Mechanics Transport Communications

ISSN 1312-3823 (print)
ISSN 2367-6620 (online)
volume 17, issue 1, 2019

Academic journal http://www.mtc-aj.com **article № 1753**

ADAPTATION AND APPLICATION OF ECALL IVS DEVICES FOR UNMANNED AERIAL SYSTEMS

Krume Andreev, Rumen Arnaudov, Marin Aldimirov
andreev.k@abv.bg

Department of Radio communication and Video Technologies, Technical University of Sofia, Sofia 1000,8 Kl. Ohridski Ave, BULGARIA

Key words: *eCall, UAS, Unmanned Aerial System, IVS, InVehicle System, HeERO, Veronica 2*

Abstract *The article explores the possibilities for adapting and using technical solutions to the existing eCall automotive system for timely signaling of incidents in the field of un-manned aerial systems (UAS). The potential benefits of using them for UAS for civil and commercial purposes are presented. The technological challenges related to the adaptation of the IVS car unit to work on board of UAS are explored. Field test results are presented to investigate the capabilities of IVS instrumentation for incident and in-flight emergency situations. Ideas for future development and research are presented. Field test results are presented to investigate the possibilities of software analysis of incidents. The experimental results show clearly distinguishable zones in the recorded data, that allow instrumental registering of emergency related events such as freefall, parachute opening and hitting the ground. This opens the possibility for timely signaling and timely submission of data from the incident to rescue teams and stakeholders. This article aims to challenge and direct the interest of institutions and companies in developing specialized modules and standards, as happened with the eCall standard.*

1. INTRODUCTION

The eCall system is a European automotive emergency system designed for making automatic emergency calls to the European emergency number 112 in the event of a road accident [1]. In the period 2011-2018, the system is being developed and implemented by the European Commission within the EU as part of the HeERO projects [2]. From the beginning of 2018 it is mandatory to be integrated in all new cars sold on the European market.

The purpose of the eCall system is not to prevent accidents, but to address the two the most influential factors for rescue intervention of already occurred ones - timely signalization and accurate localization. The result is a reduction in response time of rescue teams by up to 50% [3], which leads to more saved lives and less property damage.

In order to achieve that the eCall system consists of two main parts:

• Specialized eCall InVehicle System (IVS) installed in the car;

• Specialized eCall Public Safety Answering Point (PSAP) embedded in the European emergency call center 112.

The IVS device is capable of automatic detection of crash events. During normal travel the device is in stand-by mode. If an accident occurs the IVS wakes up and initiates an automatic emergency call to the nearest 112 PSAP. During the call initialization critical data is sent to the PSAP. This critical data is called an MSD package (minimum set of data) and contains the exact GPS location of the incident plus two previous car positions, last known heading of the vehicle, registration data, number of passengers, etc. When the data is successfully sent voice connection is established between the passengers of the car and the 112 operator assigned for the call and the normal emergency protocol is followed. This workflow is shown on fig. 1.

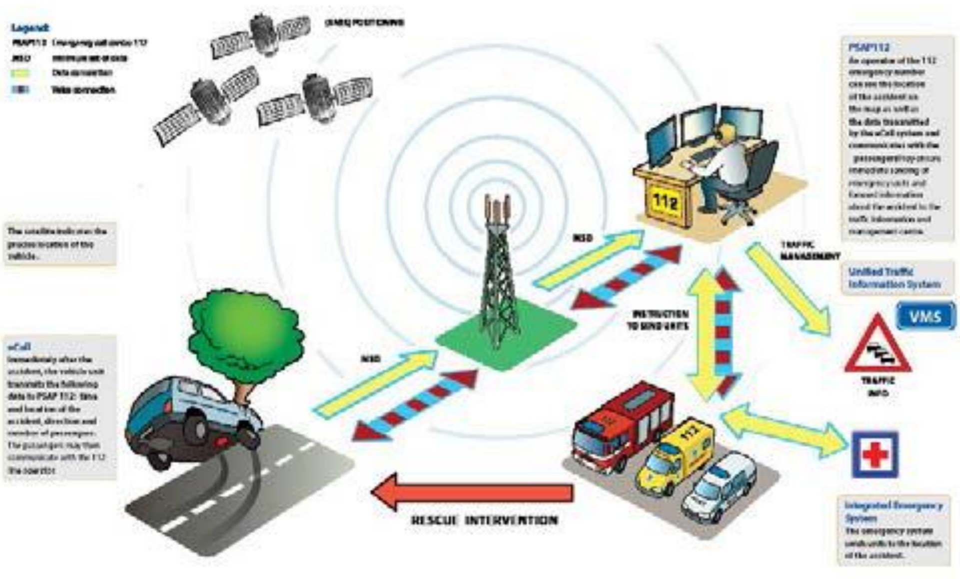

Fig.1 eCall work principle

All eCalls are marked with an eCall flag [4] while initiating the connection to the mobile network, so mobile operators can distinguish and route them with highest priority.

All of this eliminates the human factor in terms of signalling the emergency services. The eCall system is especially useful in accidents, where there are no witnesses and the car passengers are unable to call the 112 emergency number themselves. In these cases, the eCall is considered as source of truth and rescue teams will still be sent to the reported location.

The eCall system already demonstrates its benefits on EU roads, but its application can be extended beyond the automotive industry. With the increasing use of unmanned aerial systems (drones) in civil and commercial aviation, an increase in the number of incidents is also inevitable. In the case of transportation of dangerous goods, the timely signalization and accurate positioning of the UAS accident to the emergency services is critical to limiting the dangers imposed to the public. In the case of transporting high value goods, the timely and accurate positioning of the accident could prevent the goods' loss or damage from prolonged stay in unsuitable environment. Considering this a standardized Emergency Response System for unmanned aerial systems similar to the eCall would introduce the same benefits as eCall, but there is yet no standard for such a system. Instead of creating new emergency signalization standards for UAS from scratch, a more practical approach would be to adopt ideas and devices from the already developed and existing eCall system and adapt them for the context of UAS.

This article explores the challenges and enablers to adapt the eCall system in the field of UAS. Paragraph 1 examines the benefits of using the system for UAS. Paragraph 2 presents the technological advances and challenges of adapting the IVS car system to work on an UAS. Paragraph 3 presents options for developing additional features that are not part of the eCall system but are technologically feasible without changing the hardware base of the IVS device. This article aims to challenge and direct the interest of institutions and businesses in developing specialized modules and standards for detection and disclosure of UAS incidents, as happened with the eCall standard. In the case of transport of valuable goods or when special damages have been caused by the fall of the UFO, the owner is interested in clearing the clues about the accident. By timely signaling and timely submission of data from the incident to stakeholders, the possibility of this happening is reduced.

2. BENEFITS OF THE ECALL SYSTEM FOR DRONES

The benefits of timely signaling and accurate localization using eCall system for UAS are similar to those used in the automotive industry. In fact, timely signaling of an incident is of paramount importance for all types of systems. A precise localization has a particular application in moving systems. In addition, UAS should normally fly away from settlements and roads in order to prevent damage and victims in the event of an accident. This provides additional difficulty for rescue teams, as the drones can fly freely across hard-to-reach areas. In such situations, finding the exact last position of the UAS may be key to finding it.

The timely response of rescue teams is of particular importance when it comes to UASes carrying dangerous goods that may pose hazards to the environment or nearby people as a result of an accident.

Another risk to working with a UAS is that it can be stolen, and even intentional incidents may be triggered by a third party. In this case timely notification of the owner is key to reducing the risk of theft.

When transporting valuable goods or when damage is caused to the UAS due to operator error, its owner is interested in clearing the evidence about the accident, e.g. for release of responsibility or for insurance claims. Here again, the timely signaling and timely transmission of the accident data to rescue teams reduces the possibility of this happening.

3. CHALLENGES AND ENABLERS FOR ADAPTATION OF IVS FOR DRONES

For the operation of the eCall system with UAS, there is no need to change the PSAP servers at 112 emergency centers, but it is necessary to adapt the IVS device to work onboard an UAS. Key functionality in IVS is the automatic instrumental detection of a crash that "unlocks" the eCall potential. This functionality is the only one that depends on the car's systems, so its adaptation is key to the proper operation of the IVS device on board the UAS.

For automatic detection of a car crash via IVS there are two options:

- autonomous;
- non-autonomous.

According to the eCall standards, the car device detects crashes by “listening” through the Can Bus interface for an “open airbag” signal. This approach is non-autonomous because it depends on the systems of the vehicle, which makes it inappropriate for UAS.

Another option is to add an inertial system to the IVS device and perform an autonomous detection. This option, although not described in the eCall standards, does not contradict with them, and there is already such a development [5] that has been implemented under the HeERO2 project.

Existing developments for autonomous car accident detection using an inertial system [6, 7] are based on a detection of a crash, which makes them not fully applicable to UAS. A crash does not necessarily occur when there is an emergency situation with the UAS. Even when due to an accident the drone lands or crashes on the ground, it may occur at a much later point in time from the beginning of the accident. Therefore, it is necessary to define new trigger conditions for detecting the occurrence of an emergency during flight.

To investigate the possibility of defining such triggers, a series of tests was carried out. A prototype of an IVS device is attached to an UAS, equipped with a parachute. Figure 2 shows a block diagram of the IVS prototype. It is similar to the one developed in [5] as it includes the standard eCall hardware - microcontroller, GSM (with built-in InBand modem) and GPS modules, interface to the passengers. The device also contains a memory and inertial system with three 3-axis sensors. For the experiment described here, the magnetometer data is not used.

During a normal flight the occurrence of an emergency situation where the UAS falls into a free fall condition is simulated. The parachute opens during the fall and the test ends with a static UAS position after falling to the ground. Data is stored in memory and then analyzed.

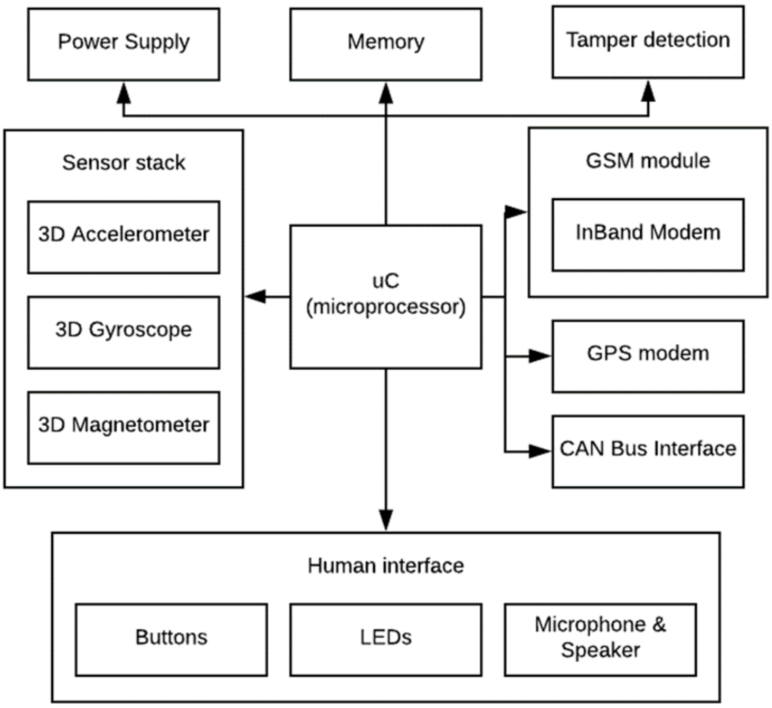

Fig.2 Block diagram of the used IVS device

Three representative tests are selected, the data of which are shown in Figures 3 to 6. In Figure 3, accelerometer and gyroscope data are displayed in the time slot around the occurrence of the accident and the fall of the UAS to the ground from the first representative test.

Three UAS states can be distinguished from the gyro data:

- normal motion;
- chaotic fall;
- static post-fall position.

From the accelerometer data, on the other hand, more states can be detected. For a more detailed analysis, Figure 4 to 6 show only the accelerometer data from the three representative tests scaled in the area around the fall of the UAS.

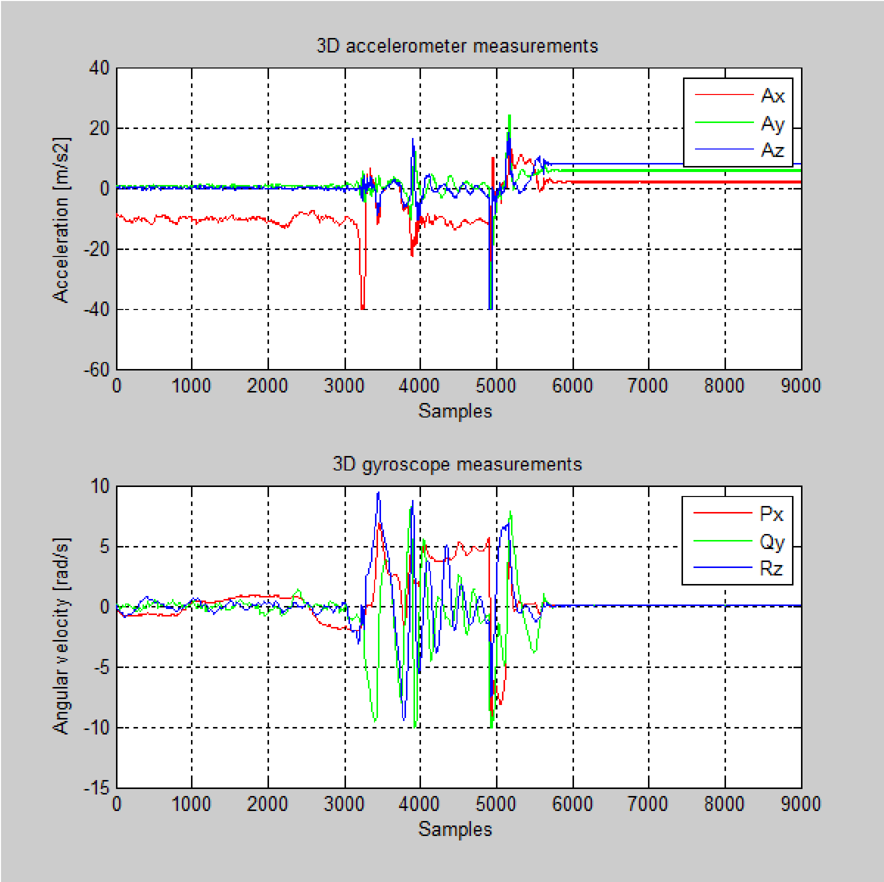

Fig.3 Inertial data in the time slot around the fall of the drones

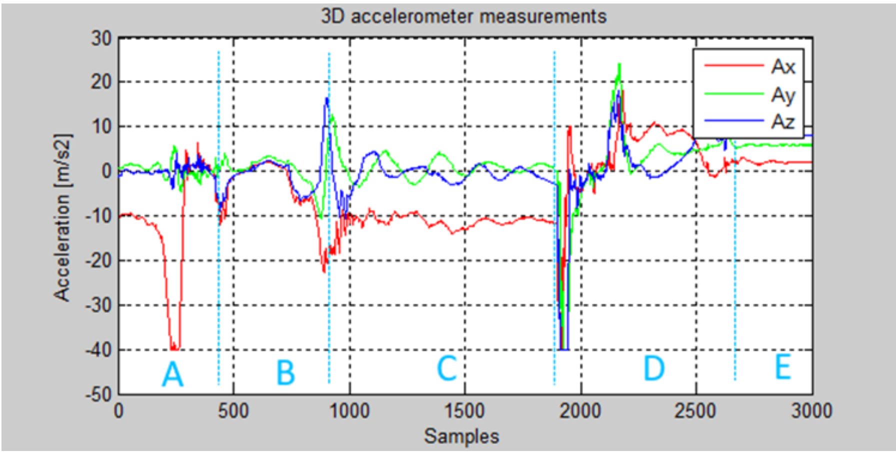

Fig.4 Accelerometer data from the first test.

All three figures show the different 5 UAS states:
- normal movement (A);
- free fall (B);
- fall with open parachute (C);
- ground impact (D);
- static after impact (E).

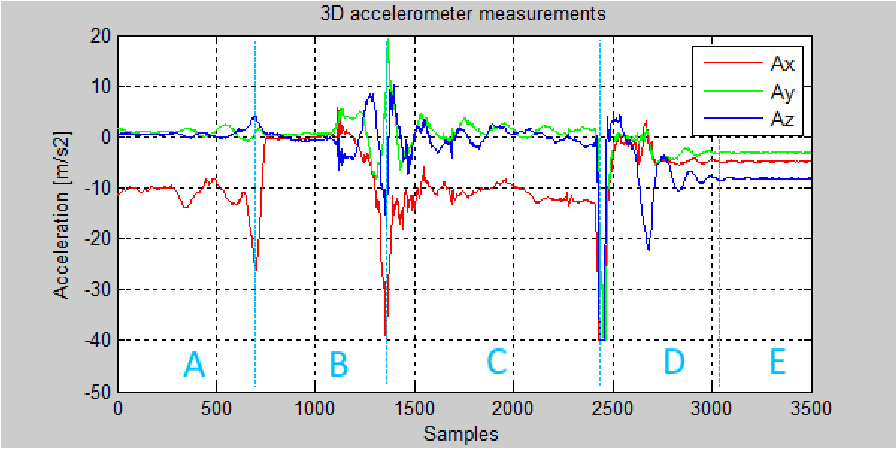

Fig.5 Accelerometer data from the second test.

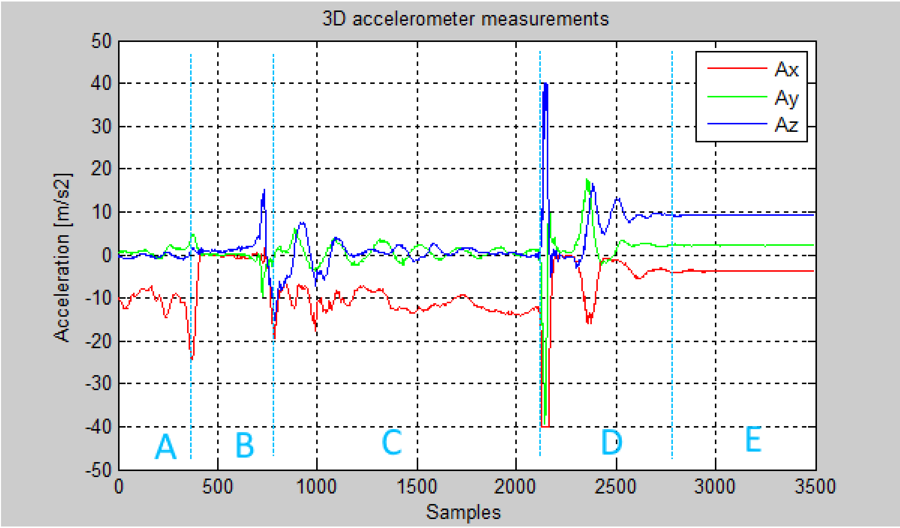

Fig.6 Accelerometer data from the second test.

The tests carried out show that it is possible using only inertial data to detect the occurrence of an emergency situation during a flight of UAS. The various trigger conditions that may be used are:

- High dynamics of angular accelerations;
- Free fall state;
- An open parachute fall state;
- Crash, followed by static position.

Based on the specific needs and implementations, these trigger conditions can be used individually or combined with the corresponding confidence ratios, similar to the Veronica 2 project developments [7].

The tests performed are not a source of information for setting specific threshold levels for the trigger conditions presented. For their definition it is necessary to carry out multiple tests with different UAS and analysis of the collected data. It may be that different types of UAS will have different thresholds.

4. ADDITIONAL FEATURES THAT ARE POSSIBLE WITH THIS HARDWARE

With the implemented IVS hardware shown in Figure 2, it is possible to implement additional features that are not part of the eCall standard but would have an added value for UAS.

1) UAS-park management:

• Receiving real-time data;

• Check of regulatory authorities for entry into prohibited airspace;

• Tracking and management by the owner of the UAS.

2) Recording data as a black box recording device:

• Automated reconstruction of the trajectory of motion, as unlike cars, there are no traces of tires [8];

• Data on whether the parachute has been opened in time to fall, attributing responsibility for damage to expensive goods;

• The ability to send accident-to-server data in real-time, minimizing the possibility of data being lost, stolen or falsified.

3) Turn on an alarm when transporting dangerous goods to alert people in the area of the incident to take measures to secure the site.

5. FUTURE DEVELOPMENT

Implementation of adapted IVS as a mandatory module in commercial UAS - development of technical solutions and extension of their functional capabilities, introduction of flight logistics in certain regulated regions, standardization, licensing, production embedding.

6. CONCLUSIONS

This article proposes the use of an adapted version of the automotive eCall system to be used for the field of unmanned aerial systems. The challenges and enablers for this adaptation are explored. The benefits of using the eCall system for UAS are presented. The technological enablers and challenges of adapting the IVS car system to work onboard an UAS are explored. Experiments are carried out to explore the possibility of instrumental detection of emergency situations during flight. The results of the experiments show distinguishability of different zones in the data for normal flight, free-fall, falling with open parachute, ground crash and static position after the crash. This proves the possibility of automatic detection of UAS accidents by adjusting the triggers of the IVS devices. Suggestions have been made to develop additional features through the available hardware.

Acknowledgment: The paper is published with the support of the project No BG05M2OP001-2.009-0033 "Promotion of Contemporary Research Through Creation of Scientific and Innovative Environment to Encourage Young Researchers in Technical University - Sofia and The National Railway Infrastructure Company in The Field of Engineering Science and Technology Development" within the Intelligent Growth Science and Education Operational Programme co-funded by the European Structural and Investment Funds of the European Union.

REFERENCES

[1] European Committee for Standardization. Intelligent transport systems - eSafety - Pan-European eCall operating requirements, London: BSI. 2011

[2] http://www.heero-pilot.eu/view/en/ecall.html, accessed at 2019.02.19

[3] A. Rooke, Press release, As HeERO expands, pan-European eCall moves to next step [Online], 2013s

[4] EN16062: Intelligent transport systems - eSafety - eCall high level application requirements (HLAP)", EUROPEAN COMMITTEE FOR STANDARDIZATION, BS EN 16062:2011, 2011

[5] N. Stoianov, Implementation of an Automated Emergency Call In-vehicle System Device. s.l., Silesian University of Technology, pp. 338-341, 2013
[6] IEEE Vehicular Technology Society. 1616 IEEE Standard for Motor Vehicle. New York: The Institute of Electrical and Electronics Engineers. 2005
[7] Continental AG. Veronica 2 project. European Commission website. [Online].2009 http://ec.europa.eu/transport/road_safety/pdf/projects/veronicaii.pdf .
[8] M. Aldimirov, R. Arnaudov, "Method for automated reconstruction of a car's path during crash from GPS/INS data using a Kalman filter". Advances in En-gineering Software. Elseiver, DOI: 10.1016/j.advengsoft.2017.10.009 , 2017

АДАПТИРАНЕ И ПРИЛАГАНЕ НА ECALL IVS УСТРОЙСТВА ЗА БЕЗПИЛОТНИ ЛЕТАТЕЛНИ СИСТЕМИ

Круме Андреев, Румен Арнаудов, Марин Алдимиров
andreev.k@abv.bg

Технически университет – София
София 1000, бул. „Климент Охридски“ 8
БЪЛГАРИЯ

Ключови думи: *eCall, UAS, безпилотна летателна система, IVS, InVehicle система, HeERO, Veronica 2*

Резюме: *В статията се разглеждат възможностите за адаптиране и използване на технически решения към съществуващата eCall мобилна система за своевременно сигнализиране на инциденти в областта на безпилотни въздушни системи (UAS). Представени са потенциалните ползи от използването на UAS за граждански и търговски цели. Разгледани са технологичните предизвикателства, свързани с адаптирането на мобилната единица за работа на борда на UAS. Представени са резултати от полеви тестове, за да се проучат възможностите на инструментариумите за инспектиране и инцидент. Представени са идеи за бъдещо развитие и изследвания. Представени са резултати от полеви тестове, за да се изследват възможностите на софтуерния анализ на инциденти. Експерименталните резултати показват ясно разграничими зони в записаните данни, които позволяват инструментално регистриране на аварийни събития като свободно падане, отваряне на парашут и удряне в земята. Това дава възможност за своевременно сигнализиране и своевременно предаване на данните от инцидента на спасителните екипи и заинтересованите страни. Тази статия има за цел да насочи интереса на институциите и компаниите към разработването на специализирани модули и стандарти, както се случи със стандарта eCall.*