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Utilization of Multirotor Drones, Small Satellites and Other Sensor Systems in Airbase Protection

Abstract: In addition to traditional sources of information, new and disruptive technologies equipped with several types of sensors produce a huge amount of real-time information. Observed physical space consists of five components: air, see, ground, space and electromagnetic spectrum. A real-time presentation of the situation in the observed space is called the common operational picture (COP), and it forms the basis of the decision making and actions. A huge amount of real-time measurements and their continuous data flow requires automated data processing to compute, update and share the COP as real-time as possible. This article discusses about the utilization of multirotor drones, small satellites and other sensor systems in airbase protection. Recent MULTICO-project is used as a case study, and conclusions are presented based on the project results, and further observations during and after the project.

Keywords: sensors, drones, small satellites, situational awareness

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1 Introduction

The rapid development of autonomous systems and sensors is changing the modern warfare. Traditional geographic battlefield has been extended to battlespace, which has the components of air, sea, ground, space and electromagnetic spectrum. These all must be taken into account in the common operational picture (COP). When the systems become more complex, there are increasing number of real-time observations. As a consequence, automated data processing is needed to compute, update and share the COP as real-time as possible. On the other hand, new and disruptive technologies are not operating alone. They must be interfaced to traditional military systems to operate jointly. One operating concept for such a networked modern warfare is the combat cloud, which was first released by US Air Force in March 2016 [1], [2].

An interesting question is, how the pre-mentioned new technologies will change the warfare? How does the use of the traditional weapon systems change, once the autonomous systems and sensors are utilized? What kind of completely new ways to operate do they provide, and are they making some currently applied methods useless in the nearby future?

This article discusses about these questions based on the experiences from MULTICO project executed on 2020-22. The project was supported by Business Finland, and the consortium had members from the industry and academia including also the National Defence University of Finland (NDU) and Finnish Air Force Academy (FAFA) in the advisory role. In addition to sensor systems, there were two rapidly developing technologies considered in this project: multirotor (multicopter) type of drones and small satellites. Both of them can be equipped with one or several types of sensors (including cameras) and actuators. In multirotor drones, the sensors can be either mounted to the drone so that they make their measurements in the air during the flight, or they can be deployed to the ground by the drone [3].

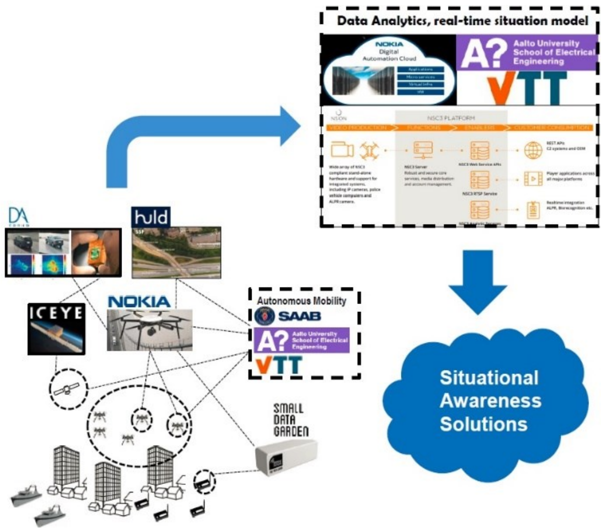

Figure 1 A system level view of MULTICO architecture.

As a part of their advisory role, NDU and FAFA defined a list of performance requirements and respective test scenarios, which were focusing on surveillance and airbase protection. MULTICO system developed in the project was first tested in the winter experiments in December 2021 and towards the end of the project in final experiments in September 2022.

2 Methods

The research consists of author's discussions and brainstorming with the Air Combat Center of Finnish Air Forces (FAF), experiences from FAF exercises and the content of MULTICO project, which includes case studies in the form of MULTICO winter and final experiments [3]. Later experiences from Russo-Ukrainian war and other crisis are also utilized in the further analysis of MULTICO results and in the conclusions about the future work.

3 Results and Conclusions

Developed architecture was able to operate as one entity, or its subsystems can operate on their own. Communication and computation architecture, cabled and wireless flying base stations, deployable LoRaWAN sensor network, Saab Sirius Compact sensor and Iceye's small satellite system operated successfully in the experiments. Some of these subsystems are already commercialized and all of them are reaching that technology maturity level.

Developed GNSS free navigation methods behaved promisingly [4], but more research and development work is still needed to reach the level or productization and commercialization. Iceye's small satellite SAR data reding and analysis should be integrated to the same COP as the rest of the system [3].

A software for deployable wireless BLE mesh network was completed [5], but the hardware must be re-designed to make it suitable for field conditions and drone deployment. Preliminary results about radio tomographic detection of the presence of people and their tracking by using software defined radios in drones were achieved, but further research is still needed to improve system accuracy and reliability.

The most important factor the multirotor drones can improve is to achieve and share the advance information about the situation and its changes as early as possible. Multirotor drones provide a view to the base area from the air. It is also flexible to change the point of view by moving them from one location to another and by zooming and changing the angle of view when hovering in one location, if there is something interesting to observe further. Night vison capability is necessary, and the simultaneous availability of daylight and night vision cameras support each other when making the observations.

When equipped with radar or suitable sensors, friendly drones can observe enemy drones and their data traffic from the air, and also disturb them. An important direction to investigate further is the possibility to use multirotor drones to obfuscate missiles.

The property to deploy sensor networks on the ground using multirotor drone is very useful. Deployed sensor networks can be used for the securing and monitoring of targets, and also for surveillance and for harassing the enemy. However, the reliability of the sensor systems in different weather and electromagnetic spectrum conditions is a critical factor.

Wireless flying cellular base station is a good way to establish rapidly an efficient temporal network. Cell area can be limited based on the particular need, and the cell can also move with the group it serves. Cabled flying base station is rapid to set up and disassemble compared to the tactical mast.

A fundamental thing, that must be solved to use multirotor drones in the airbase area during the air operations, is the drone location information sharing with the air traffic control. Drones must be included to the same airspace management with other aircraft.

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