SELECTION OF UNMANNED AERIAL SYSTEM (UAS) FOR DISASTER RELIEF OPERATIONS: A COMPARISON

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ABSTRACT: *This paper presents short comparison of different type of unmanned aerial systems (UAS) for the disaster relief application. Brief study of available UAS is carried out and compared in terms of control, flight time, maneuverability, cost, payload and etc. In the end on the bases of comparison, suitable vehicles for disaster relief operations are suggested. Unmanned helicopters and multi-rotor copters are considered to be the most suitable vehicles for this purpose due to many factors including their maneuverability, agility and wind disturbances.*

Keywords: Disaster Relief, Radio Control and UAV.

1. INTRODUCTION

Increasing trend of natural disasters around the world, especially in Asia is causing more damages in terms of assets and lives [1,2]. Disaster trends from 1985-2014 are shown in TABLE.I. Total of 10,068 disasters occurred causing 1.885 million killing and 2,475.5 million US dollars damages. It has been observed that Asia is the leading region in terms of disaster occurrence (38.1%), killing (61.28%) and damages (47.1%). It is observed from statistics that from 2000-2004 there were maximum number of disaster occurrences (23%) and killings (22.8%) [3]. Maximum property damages due to natural disasters were recorded during 2010-2014 (44.3%. Number of disaster occurrences and killings are much larger if other disasters than natural disasters are also included.

Table.I. Region Wise Impact of Natural Disasters From 1985-2014[3]

Region	Occurrence	Killed (Million)	Injured (Million)	Damage ($)
Africa	2,043	0.17	0.07	18.5
America	2,429	0.38	2.6	914
Asia	3,836	1.16	3.1	1,168
Europe	1,341	0.17	0.06	311
Oceania	419	0.005	0.008	64
Total	**10,068**	**1.885**	**5.838**	**2,475.5**

Normally for disaster relief and rescue operations, full scale surveying using manned helicopters is carried out in most of the counties. Unfortunately due to very less resources in under developing countries many lives were lost in previous natural disasters. All these circumstances has forced the world to think of cheap and effective alternated of manned surveying to save more lives. It has already been proposed in literature that the use of small and medium size unmanned aerial systems can be cheap, fast and effective solution for the problem of initial surveying in case of disaster struck [4-12].

Trend of using UAS for disaster relief, rescue and monitoring purposes is very common from last decade or so. Due to the certain limitations of national security issues[13,14], research in the field of UAS is not progressing with the much speed and not much direct literature available due to the fact that most of the research on this topic is carried out in defense research facilities. But now a days, by floating the idea of integration of defense and civil unmanned activities, research in the field is on the flow in civil educational institutes and industries as well.

Selection of suitable aerial platform for the disaster relief operations is always important topic in this research area. There are different aerial systems like fixed wing aircraft, helicopters, multi-rotor copters, cable driven robots, captive balloon type systems and etc. Now the important question is, how one want to utilize these systems? Individually or in collaboration. Each aerial platform has its own advantages and disadvantages depending upon the capabilities, size, endurance, reliability, quality and cost of systems. Selection of aerial system for disaster relief and monitoring purpose is always been an issue while working on these projects. In most of the literature available, rotary wing vehicles are used as the base platform to develop such a systems due to their capability of hovering, low altitude flights and agile movements in general [15-17]. But there is no proper comparison of all available systems is available in literature which can effectively help the reader in selecting the vehicle according to their situations.

This research is carried out to provide the solution for the selection of suitable aerial system for disaster operations by comparing different available systems. Comparison in terms of quality, endurance, reliability, cost, payload, control, size, handling, flight time and etc is carried out in the research. This comparison will significantly help the reader in the selection of aerial system for disaster situations.

Table.II. Clasification of Unmanned Aerial Systems (Uas) By Size

Category	Range (km)	Altitude (m)	Endurance (Hours)	Weight (kg)	Example
Micro and Mini (MUAV	<10	300	<2	<30	Md4-200
Medium Altitude Long Endurance (MALE)	>500	15,000	24-28	1,500-7,000	Predator
High Altitude Long Endurance (HALE)	>2,000	20,000	24-28	4,500-15,000	Global Hawk
Vertical Takeoff and Landing (VTOL)	x-204	x-6,100	0.18-8	0.019-1,400	MQ-8

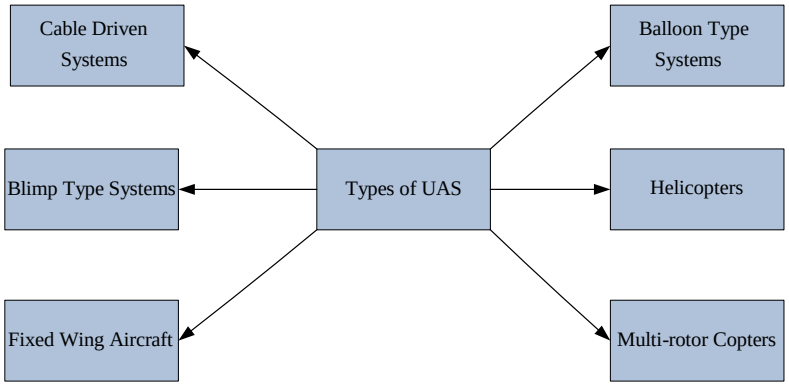

Fig. 1. Classification of UAS by Different Aerodynamic Structure

2. CLASSIFICATION OF UNMANNED AERIAL SYSTEMS (UAS)

This section includes the details of different type of UAS that are being or can be used for disaster relief and monitoring operations. Classification of UAS on the bases of size and aerodynamic structure is discussed in this section.

TABLE.II. shows the size wise classification of unmanned aerial vehicles including Micro and Mini Unmanned Aerial Vehicle (MUAV), Medium Altitude Long Endurance (MALE) vehicles, High Altitude Long Endurance (HALE) vehicles and Vertical Takeoff and Landing (VTOL) vehicles. Vehicles falling in MUAV category usually small in size (up to 30 kg), few kilometers of communication rang, few hundred meters of altitude and very short flight timings. These vehicles do not have much of payload capacity hence cannot be used for rescue or delivery purposes but only for the surveying with in short area. Small size is used as advantage to go in areas where full scale vehicles cannot enter. Examples of MUAV are Aladin Reconnaissance System, md4-200 and Nano Hummingbird.

MALE category contains some larger and complex vehicles. They can fly beyond several thousand kilometers with the flight time of up to 24 hours. These are heavy vehicles and used for the transportation of goods and ammunition purposes. Examples of MALE are Predeator, Heron and Talarion. HALE category is for high altitude and heavy vehicles category usually known as proper drone (size of full scale vehicles) fully equipped with all features. Example of HALE is Global Hawk American Drone. VTOL vehicles category especially referred to rotary wing vehicles which can take off and land in vertical position and requires minimum possible space rather than a long runway. Examples of VTOL are RQ16 T-Hawk and Cam Copter S-100.

Different types of UAS based on aerodynamic structure are fixed wing aircraft, multi-rotor aircraft, helicopters, blimp type robotic systems, cable driven systems and info balloon type systems. Fig.1 shows the aerodynamic wise classification of UAS.

Fixed wing aircraft uses the lift generated by wings by forward air speed and shape of wings. Thrust for the forward air speed is provided by the engine of aircraft. Control of fixed wing aircraft by remote is relatively easy from helicopter. Maneuvers are controlled by the movements and structure of wings attached with servo motors. They cannot hover, but can quickly scan the area are usually used for remote sensing and delivering goods purposes in disaster relief applications. Unmanned helicopters are VTOL category vehicles and can hover and have agile movements. A rotating blade fixed on swash plate cause to lift the vehicle up by pushing air down. Unmanned helicopters are usually controlled by five servo motors (throttle, pitch, yaw, aileron and rudder) using controller. Short flight time and low payload capacity is considered as the major limitation of such type of vehicles. Flying of unmanned helicopters is

Fig. 2. Different Unmanned Aerial Systems Including, From Left to Right Unmanned Helicopter, Fixed Wing Aircraft, Quad Copter, Balloon Type System, Blimp Type System and Cable Driven Robot. Source:[19]–[23]

Table.III. Feature Based Comparison of Different Aerial Systems.

Feature	Fixed Wing Aircraft	Rotary Wing Aircraft	Captive Balloon System	Blimp Type System	Cable Driven Robots
Size	Small, Medium, Large	Small, Medium, Large	Large	Large	Medium
Cost	Expensive	Expensive	Cheap	Cheap	Cheap
Speed	Very Fast	Fast	Slow	Slow	Slow
Control	Simple	Complex	Simple	Simple	Simple
Hovering	No	Yes	Yes	Yes	Yes
Reliability	Yes	Yes	No	No	No
Flight Time	Short	Short	Long	Long	Long
Maneuverability	No	Yes	No	No	No
Payload Capacity	High	Medium	Very Low	Very Low	No
Disturbance Effect	Less	Less	High	High	High
Quality of Information	Medium	High	Poor	Poor	Poor

considered difficult and proper training is required before flying these otherwise fatal damage could occur.

Another type of rotary wing systems include the Quad-copters, works on the principle of speed variation of one motor with respect to other to fly. Usually DC motors are used in quad-copters and requires more power to be operated so problem of short flight times is very common in such vehicles. These are highly stable vehicles and capable of lifting reasonable weight as well and used for collecting photogrammetry information from disaster sites. Balloon type robotics systems are stationary systems fixed at certain altitude and works on the gases lighter than air. These systems are usually used for the long term area inspection and monitoring. Disadvantage of these systems is the requirement of gases refiling and high disturbance to the winds. Blimp type robotic systems are slow and usually large in size systems and also used for the long term inspection of affected area. Cable driven robots are also type of balloon type systems but they are controlled by set of ropes and by changing the length of ropes position of system is changed. These are usually not so high and also used for area monitoring of disaster struck area. Fig.2 shows the pictures of all type of discussed UAS in this section.

COMPARISON AND ANALYSIS

This section includes the featured based comparison of unmanned aerial systems discussed in above sections specifically for the application in the field of disaster relief

and rescue. Feature on which comparison is based includes size, cost, speed, control, hovering, reliability, maneuverability, payload capacity, flight timing, quality of information and effect of disturbances.

TABLE.III. shows the feature based comparison of UAS. Talking about the size requirement in disaster relief operations, for initial surveying usually small and medium sized systems are required to get the visual information and return to the base station so either small sized fixed wing aircraft or rotary wing aircraft are to be used for initial surveying. Although both systems are in the cost expensive category of unmanned aerial systems discussed but still they are way less cheaper than the full scale aerial vehicles used currently for surveying. For initial survey the speed of information gathering is the major factor as first 3 days are most important for the victims to survive so both fixed wing and rotary wing systems are fast for information gathering and delivering and both can be either controlled by remote or can be fully autonomous using autopilot.

Although control of rotary wing vehicles especially helicopters is very complex but advantage of using these vehicles is disaster situation is their hovering capability and high maneuvers which in case of fixed wing systems not available and considered as the major limitation of using fixed wing aircraft for disaster surveying. Flight timing and payload capacity are important factors whenever unmanned systems are under discussions. Rotary wing and fixed wing both systems usually have short flight times and less payload capacity, therefore considered as the drawback of the systems in this case. For rescuing of victims full size rotary wing systems are preferred due to their hovering and agile movement features.

For long term surveys of the disaster struck areas balloon type, blimp type and cable driven systems are preferred. Major problem of not using balloon type, blimp type and cable driven systems as individual solution for disaster relief is their less maneuverability, large size, slow speed, unreliable and low quality of information. Although for long term analysis of the area in collaboration with either fixed wing or rotary wing system can provide significant help.

3. CONCLUSION

From the comparison carried out in the article it had been concluded that rotary wing systems are preferable choice for the quick initial surveying operations and Performance can be enhanced by improvements in flight time, payload capacity and control areas. For the goods delivering and as a communication relay, fixed wing aircraft are found best among the discussed systems. For long term analysis of the area like weather monitoring and damage assessments, balloon type, blimp type and cable driven aerial systems are preferred. Talking about single vehicle solution to the problem, rotary wing systems custom designed according to requirements discussed in article are the best options. In collaboration all the systems can work and provide information specialize to them and can help significantly but for stand-alone single solution, either helicopter or multi-rotor copter should be used.

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