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Ambulance Drone Support System (ADSS)

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***Abstract*—Thousands of people die because of Ambulance Delays. The time taken by ambulance to reach a patient depends a lot on the route, distance and the traffic en route . The helicopter support is working in certain places, but requires a lot of money, and open space for landing. What if there was a way to support the patient to survive long enough for the ambulance to arrive. The Ambulance Drone Support System is a way by which we can support a patient long enough for the ambulance to come and take matters in hand from there.**

***Index Terms*—Asphyxiation, Drone, Portable Oxygen Supply.**

I. INTRODUCTION

On an average, an American Driver spends at least 14 days on road per year, while a British Driver spends as much as 16 working days on the road per year stuck in the traffic Jam, on an average [1]. It is far worse in India or Bangladesh where a driver might actually spend as many as 40 working days per year. What's worrying is that there is an exponential growth in these figures. Now imagine an emergency requirement of an Ambulance to a place where there is a slow moving traffic or at times, traffic Jam. If the hospital has aerial support via Helicopter and co-incidentally the patient's location has an open space nearby for the helicopter to land, you're in the biggest charm of luck. However, most of the times, this is not the case.

When there is a patient who is in an urgent need of doctor's attention, there are chances that the patient might not survive the time that it takes for an ambulance to reach him. According to a recent article in The Dailymail (UK), thousands die because of the Ambulance delays[2]. The biggest problem is that even if the ambulance goes to a location as close as a couple of miles, it might still take about 15 minutes for it to reach the patient. These 15 minutes can be vital to decide whether or not, the patient will survive. In the emergency cases of Heart Attacks or Asphyxia/Asphyxiation, the patient could easily die in those 15 minutes or potentially drift away from any possibility of saving. This becomes even worse if the distance is more. Effectively enough, the chances of finding traffic Jam or a slow moving traffic also increases dramatically which works like final nail in the coffin in the emergency situations. Thus, what could be done to improve their chances of survival is a debatable subject. Should people keep those ailments or aids of emergency situations such as the ones mentioned above, at home? Or should we cross our fingers and hope that such an emergency crisis will not come to us.

Asphyxiation is a condition of severely deficient supply of oxygen to the body that arises from abnormal breathing. An example of asphyxia is choking. Asphyxia causes generalized hypoxia, which affects primarily the tissues and organs. There are many circumstances that can induce asphyxia, all of which are characterized by an inability of an individual to acquire sufficient oxygen through breathing for an extended period of time. Asphyxia can cause coma or death [3].

At the time of Asphyxiation, in certain cases, the body needs an immediate and concentrated oxygen supply. If this is not the first Asphyxiation situation for the patient, and there is a history of Breathing problems for the patient, there is a possibility that there is an oxygen cylinder at home that could be used. However, if this is the first time and/or there is no supply of oxygen cylinder at home, the need of one becomes essential. The fact that the ambulance might take somewhere between 10 to 40 minutes to reach the patient, depending upon the location and traffic, only aggravates the problem. This is where the Ambulance Drone Support System might come in handy and reach the patient in a straight line, surpassing all the traffic problems and cutting down the travel time to the patient by as much as 95% in some cases. This increases the chances of survival for the patient till the ambulance arrives, by a prodigious percentage.

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II. ASPHYXIATION

Asphyxiation is a condition of severely deficient supply of oxygen to the body that arises from abnormal breathing. Situations that can cause asphyxia include but are not limited to: the constriction or obstruction of airways, such as from asthma, Laryngospasm, or simple blockage from the presence of foreign materials; from being in environments where oxygen is not readily accessible: such as underwater, in a low oxygen atmosphere, or in a vacuum; environments where sufficiently oxygenated air is present, but cannot be adequately breathed because of air contamination such as excessive smoke.[3]

In fatal crowd disasters, compressive asphyxia from being crushed against the crowd causes the large part of the deaths, rather than blunt trauma from trampling. This is what occurred at the Ibrox disaster in 1971, where 66 Rangers fans died; the 1979 The Who concert disaster where 11 died; the Luzhniki disaster in 1982, when 66 FC Spartak Moscow fans died; and at the Hillsborough disaster in 1989, when 96 Liverpool fans were crushed to death in an overcrowded terrace. In confined spaces, people push and lean against each other; evidence from bent steel railings in several fatal crowd accidents have shown horizontal forces over 4500 N (equivalent to a weight of approximately 450 kg, or 1014 lbs). In cases where people have stacked up on each other forming a human pile, estimations have been made of around 380 kg (838 lbs) of compressive weight in the lowest layer.[3]

Other causes of oxygen deficiency include but are not limited to

- Acute respiratory distress syndrome
- Carbon monoxide inhalation, such as that from a car exhaust and the smoke's emission from a lighted cigarette: carbon monoxide has a higher affinity than oxygen to the hemoglobin in the blood's red blood corpuscles, bonding with it tenaciously, and, in the process, displacing oxygen and preventing the blood from transporting oxygen around the body
- Contact with certain chemicals, including pulmonary agents (such as phosgene) and blood agents (such as hydrogen cyanide)
- Drowning
- Drug overdose
- Exposure to extreme low pressure or vacuum to the pattern (see space exposure)
- Hanging, specifically suspension or short drop hanging.
- Self-induced hypocapnia by hyperventilation, as in shallow water or deep water blackout and the choking game
- Inert gas asphyxiation
- Ondine's curse, central alveolar hypoventilation syndrome, or primary alveolar hypoventilation, a disorder of the autonomic nervous system in which a patient must consciously breathe; although it is often said that persons with this disease will die if they fall asleep, this is not usually the case
- Respiratory diseases
- Sleep apnea
- A seizure which stops breathing activity
- Strangling

There are a few known ways to aid the patient in situations of Asphyxiation that require knowledge of some first aid measures such as a CPR. However, many a times, this is either not known, or not quite enough. In those situations, there is a certain immediate need to support the patient directly with the Oxygen supply. Asphyxiation causes more deaths in children under the age of 14 and, those over the age of 50. However, there is always a possibility of an Asphyxiation situation to any age group, due to accidents and at times, although very rarely, due to natural causes as well. Thus, emergency situations regarding Asphyxiation can be more common than we think. As it stands, it is one of the most common ways of death world-wide.

III. PORTABLE OXYGEN SUPPLY

Oxygen Cylinders come in various sizes, containers, the containers of various materials, etc. The priorities decide the size and material of the cylinders. The Oxygen Cylinders that are easy to carry around are known as Portable Oxygen Cylinders or the Portable Oxygen Supply. The portability of the Oxygen Cylinder is dependent on the material of the Oxygen Cylinder, as well as the Size of the Oxygen Cylinder. Obviously, what is a blessing can be the curse at times. That is, the small size can be a blessing because of its portability, but it can be a curse as because of its small size, the Oxygen content in the cylinder is also very less.

Certainly, whether the cylinder size is a blessing or a curse, entirely depends on the nature of the use for the Oxygen Cylinder. Some cylinders are used to provide continuous support to the patient for a long duration, such as a few days, or even a whole week. These cylinders are huge in size so that they can hold a lot of Oxygen Supply, but at the same time, their huge size makes their portability a big problem. However, the requirement of our design is to support the patient long enough to make sure his situation doesn't deteriorate until the Ambulance arrives. Thus, we need a cylinder that can hold enough oxygen to support the patient for as long as a couple of hours (in extreme cases), and make sure it is portable and light weight as well. There are a number of sizes of the Oxygen Supply Cylinders available in the market, depending on the needs.

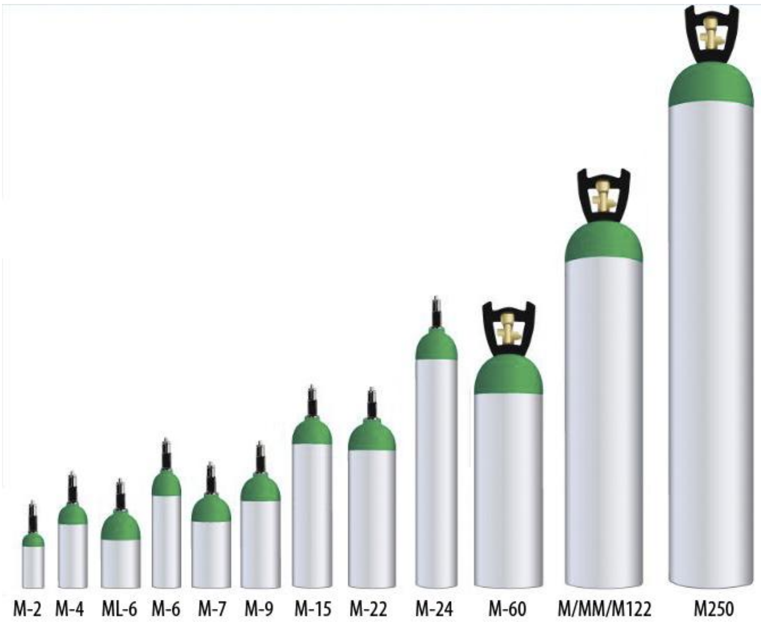

Fig.1 Different Types of Oxygen Cylinders Available in the market, with their respective names[4]

The sizes of these cylinders range widely, with the M-2 size cylinders being as small as 5.3 inches in height, and 2.5 inches in diameter, and the M250 size cylinder standing as tall as 52 inches in height(4 feet 4 inches), and 9 inches in diameter. As clear, the M-2 being the most easily portable cylinder whereas the M250 is the most difficult to move around.

Another aspect to influence their portability is the dry weight as well as the filled weight of the cylinders. The dry weight ranges from 0.7 lbs in the M-2 to 114 lbs in the M250. As clear, the M-2 is very easily portable as it is neither huge, nor heavy. The reason for these cylinders being not too heavy is that they are all made from Aluminum, which is a very light weight material. Thus the cylinders don't possess a lot of weight.

Finally, the capacity of each of the cylinders is what decides the use of these cylinders. The capacity can range from 42L in the M-2 to a whopping 7080L in the M250. Now, the question is, if concentrated for a single person, who is the patient in this scenario, how much oxygen he needs to survive in normal conditions. Let's find out with the help of the following:

A human needs approximately 2lbs of oxygen supply per day (which is equal to 0.9Kg), to survive in normal conditions. The question is, how much Oxygen are we talking about, in terms of Litres. Oxygen has a molar mass of 16 grams. The oxygen gas however, is O_2, and thus has 32 grams per mole. Also, one mole of gas at standard pressure and temperature takes up 22.4 liters.

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Volume 4, Issue 3, May 2015

Molar mass of Oxygen (O) = 16g
Molar mass of Oxygen Gas (O_2) = 32g
One mole gas at Standard Pressure takes = 22.4L

So, Daily intake of Oxygen gas (in Litres) required for a person to survive under normal conditions is :

0.9 kg x (1000 g/1 kg) x (1 mole O_2/32 g O_2) x (22.4 L/1 mole O_2) = 630L of oxygen per day

Now this gives us the daily requirement of oxygen under normal conditions. Let us find out how much oxygen is needed to survive per hour, considering the ambulance delays are not going to go beyond a couple of hours at max :

Oxygen Needed per day under normal conditions = 630L
Oxygen Needed per hour under normal conditions = (630/24)L
= 26.25L per hour

Now, as we can recall from the data given earlier, the smallest cylinder, M-2 has the capacity to hold up to 42L. If we were to use the M-2, it can support a person, under normal conditions, up to approximately 1.6 Hours or 1 hour and 36 minutes. Remembering, that this is under the normal conditions, but we need them under critical conditions and thus, there is a chance that the oxygen supply lasts almost half the time we deduced. That means, there is a possibility for the oxygen supply to last less than an hour. Thus, we need at least a little more support than the M-2.
From the following chart, we can find out the exact capacity, sizes and weights of the respective cylinders:

Table I [4]

NAME	M-2	M-4	ML-6	M-6	M-7	M-9	M-15	M-22	M-24	M-60	M/MM/M122	M250
Diameter (in.)	2.5	3.2	4.3	3.2	4.3	4.3	4.3	5.3	4.3	7.3	8	9
Height (in.)	5.3	8.5	7.6	11.5	9.1	11	16.5	16.5	25.5	23	36	52
Empty Weight (Kg)	0.31	0.73	1.3	1	1.5	1.67	2.4	3.63	3.58	10.12	17.92	51.71
Capacity-L (at 2200psi)	42	113	165	164	198	255	425	640	680	1738	3455	7080
Transport Method	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Wheelchair Bag or cart	Not Portable	Not Portable	Not Portable
Regulator Type	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 540	CGA 540	CGA 540

As clear from the table above, the M-4 is capable with the capacity of 113L of Oxygen Gas. If we were to use M-4 as the oxygen supply cylinder, it can support a person, under normal conditions, up to approximately 4.3 Hours or 4 hour and 18 minutes. Again, remembering, that this is under the normal conditions, but we need them under critical conditions and thus, there is a chance that the oxygen supply lasts almost half the time we deduced. That means, there is a possibility for the oxygen supply to last about approximately two hours or more. This fits the requirement and is not comparatively very heavy than the M-2.

Finally, the weight mentioned here is the empty weight of the Cylinders. Once filled with the oxygen gas at 2200psi, their weight increases. Again, the weight of Oxygen is 32gms/mol and the density is 1.429gm/l. We know,

Density = M/V

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Volume 4, Issue 3, May 2015

$$1.429 = 32/V$$
$$V = 32/1.429$$
$$= 22.4L$$

This means, the Standard molar volume of Oxygen gas is 22.4L. Thus, the number of moles in 42L of oxygen gas is 1.875 and that in 113L of oxygen gas is 5.04 moles. Now, each mole has a weight of 32 grams. Thus, additional weight to be added to the dry weights of M-2 and M-4 respectively are 60grams or 0.06Kg, and 161.43grams or 0.16Kg. Thus, the total weights (including Oxygen Gas) of the M-2 and M-4 cylinders are 0.37Kg and 0.89Kg, respectively.

IV. DRONE SUPPORT

This module is a the most important part of this system. We need a drone powerful enough to carry itself and the Oxygen Cylinder Container along with itself, and have enough battery to cover distances of even 20 miles. Another aspect that needs to be taken into consideration is the possibility of theft, and to ensure that it is taken care of most of the times, if not all. In other words, there must be a mechanism to ensure the safety of the Drone as well. A drone can be of different kinds namely, a mono-copter, a bi-copter, tri-copter, quad-copter, hexa-copter, octa-copter, and so on. The names actually denote the number of Motors and Propellers in the system. Obviously, as we add more motors and propellers to the system, it is capable of generating more thrust. However, with the addition of more motors and propellers to the system, it makes the system heavier and more importantly, drains the battery quicker, which can be a bit of a problem in long distance journeys. So, we need to find the best combination to have enough thrust to carry the Oxygen Cylinder plus the adjusted weight and not be too quick to drain. Thus, we decided to go with the quad-copter, i.e. the system containing a total of four Brushless Direct Current (BLDC) Motors. The components used in this module are as follows:

a) BLDC Motors
b) Electronic Speed Controllers
c) Fiber Glass Propellers CW & CWW
d) GoPro Camera with Gimbal
e) 8000mAh Battery
f) A 6-Channel Transmitter(Tx) & Receiver(Rx)
g) Flight Control System (KK2.1)
h) GPS system
i) Aluminum Frame with Acrylic Base Plate
j) Carry Bag for Cylinders

The BLDC Motors are the Brushless Direct Current Motors. In the drones, they are used along with the Propellers to give the drone, the necessary thrust. The 8000mAh Battery powers the drone, and we need this huge battery because of the fact that we need the Drone to be able to go up to 20 miles away without the battery giving up. Also, to be able to fly that far, we need a Tx-Rx set with huge connectivity range. Since, we would be flying the drone out of our direct sight, we need a GoPro Camera with a Gimbal(which helps in adjusting the tilts and movements with camera) in order to fly this drone using Point Of View**(**POV**).** The Tx-Rx are of 6-channels in order to control the Throttle**,** Rudder**,** Ailerons**,** Elevator & the other two can be Auxiliary channels which can be used for the GPS system**.** We need the GPS system in order to be accurate & efficient in finding the displacement route to the patient, as well as to be safe from theft for the Drone. The Frame can be made of many materials, like PVC, Acrylic, Aluminum, etc. We prefer Aluminum for our drone for a reason that it is very light-weight & doesn't break easily in contrast to its counterparts. Also, at times of crash, it would rather bend than break and thus saving some parts of the system (at least) from a potentially lethal damage. The Electronic Speed Controllers are connected to the Motors and the Flight Control System, and they are the reason for proper adjustment of the speeds of each BLDC motor. Finally, a Carry bag is used to carry the Oxygen Cylinder to the Patient. Dividing the Drone Design into the following categories would be germane:

- **Architectural Design of the Drone Frame**
- **Relevant Component Requirement Evaluation**

Architectural Design of the Drone Frame: The frame plays a crucial role since it is the structure that holds all the components together and is dependent on a number of factors where the material selection and proper dimensioning is vital. Choosing the right material relies mostly on strength, weight, machinability and vibration

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ISO 9001:2008 Certified
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Volume 4, Issue 3, May 2015

resistivity. Aluminum was chosen as a better option due to its inherent strength, rigidity, light weight, easy machinability, and availability. This combination of the properties of Aluminum makes it a suitable material for an aerial vehicle. The quad-copter design involves a symmetric X configuration.[6] Considering the dimensioning, the lengths of the two bars which forms the X was determined based on the propeller blade length and its cross section was determined through a stress calculation. The length of a propeller is about 10 inches; therefore the motor-to-motor length should be at least 10inches or more. One arm of the quad-copter (from center to motor end) acts as a loaded cantilever beam, fixed at center as it is shown in Figure 2.

Fig.2: Arm of the Quad-copter [6]

The inertial frame is defined by the ground, with gravity pointing in the negative z direction. The body frame is defined by the orientation of the quad-copter, with the rotor axes pointing in the positive z direction and the arms pointing in the x and y directions. We used the Aluminum Frame of length 11 inches per arm, from center to the motor and the cross-sectional area of each arm being $1cm^2$.

There are two common stable configurations for a quad-copter frame: The Plus (+)-Configuration and the X-Configuration. The motors along with propellers are set up in the way as shown in Figure 3.

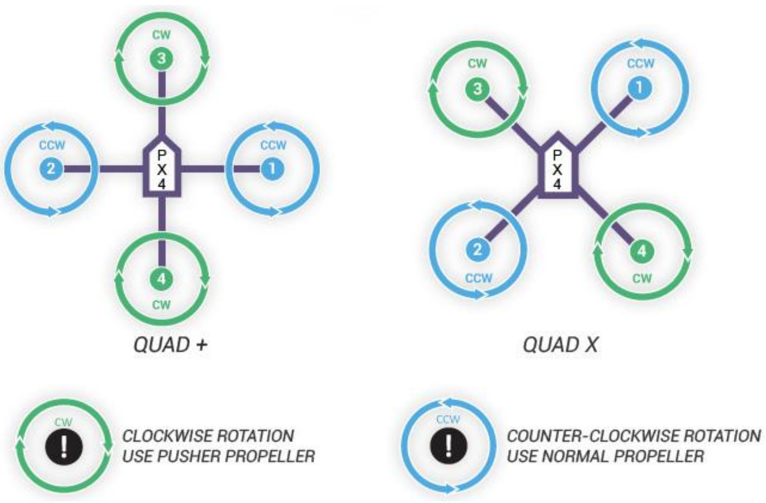

Fig.3 : Quad-Copter Configurations[5]

We are going forward with the X-Configuration as it seems a little easier and suits better for our needs. Necessary calculations are carried out in order to select the appropriate sets of Motors and Propellers for our work. We need to calculate the overall weight of the Drone System in approximation, including the Filled Oxygen Cylinder with the carry bag. We need the upward thrust which should be at least twice of the overall weight of the drone system, in order to work well :

Weight of the Aluminum Frame (including acrylic plate)	**:**	**221 grams**
Weight of the Battery	**:**	**644 grams**
Weight of 4 propellers of 10x4.5cms	**:**	**120 grams**
Weight of 4 ESCs of 30A	**:**	**92 grams**
Weight of Flight Control Board	**:**	**59 grams**
Weight of Excess Wiring	**:**	**90 grams**

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International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 3, May 2015

Weight of 4 BLDC Motors	**:**	**200 grams**
Weight of the Filled Oxygen Cylinder with Carry bag	**:**	**920 grams**
Total Weight	**:**	**2346 grams**
Thus, Total Thrust needed	**:**	**4692 grams (4.7Kg) or more**

Now that we know how much thrust we need to lift off the ground, let's find out the thrust that our system with the selected BLDC motor and Propellers generate. We selected the BLDC motor with 1400KV ratings. What this means here is, the motor will Rotate at a speed of 1400 RPM per volt. Now the battery that we selected gives 11.1volts. Thus, each motor will rotate at the RPM of 15450. With the selected pair of Motor and Propellers, each pair is capable of giving a constant thrust of 2880 grams or 2.88 Kg.

Thrust generated per Motor & Propeller	**:**	**2880 grams**
Thrust generated by 4 Motors & Propellers	**:**	**11550 grams (11.55Kg)**

Thus, the System is capable of Carrying the Weight of almost 5.5 Kgs

Now, obviously, the lesser the weight it carries, the more battery life it will have, as it will take lesser amount of power from the ESCs which in turn will take lesser power from the Battery. The 8000mAh battery lasted for about 35 minutes (34 minutes and 18 seconds to be precise) on an average, with fully loaded drone.

V. RESULT

We simulated four different scenarios depending on the Routes, first three in Mild Traffic densities. First scenario consisted of a zigzag route (Figure $4_{(a)}$). The second scenario consisted of a semi circular route (Figure $4_{(b)}$). The third scenario consisted of a perpendicular route (Figure $4_{(c)}$). Finally, the fourth scenario consisted of a straight line (Figure $4_{(d)}$) but had heavy traffic. Necessary details were observed during each scenario and readings were taken down (Table II).

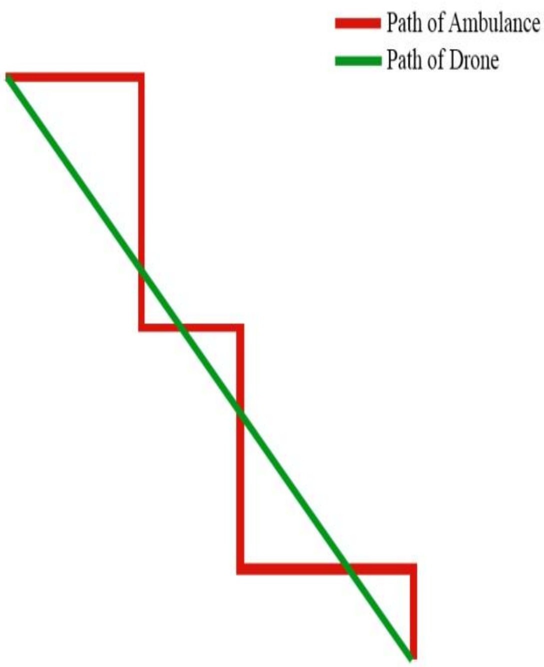

Fig.4(a) : Zigzag path of ambulance v/s Straight Aerial Path of Drone

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 3, May 2015

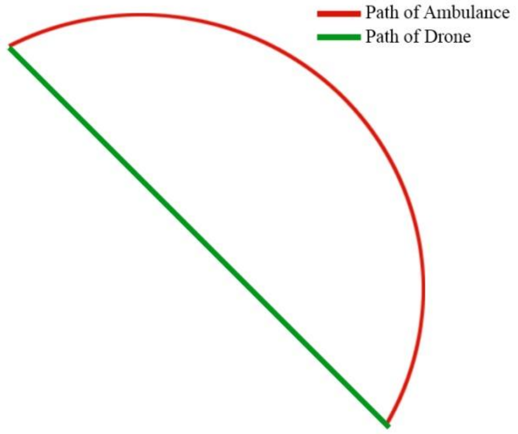

Fig.4(b) : Semi-Circular path of ambulance v/s Straight Aerial Path of Drone

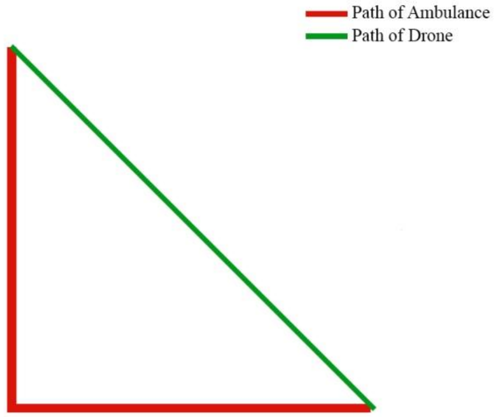

Fig.4(c): Perpendicular path of ambulance v/s Straight Aerial Path of Drone

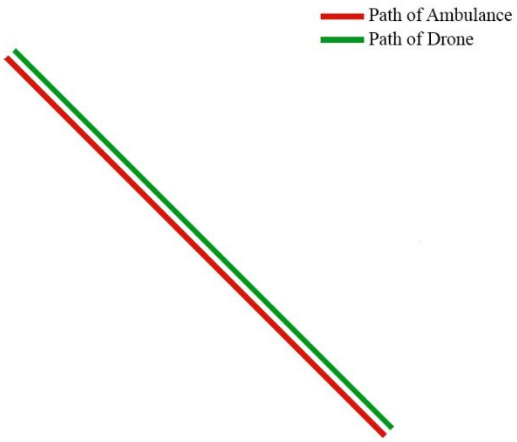

Fig.4(d): Straight ground path of ambulance v/s Straight Aerial Path of Drone

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ISO 9001:2008 Certified
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Volume 4, Issue 3, May 2015

The ambulance and drone were both sent out at the same time and their respective journey details were noted down as in table II.

Table II

Scenario	Vehicle	Distance	Time Taken	Average Speed	Max. Speed
Scenario 1	Light Ambulance	15.20Km	28 min 30 sec	32km/h	59Km/h
	Heavy Ambulance	15.20Km	30 min 24 sec	30km/h	55Km/h
	Drone	9.30Km	12 min 24 sec	45km/h	54Km/h
Scenario 2	Light Ambulance	37.68Km	51 min 22 sec	44km/h	50km/h
	Heavy Ambulance	37.68Km	55 min 07 sec	41km/h	48km/h
	Drone	12.00Km	16 min 00 sec	45km/h	54km/h
Scenario 3	Light Ambulance	16.00Km	18 min 26 sec	52km/h	64km/h
	Heavy Ambulance	16.00Km	20 min 00 sec	48Km/h	54km/h
	Drone	11.40km	15 min 20 sec	45km/h	54km/h
Scenario 4	Light Ambulance	10.00Km	19 min 20 sec	31km/h	41km/h
	Heavy Ambulance	10.00Km	23 min 04 sec	26km/h	33km/h
	Drone	10.00Km	13 min 19 sec	45km/h	54km/h

As it is clear from the Table II, it doesn't matter what path it is from the Hospital to the patient. The Drone finds the smallest distance to the patient from Hospital and thus the distance is reduced by even more than half in certain scenarios. It shows a remarkable improvement in the chances of survival of the patient, even if he is really far away from the hospital. Also, even in a straight route, the Ambulance may suffer from heavy traffic in certain times and routes, however the drone will be indifferent to that as it is in the air.

VI. CONCLUSION

This paper aimed to provide a feedback regarding the degree of practicality for the existence of ADSS in natural environment. The comparison to regular ambulance and how it can be useful in support of those ambulance rather than replacing them was another aspect taken into consideration. Clearly, from the Asphyxiation module as well as the introduction module, it was evident that many lives suffer because their urgent need of support from ambulance wasn't met because of ambulance delays. Obviously, we can't ensure that the ambulance will reach them faster, so we thought of rather supporting the patient long enough to cover for ambulance delays by using the Drone. In this paper, we focused on the Asphyxiation Patients and their urgent need of Oxygen Supply. As clear from all the calculations in the paper, The Drone could support a patient who is about an hour away from ambulance support, to get the Oxygen Supply within 15-16 minutes and get the Oxygen Support which can last up to 3 and a half hours. This increases the chances of his survival dramatically. The result of this ADSS was really promising and practicality was definitely not a problem. In contrast to the other option being a Helicopter, it was small and could attend a patient even in a very enclosed building structure, and even small hospitals can afford a bunch of these drones due to their effectively lower cost. At one place, the Helicopter will cost at least 1.2 million USD, and the patient will receive a hefty bill of about 12000 to 25000 USD whereas, a drone will cost somewhere around 500 USD. It's flight would cost only electricity, and the patients will receive a bill of around 80 USD. The practical effectiveness, usability and even the cost effectiveness makes the ADSS a huge success. All in all, the practicality of ADSS surpasses the estimation of their existence. In future, we can always add up to support different kinds of patients who need urgent attention from doctors, such as the patients of Heart Attack. This will open up a completely different field of possibilities for dedicated Researchers and innovators to improve on these aspects of ADSS and create problem specific drones. It will definitely be in favor of those patients who might have

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Volume 4, Issue 3, May 2015
lost their lives due to ambulance delays, but they rather stay alive because of the Ambulance Drone Support System. Future enhancement possibilities include a support system dedicated to patients of Heart Attack. Since, Heart Attack is one of the most common causes of Emergency Delay Fatalities around the globe, it comes out as one of the most prominent and important aspect to look at, for improvement. Apart from Heart Attack, possibility of providing support in terms of wide open wounds that require sutures immediately to avoid huge amount of loss of blood, this paper opens an opportunity for researchers to add capabilities such as mentioned above, and help in improving chances of survival of humans worldwide.

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AUTHOR BIOGRAPHY

Syed Ali Shahbaz completed his Bachelor of Technology in Computer Science & Engineering from Invertis Institute of Engineering & Management, a college affiliated to Gautam Buddha Technical University (a.k.a. Uttar Pradesh Technical University), in the year 2013. Over the past few years, he has developed an interest in multi-disciplinary subjects ranging from arts and paintings, to robotics and graphic designing. Shahbaz was recognized as the most creative C programmer and received an award at CETPA Infotech, 2012. An exhibition of a few of his art work received the first prize at the Art Gallery, Invertia-2012. In 2010, he participated in the Robo-sapiens robotics workshop, which effectively sparked his interest in the robotics field, thus forcing him to better understand and indulge in the robotics for human welfare. The HRAR was his first contribution to the Robotics for Human Welfare. He followed his willingness of research for human welfare and came up with the ADSS, yet another system which improves the possibility of survival of patients in emergency situations.