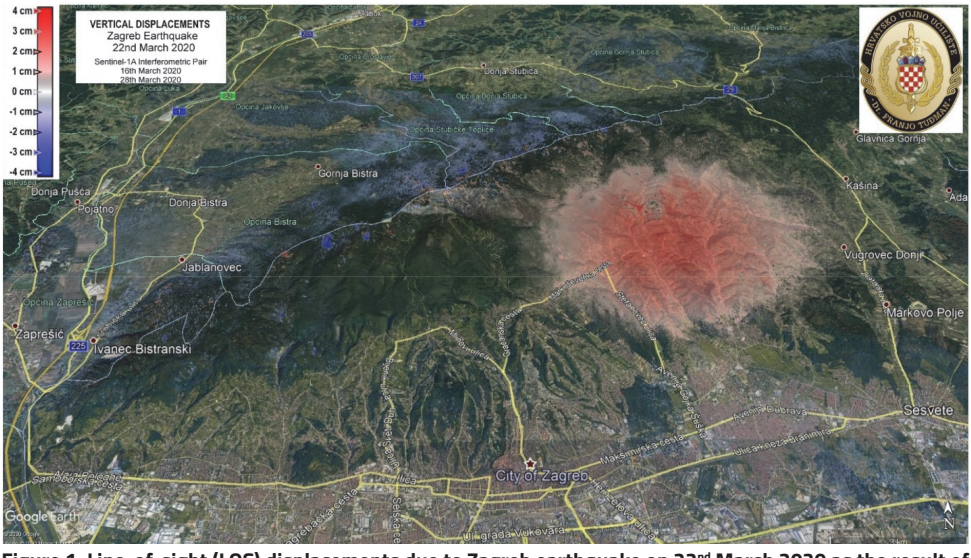

Figure 1. Line-of-sight (LOS) displacements due to Zagreb earthquake on 22nd March 2020 as the result of differential interferometry with a pair of synthetic aperture radar Sentinel-1A satellite images

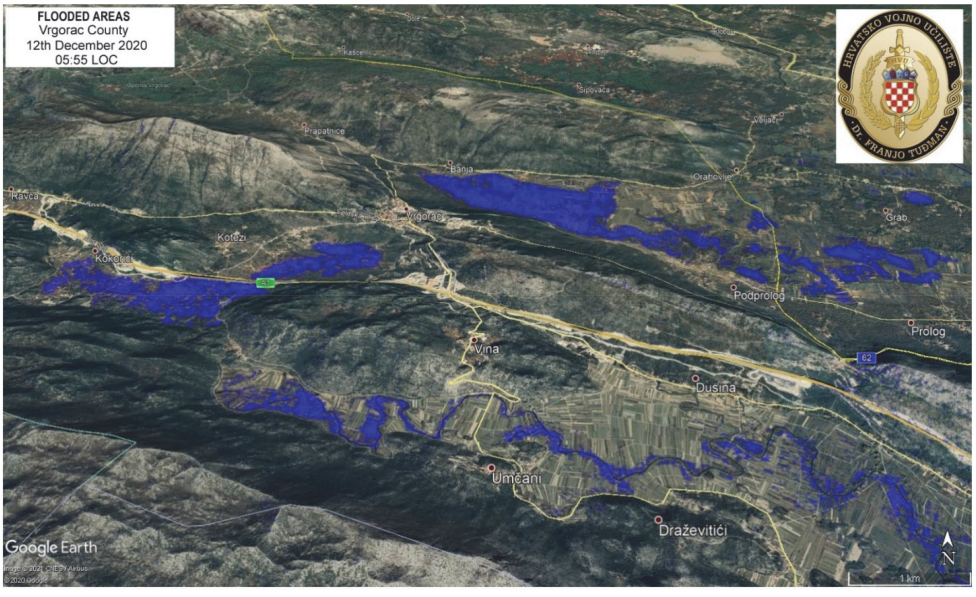

Figure 2. Flooded areas in the Vrgorac County on 12th December 2020 at 05:00 local time as the result of polarimetric processing of a synthetic aperture radar Sentinel-1A satellite image

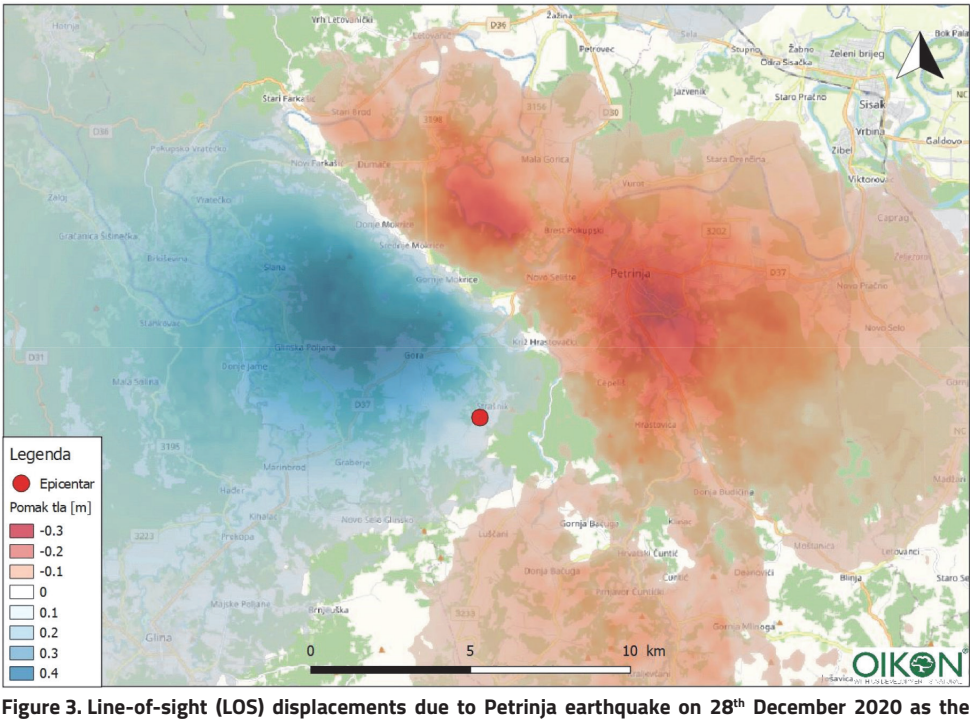

Figure 3. Line-of-sight (LOS) displacements due to Petrinja earthquake on 28th December 2020 as the result of differential interferometry with a pair of synthetic aperture radar Sentinel-1A satellite Acquisition dates of analysed images are 18th December 2020 and 30th December 2020.

4 Recommendations and conclusion

Due to constant risk of natural and technological disasters, in preparation for the occurrence of these catastrophic events, we recommend the establishment of a national civil-military system for GEOINT in crisis-relief operations in Croatia. This system should exploit the existing organizations and capabilities, to include commercial enterprises and academics and not to burden the existing Armed Forces and Civil Defence with an additional organization. The proposed GEOINT system would spend most of its time realistically estimating hazards based on analysis of previous events [10] , creating velocity deformation maps using Permanent Scatterers (PS) and Small BAseline Subset (SBAS) methods, risk management of natural and technical hazards and more, which opens the possibility for permanent scientific research. On the other hand, Armed Forces and Civil Defence systems would spend most of their time building international cooperation, building a civil-military organization, organizing and conducting exercises based on which, together with lessons learned from realized operations, they will constantly upgrade doctrine and conduct training. It is necessary to organize and check, by organizing exercises, the dissemination system of GEOINT products, including the implementation of alternative communication systems, such as the proposed EU GovSatCom. A system of dual, education and training use should be developed with the opportunity to create a corps of reserve officers, specialists for GEOINT. The national system for GEOINT must provide for the flat-rate procurement of complementary commercial imagery and GIS bases, include international cooperation to activate the ICSMD, and the necessary bilateral cooperation with neighbouring countries.

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