International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:11, No:11, 2017

Rescue Emergency Drone 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 the convergence of hazards, malfunctioning of vehicles and human negligence that have adverse economic and health impacts and effects. Unfortunately, avoiding them completely is very difficult, but with quick response to rescue and first aid, the mortality rate of inflicted persons 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, Rescue Emergency Drone (RED) can provide faster and real-time crash site risk assessment to emergency medical services, thereby helping them to quickly and accurately assess a situation, dispatch the right equipment and assist bystanders to treat inflicted person properly. To conduct a research in this regard, the case of a traffic roundabout that is prone to frequent traffic accidents on the 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 RED from a fire station of the town to the presumed crash site. The results of the study demonstrate the robustness of RED 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 in the world is traffic accidents. According to statistics of the World Health Organization, in recent years almost 1.25 million people lost their lives worldwide due to traffic accidents, while as many as 20-50 million people suffered injuries, and unfortunately many of them are disabled for rest of their lives [1].

In the event of a traffic accident, it is vital that a seriously injured person receive medical attention within minutes of the event. Emergency management services need to be well prepared to provide immediate medical help to save lives and enable that person to contribute to the welfare of society again. Some medical experts term the first 60 minutes as the "golden hour" in trauma injuries and emergency medical service (EMS). After this initial critical time, morbidity and mortality increases considerably if injured persons are not given medical treatment [2].

It is important to note that average response time to emergencies in the 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 the minimum time required to save their life may differ, achieving this minimum time is crucial. However, a severely injured person suffering either a brain or chest injury must be treated within first few minutes. For example, a cardiac arrest victim must be given first aid within 3-5 minutes, as failure to be treated within this time reduces the chances of survival to as low as 8% [5], [16].

Recent years accidents and casualties in Denmark are depicted in Table I.

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 the European Union alone, of the approximately 800,000 people annually who suffer cardiac arrest, only 8% of them survive [7]. This can be tackled through use of fast RED, since RED are faster than conventional means of transport and have become an emerging technology in everyday life in recent years. RED can be useful in providing medical assistance to injured persons. The induction of RED into emergency services is vital to achieve the following goals:

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

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

Emergency services response to traffic accidents differs between countries; in Denmark, the local fire and rescue

Anders S. Kristensen is the head of risk center, Denmark. (Phone: + 45 42180842, email: ask@civil.aau.dk).
Dewan Ahsan is the associate professor of department of sociology, environmental and business economics, Southern Denmark University, Esbjerg Campus, Denmark (Phone: +45 71472341, e-mail: dah@sam.sdu.dk).
Saqib Mehmood is working as a research assistant with Aalborg University Esbjerg, Denmark. He has recently graduated in MSc Risk and Safety Management from Aalborg University, Denmark (Phone: +45 27 51 71 72, e-mail: sam@civil.aau.dk).
Shakeel Ahmed is working as a research assistant with Aalborg University Esbjerg, Denmark. (Phone: +45 41 82 28 56, e-mail: sah@civil.aau.dk).

services (FARS) of municipalities, along with the assistance and regulation of the 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 on 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 RED at a hypothetical traffic accident at Korskro roundabout. Response time is a critical factor in saving lives and FARS tries their best to reach the scene of accident in the fastest time possible. The response time from the Esbjerg fire station and the outskirts of the town is depicted in Fig. 1. The green area in Fig. 1 shows a response time of 10 minutes, while the yellow area represents 15 minutes of response time. According to the figure, the accident site of Korskro roundabout is in the green area and has a minimum response time of 10 minutes.

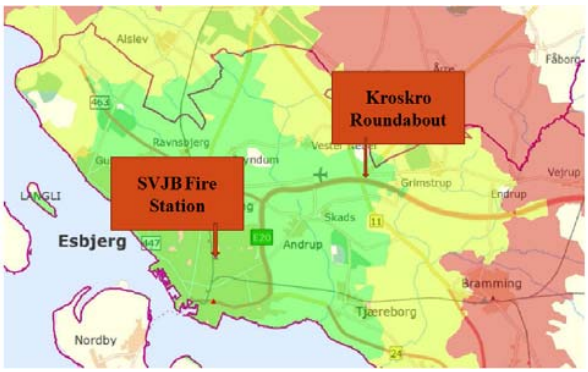

Fig. 1 Esbjerg Fires Station Response Time [8]

TABLE II
YEARLY CASUALTIES DUE TO TRAFFIC ACCIDENTS IN ESBJERG TOWN [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 Table II, the number of casualties has dropped significantly. For instance, in 2005 there were total 165 casualties recorded, among them, four persons were killed, 90 were seriously injured and the rest were slightly injured. Moreover, in 2015, the number of casualties dropped to 86, among them, seven persons were killed, 42 were seriously injured and 37 were injured slightly. Though Table II shows that there is a declining trend in casualties over the past few years, the need to maximize safety, save the lives of severely injured, and administer first aid to the injured in shortest possible time, remains.

III. APPLICATION OF RED FOR RESCUING INJURED PERSONS

For the application of an appropriate RED, we considered a system that is either being used or developed for emergency and rescue purposes. The following four RED are considered [10]:

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

Fig. 2 RED for Emergency Services

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

The Aeryon Lab's SkyRanger has a range of 3 km with a speed of 50 km/h and a flight time of up to 25 minutes [11]. Camcopter S-100 is a Vertical Takeoff and Landing (VTOL) RED that has a flying range of 200 km [12]. Camcopter S-100 is fairly a large drone, like a small helicopter that requires a huge amount of resources to operate and special requirements to land and take off from a solid footing and safe area without obstacles such as trees and electric poles nearby. This limits the flights of Campcopter S-100 to be dispatched for rescue operations to any traffic crash site. The RED by DJI, like Phantom 4, is slower in speed and can a maximum fly 5 km with a speed of 72 km/h [12], [14]. However, a RED having capabilities such as those of Drone Ambulance can carry AED that can be used for providing first aid to a person suffering cardiac arrest, communicating live to persons at the scene of a crash and assessing the crash site faster. Moreover, AED can be applied to both cases of traumatic and non-traumatic cardiac arrests. As the result of a traffic crash, a victim may suffer cardiac combustion, as the result of trauma caused by the steering wheel, pulmonary oedema or due to excessive blood loss. Fortunately, most of such cases are treatable, especially for young and healthy crash victims [5]. A bystander close to the victim can also be guided by a rescue worker who is online guiding the RED to assist in first aid. This RED has a flight speed of 100 km/h and can carry a payload of 4 kilograms for up to 12 km [3], [7].

TABLE III
SPEED AND RANGE OF EMERGENCY RED

RED	Speed	Range
Camcopter S-100	222 km/h	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

The survival rate of victims of cardiac arrest is only 8%. However, the survival rate can be improved significantly up to 38% if they are administered first aid using an AED by any layman, prior to the arrival of the emergency response team [3], [15]. A layman basically is not that good at performing first aid techniques, however with the help of live instructions through video support between a lay man and RED emergency response operator, their actions and assistance can increase the survival chances of victims of a cardiac arrest. It is estimated that only 20% of untrained individuals can successfully apply AED; however, this statistic can be increased to 90% guided by personalized and timely instructions by the professional emergency management's responsible person [3]. Furthermore, the presence of the emergency operator's voice through the speaker of RED helps reducing the panic at the scene. Therefore, it is important to induct RED, such as Drone Ambulance, into emergency services, as providing emergency supplies to victims and establishing real-time communication between a bystander and a trained operator can surely work [16].

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

IV. RESPONSE TIME OF RED

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

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

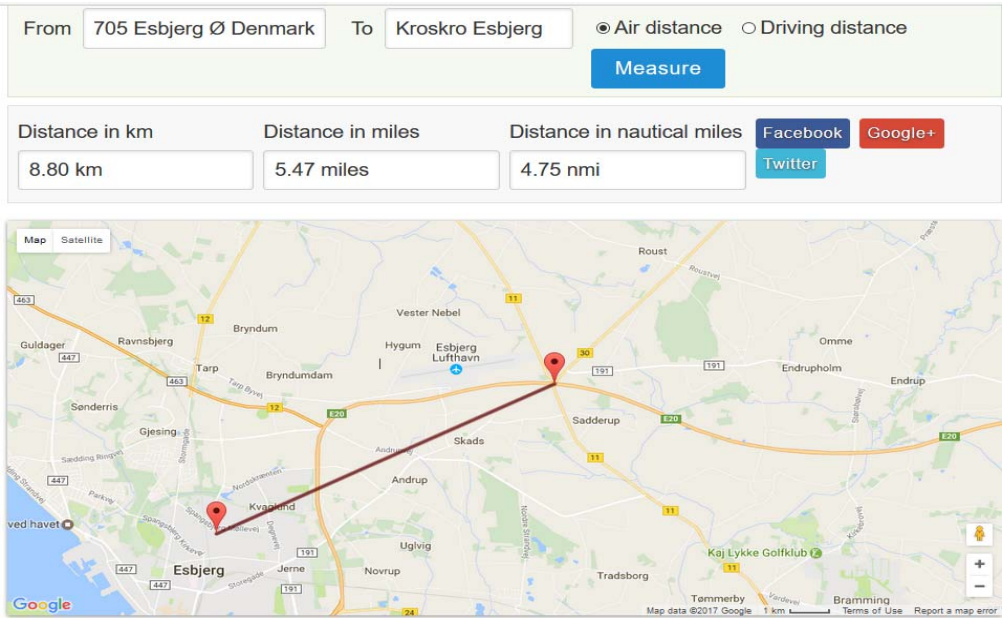

Fig. 3 Aerial Distance from Fire Station to the Accident Site [17].

The RED flies at a speed of 100 km/h. The aerial distance from the fire station to the accident site is 8.80 km, which is shown in Fig. 3. The RED reaches Korskro roundabout in 05:16 min. According to the south-west regional fire station service of Denmark [8], the incident commander takes at least 10 minutes to reach Korskro roundabout from fire station located at Vibevej 18, 6700 Esbjerg. During rush hour, this time can be extended by 12 min or more. Therefore, the response time for RED is faster than the average response time of a conventional vehicle.

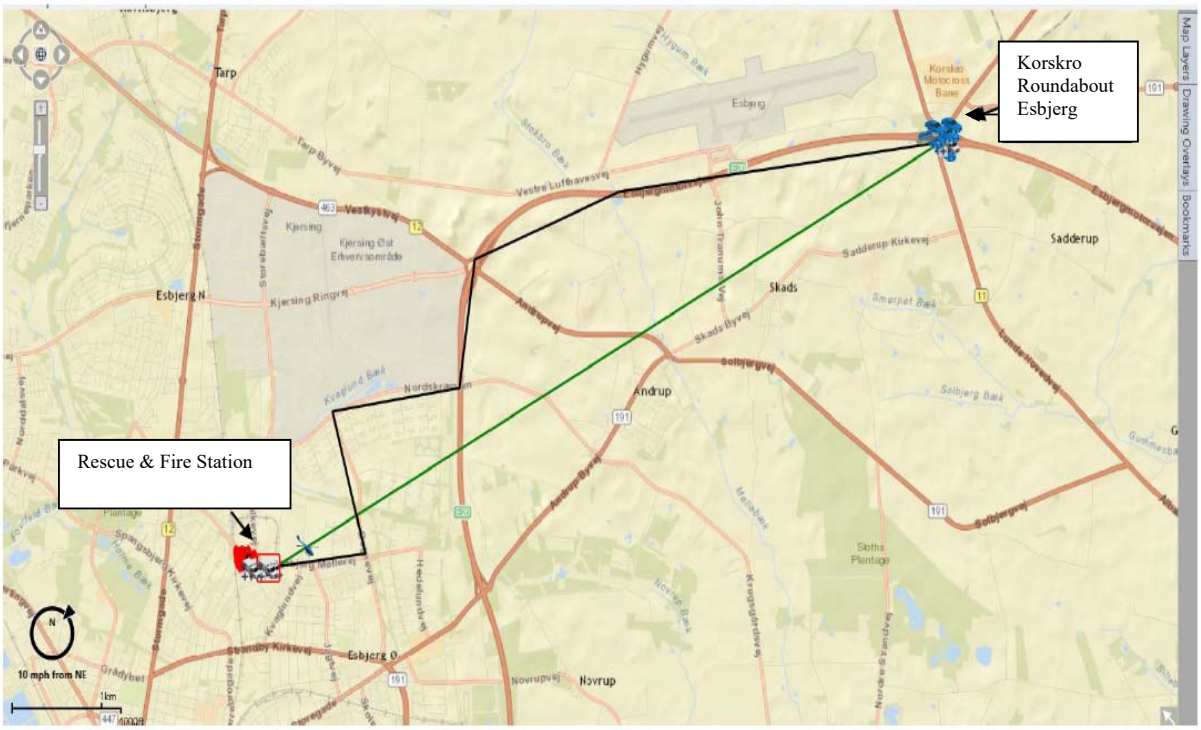

Fig. 4 EDMSIM Simulated Emergency Response from Fire station to the Scene of Accident [18]

EDMSIM is used to verify the response time depicted Fig. 4. As can be seen in the figure, the green line shows a straight-line distance from the fire station to the roundabout, which is a shorter distance compared to that of the ground route taken by the emergency vehicles, as depicted by the black line. By inserting the relevant statistics and figures, EDMSIM also proves that the RED will reach a destination faster than emergency and rescue vehicles. The response time of the RED to the scene was 05:16 min, while it was 10 min for the Incident commander to attend by vehicle.

Ahead of the arrival of the emergency, a Drone Ambulance can crew reach the scene of an accident and provide valuable First-Person View (FPV) footage that can help emergency management services to quickly and accurately assess the situation and the health status of injured victims.

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, which lasted for 28 months, followed-up with the use of 807 publicly available AEDs (PADs) installed at different locations in Denmark. It was found that out of 48 cases of cardiac arrest where an AED was applied 22 lives were saved [19], [20]. Therefore, if AEDs can be made available to the victims of a cardiac arrest in remote areas and at locations where there are not any PADs installed, by means of RED flights, the survival rate should further be increased; thereby, improving the overall preparedness of emergency management services. This can also help improve survival chances of severely injured persons in traffic accidents by reducing response time.

IV. Limitations, 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, the human resources required to operate the system, and a traffic accidents risk mapping of Denmark to cover the roads prone to sever traffic accidents are also not considered.

Beyond Visual Line of Sight (BVLOS) drones are not approved for flight operations yet in Denmark. It is important to know the acceptability of public towards drones. For this a comprehensive study of risk perception of drones in Denmark needs to be carried out before integrating them into emergency services.

The training of rescue crew staff in the use RED and its integration into the emergency response system should be planned. There is a need to improve RED technology to meet the challenges of working specifically as first emergency responders. These improvements could be in the form of lights for night flights, markings to distinguish them as emergency service drones, longer flight range, front, left and right collision avoidance capability that should divert the RED in a safe direction without crashing it against obstacles coming in flight path, more intelligent to undertake autonomous flights, quicker, more resilient, and with data sharing capabilities, etc. [12], [21]. A scientific survey in Esbjerg town should be conducted to determine the risk perception of RED in the public's mind as well as their acceptability towards this new technology and its incorporation into the emergency services.

Nonetheless, apart from the delivery of medical aid, RED can provide faster assessment of a crash site that can help emergency services to dispatch the appropriate resources to deal with the emergency and avoid responding to any false alarms, which in turn, will reduce operational costs.

V. Conclusion

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

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