Unmanned Aerial System for Fast Response to Medical Emergencies due to Traffic Accidents

Anders S. Kristensen, Dewan Ahsan, Saqib Mehmood, Shakeel Ahmed

Abstract— Traffic accidents are a result of convergence of hazards, malfunctioning of vehicles and human negligence that have both economic and health adverse impacts and effects. Unfortunately, avoiding them completely is very difficult but with quick response to rescue and first aid, the mortality rate of inflicted person can be reduced significantly. Smart and innovative technologies can play a pivotal role to respond faster to traffic crash emergencies comparing conventional means of transportation. For instance, Unmanned Aerial Systems (UASs) can provide faster and real time crash site's risk assessment to emergency medical services, thereby helping them to quickly assess, dispatch right equipment and assist bystanders to treat inflicted person properly. To conduct a research in this regard, a case of a traffic roundabout that is prone to frequent traffic accidents in outskirts of Esbjerg, a town located on western coast of Denmark is hypothetically considered. Along with manual calculations, Emergency Disaster Management Simulation (EDMSIM) has been used to verify the response time of UAS from a fire station of the town to the presumed crash site. Results of the study demonstrates the robustness of UAS into emergency services to help save lives.

Keywords: Automated External Defibrillator, Medical Emergency, Fire and Rescue Services, Response Time, Unmanned Aerial System

I. INTRODUCTION

One of the leading causes of non-natural deaths are traffic accidents in the world. According to statistics of World Health Organization in recent years almost 1.25 million lost their lives worldwide due to traffic accidents. As many as 20-50 million people suffered injuries and unfortunately many of them become disabled for rest of their life [1].

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It is very crucial that the seriously injured person during an event of a traffic accident must get medical attention within first few minutes. The emergency management services need to be well prepared to provide an immediate medical help to save his/her life and enable him/her to contribute to the welfare of society again. Some medical expert term the first 60 minutes as "golden hour" in trauma injuries and emergency medical service (EMS). After this initial critical time, the morbidity and mortality increases considerably if injured persons are not given medical treatment [2].

It is important to note that on average response time to emergencies in European Union is 10 minutes [3]. And the first 10 minutes according to some experts are termed as 'Platinum Time' in response to accidents [4]. Though every injured person's severity of injury and initial medical treatment along with minimum time required to save his/her life may differ but achieving this minimum time is crucial. However, the severely injured person who suffer either brain or chest injury must be treated within first few minutes. For example, cardiac arrest victim must be given first aid in 3 to 5 minutes and if he/she is not treated within this time chances of survival are as low as 8 % [5] [17].

Recent years accidents and casualties in Denmark are depicted in following table.

TABLE I

CASUALTIES IN DENMARK DUE TO TRAFFIC ACCIDENTS FROM 2005-2015 [6]

Year	Total Casualties	Killed	Seriously Injured	Slightly Injured
2010	4408	255	2063	2090
2011	4259	220	2172	1867
2012	3778	167	1952	1659
2013	3585	191	1891	1503
2014	3375	182	1797	1396
2015	3334	178	1780	1376

Due to delayed response in European Union alone there are around 800,000 people annually suffer a cardiac arrest and only 8 percent of them survive [7]. This can be tackled through use of fast Unmanned Aerial Systems (UASs) since UAS are faster than conventional means of transport and these have become an emerging technology in everyday life in recent years. These can be handy to help provide medical assistance to injured

persons. The induction of UASs into emergency services is vital to achieve following goals,

- Quick assessment of the site of accident by emergency services
- Reduce response in giving first aid (by providing first aid kit) or assisting in CPR through Automated External Defibrillator (AED).
- Live communication to bystanders or minor injured persons to guide them in assisting CPR or providing first aid to the injured.

II. Incorporation of UAS into Fire and Rescue Service of Esbjerg

Emergency services of different countries respond to traffic accidents. In Denmark, the local fire and rescue services (FARS) of municipalities along with the assistance and regulation of Danish emergency management agency (DEMA) responds to traffic and other emergency calls.

According to the fire station responsible for Esbjerg emergency services Sydvestjysk Brandvæsen (SVJB) the Korskro roundabout in the outskirts of Esbjerg, a town located on western coast of Denmark is prone to frequent traffic accidents. On average, 5-7 accidents per year are recorded on this roundabout. This paper analyzed the use of UASs in a hypothetical traffic accident at Korskro roundabout. Response time is a critical factor in saving lives and FARS tries their best to reach at the scene of accident with fastest time possible. The response time from Esbjerg fire station and its outskirts is depicted in the following figure.

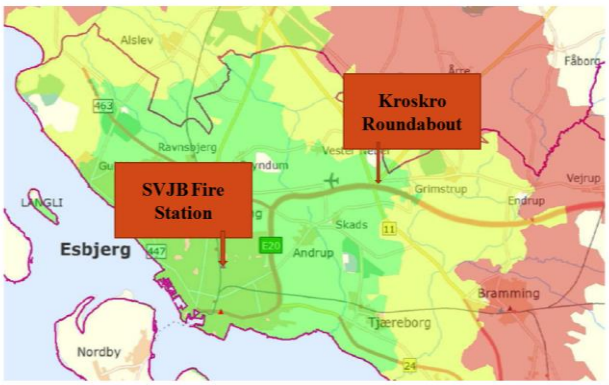

Fig 1: Esbjerg Fires Station Response Time [8]

Green area in the fig. 1 shows a response time of 10 minutes while yellow area represents 15 minutes of response time. According to the above figure accident site of Korskro roundabout is in green area and it has a minimum response time of 10 minutes.

TABLE II

Yearly Casualties Due to Traffic Accidents in Esbjerg [9]

Years	Total Casualties	Killed	Seriously injured	Slightly injured
2005	165	4	90	71
2006	169	7	73	89
2007	162	7	88	67
2008	107	3	51	53
2009	139	6	64	69
2010	96	4	46	46
2011	110	6	53	51
2012	102	7	49	46
2013	61	1	32	28
2014	83	2	47	34
2015	86	7	42	37

According to the above table, that number of casualties have dropped significantly. For instance, in year 2005 there were total 165 casualties recorded, among them 4 persons were killed, 90 were seriously injured and rest were slightly injured. Moreover, in year 2015 number of casualties dropped to 86, among them 7 persons were killed, 42 were seriously injured and 37 were injured slightly. Though table-II shows that there is a declining trend in casualties for the past few years but there is need to maximize the safety and save lives of severely injured and provide first aid to minor injured in shortest possible time.

III. Application of UAS for Rescuing Injured Persons

For application of an appropriate UAS we considered UASs that are either being used or developed for emergency and rescue purposes. The following four UASs are considered [10],

- Campcopter S-100
- Aeryon Lab's Sky-Ranger
- DJI Phantom 4
- Drone Ambulance

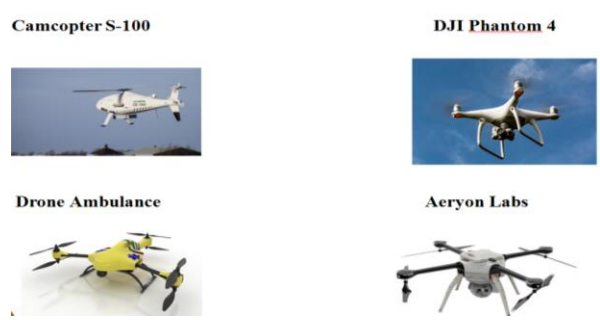

Fig. 2 UAS for Emergency Services

Camcopter S-100 and Aeryon Lab's sky ranger are the two UASs that are being used for search and rescue services [11] [12]. While DJI phantom-4 is used and tested by European Emergency Number Association (EENA) for search and rescue operations [13]. However, Ambulance Drone is a prototype built and tested by Alec Momont of Delft University [3].

The Aeryon Lab's Sky-Ranger has a range of 3 km with a speed of 50 km/h and a flight time of up to 25 minutes [11]. While Camcopter S-100 is a Vertical Takeoff and Landing (VTOL) UAS that has a flying range of 200 km [12]. Camcopter S-100 is fairly a large drone like a small helicopter that requires huge amount of resources to operate and special requirements to land and take off from a solid place without trees and electric poles nearby. This limits the flights of Campcopter S-100 to be dispatched for rescue operations to any traffic crash site. A UAS by DJI like Phantom 4 is slower in speed and it can maximum fly 5 kilometers with a speed of 72 km/h [12] [14].

However, a UAS having capabilities such as Drone Ambulance can carry AED that can be used for first aiding a person suffering cardiac arrest, communicating live to persons at the scene of crash and assessing the crash site faster. Moreover, AED can be applied to both cases of traumatic and non-traumatic cardiac arrests. Due to a traffic crash a person may face cardiac combustion for example due to a trauma caused by steering wheel, pulmonary oedema or due to excessive blood loss. But fortunately, most of such cases are treatable in especially for young and healthy people [15]. A bystander close to the victim can also be guided by a rescue worker who is online handling the UAS to assist in first aid. This UAS takes flight with speed of 100 kilometers per hour carrying a payload of 4 kilograms for up to 12 km [3][7].

TABLE III
SPEED AND RANGE OF EMERGENCY UASS

UASs	Speed	Range
Camcopter S-100	222 Km	200 Km
DJI Phantom 4	72 km/h	4.96 km
Aeryon labs	50 km/h	3 Km
Drone Ambulance	100 Km/h	12 Km

It is significant to note that the victims of cardiac arrest can be saved up to 38% if they are provided first aid by using an AED before the emergency response team arrives [3] [16]. A lay man basically is not that good in performing first aid techniques, however with the help of live instructions through video support between a lay man and the UAS operator of emergency response, can increase the surviving chances of victim of a cardiac arrest. It is estimated that only 20 % untrained layman can successfully apply AED but this can be increased to 90% due to a personalized and timely instructions by a professional emergency management's responsible person [3]. Furthermore, the panic of the situation decreases with the presence of the emergency operator through the speaker of UAS. Therefore, it is important to induct UAS such as drone ambulance into emergency services that can provide emergency supplies to victims and can establish a communication in real time between a bystander and operator can surely work [17].

Campcopter S-100 is too big and expensive to serve the purpose of aiding emergency crew comparing Drone Ambulance. Therefore, based on the above facts of comparison among these four UAS, Drone Ambulance is best to achieve the three objectives of this article. In the case of accident at Korskro roundabout the distance from fire station to the site of accident Korskro is 8.80 km. Drone ambulance having a covering area range of 12 km with a speed of 100 km/h is suitable for the application of this example [3].

IV. RESPONSE TIME OF UAS

For research whether an Unmanned Aerial Vehicle (UAS) like Drone Ambulance can respond to the emergency call faster, manual calculations along with Emergency Disaster Management Simulation (EDMSIM) are performed. This UAS can carry first aid tools and medication such as AED.

The calculations based on distance and speed of UAS prove that the UAS reaches from Fire station located at Vibevej 18, 6705 Esbjerg Ø to the site of accident at Korskro in 05:16 minutes.

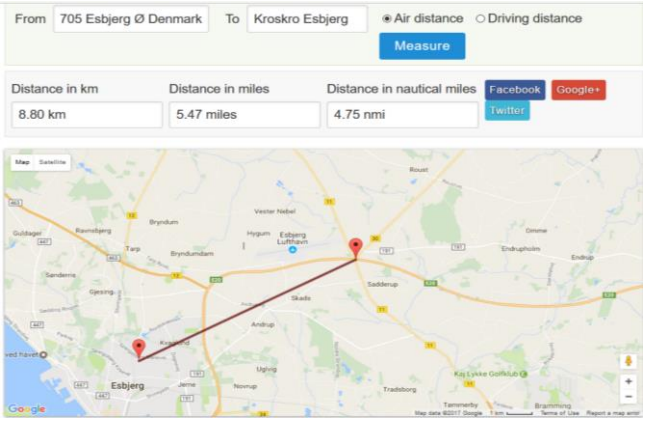

Fig. 3: Aerial Distance from Fire Station to the Accident Site [18].

UAS flies with speed of 100 kilometer per hour. The aerial distance from fire station to the accident site is 8.80 km, which is shown in the above fig. 3. UAS reaches at Korskro

roundabout in 05:16. According to chef of fire station the incident commander is well prepared to respond to the emergency call but it takes at least 10 minutes for him to reach at Korskro roundabout. In rush hour time, this time can be 12 minutes or more. Therefore, the response time for UAS is faster than average response time of conventional vehicle.

EDMSIM is used to verify the response time as depicted in the following figure.

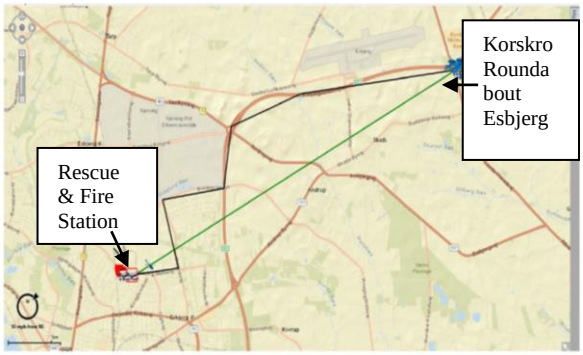

Fig. 4: EDMSIM Simulated Emergency Response from Fire station to the Scene of Accident. [19].

The green line in the fig. 4 shows a straight-line distance from fire station to the roundabout which is short distance comparing to the ground route of emergency vehicles depicted by black line. By inserting the relevant statistics and figures EDMSIM also proves that UAS will reach faster than emergency and rescue vehicles. The response time of UAS is 05:16 minutes comparing 10 minutes of Incident commanders' vehicle.

Before the emergency crew reaches at the scene of accident the Drone Ambulance can also provide valuable First-Person View (FPV) footage that can help emergency management service to quickly assess the site of crash and inflicted person's health condition.

A Danish study found that provision of immediate AED to perform CPR on cardiac arrests patients increased the survival chances from 8 % to 57 % in Copenhagen, Denmark. The study that had a period of 28 months, followed-up the use of 807 publicly available AEDs (PADs) installed at different places in Denmark. It was found that out of 48 cases of cardiac arrest where an AED was applied 22 lives were saved [20] [21]. Therefore, it is believed that the immediate availability of AEDs and first aid kit through UASs will also improve the preparedness of emergency management services and reduce response time. Thereby it will help improve survival chances of severely injured persons in traffic accidents.

IV. Limitation, Discussion and Future Perspectives

This study has not estimated the budget that is required for emergency services to incorporate this innovative technology into its services. The expected protocol to follow during an emergency call, human resources required to operate the system, a traffic accidents risk mapping of Denmark to cover the roads prone to sever traffic accidents are also not considered. However, being Beyond Visual Line of Sight (BVLOS) this UAS has hurdles of getting approval from regulators and biased and lack of knowledge based risk perception present in public's mind.

The rescue crew staff training to use UASs and integration of UASs into emergency system should be planned. There is a need to improve UAS's technology to meet challenges of working specifically as first emergency responders. These improvements could be lights for night flights, markings on drones to let people know these are emergency service drones, longer range of flights, collision avoidance, more intelligent to have autonomous flights, quicker, more resilient and data sharing etc. [12] [22]. There should be a scientific survey in Esbjerg to know the risk perception of UASs in public's mind as well as their acceptability towards this new technology and it incorporation into the emergency services. Nonetheless, apart from delivery of medical aid, UAS can provide faster assessment of crash site that can help emergency services to dispatch appropriate resources to deal with emergency and avoid any false alarms to reduce operational costs.

V. Conclusion

With the incorporation of UAS into Fire and Rescue Services the response time can be reduced in giving first aid (by providing first aid kit) or AED CPR guidance/assistance through live instructions to bystanders. Moreover, the assessment of the crash scene can be performed in faster and efficient way to dispatch the appropriate vehicles such as fire truck, rescue truck, incident commander and ambulances to deal with emergency effectively by saving the time and precious resources.

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