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The uses of unmanned aerial vehicles –UAV's- (or drones) in social logistic: Natural disasters response and humanitarian relief aid

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Abstract

This paper evaluates the crucial role of unmanned aerial vehicles –UAV's- (or Drones) in the case of natural disasters response and humanitarian relief aid. The primary objective of this paper is to evaluate how unmanned aerial vehicles –UAV's- (or Drones) in the present or near future can help survivors in the case of a tsunami, earthquake, flooding, and any natural disaster. Initially, we assume that in any natural disaster always exist the high possibility of damage to the infrastructure, transportation systems, telecommunications systems access, and basic services immediately. This research proposes three areas the uses of unmanned aerial vehicles –UAV's- (or Drones) in the case of natural disasters response and humanitarian relief aid. These are (i) the aerial monitoring post-natural disaster damage evaluation, (ii) the natural disaster logistic and cargo delivery, (iii) the post-natural disaster aerial assessment.

Keywords: Drones; UAV's; Natural disasters; Policy modelling; Indicators

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1. A general review about the origins of the unmanned aerial vehicles –UAV's- (or drones) and its applications

The construction of the first unmanned aerial vehicle –UAV- (or Drone) was developed in the War World I (WWI) in 1918 with the creation of small planes under the concept of cruise missiles (self-flying aerial torpedo) to attack enemies in short distances. The two creators of the first UAV is Orville Wright and Charles Kettering (electrical engineer). The self-flying aerial torpedo (or Kettering Bug) was a wooden biplane (530 pounds that including a massive bomb of 180 pounds) able to fly a distance of 75 Miles respectively. This incredible machine the operator focus in evaluating the wind speed, direction, distance to fix the engine revolutions of the Kettering bug that can crash into a fixed target. In fact, the UAV's technology in WWI is more oriented to attack strategic points without return.

According to Smithsonian museum, the first experimental UAV developed in the 1950s with the ability to return satisfyingly after a mission, but the first UAV built during the first World War [1]. Therefore, in the War World II (WWII) the American Air Force starts to use small and conventional planes by using radio remote controls from England to spy on the Nazi Germans troops moves in France, Belgium, and Holland. Later, in the 60s and 70s starts the construction of UAV's formally by the American Air Force engineers with better electric systems to manage medium range flaying's without pilots to observe enemies' moves faster and high precision.

The significant improvement of UAV's development was between the 1980s and 1990s. The uses of sophisticated computers, digital cameras with a high resolution, advanced electronic controlling systems, extensive coverage remote radio control reception systems, and light materials such as plastic and carbon fibers in the construction of light UAV's, together with advanced GPS and monitoring remote systems. Finally, from 2000 to 2017 the advanced UAV's systems performance is growing geometrically in quality and quantity. The application of UAV's is moving from military to a private use by consumers around the world. The large variety of UAVs is according to its size, power, and applications.

This paper proposes a large list of UAV's applications such as military, commercial, natural disasters, health, construction, private uses, education, research, entertainment, sports, national security, logistic, firefighter, agriculture, geology, astronomy, meteorology, and environment. Additionally, we need to know the difference that exists between RC Planes, Quadcopters, Drones, Smart-Platforms (SP), and Large UAV's (LUAV's) respectively. This research will remark the difference that exists between LUAV's and RC Airplanes, Quadcopters (see Fig. 1), Drones, Smart-Platforms (SP) (see Fig. 2), and is easy to differentiate among them. The RC planes are any prototype that tries to represent a large real plane on a small scale. The Quadcopter is a formal aerial transportation with a precise instrumentation of flying and many applications and uses.

However, the Smart-Platforms (SP) is based on the same concept of Quadcopters but with larger and stronger electric engines together with large structures to flying more long distances to carry heavy cargo in the different type of missions. Finally, we have the Large Unmanned Aerial Vehicles (LUAV's) is a large aircraft with massive proportions, larger engines with high power, together with sophisticated software and hardware systems to flying long distances. The LUAV's never requested any pilot to fly, and the LUAV's work based on a controller with experience that he/she can control the LUAV's with using by high or short wave reception remote controls systems or advanced computer systems. At the same time, we need to classified and differentiated RC Planes, Quadcopters, Drones, Smart-Platforms (SP), and LUAV's. Firstly, the main difference depends on the take-off/landing style systems: vertical or horizontal), altitude levels, radio remote control reception systems, GPS systems, camera systems, different materials, energy supplier systems (battery or gasoline), mechanical or electric engines, and endurance respectively.

Usually, the take-off/landing horizontal style systems can be observed mainly in Quadcopters (three rotors, four rotors –classic-, five rotors, six rotors, eight rotors, eighteen rotors) and Smart-Platforms (SP). The pros of take-off/landing horizontal style systems can be landing anywhere and anytime, but the cons of the take-off/landing horizontal style systems show many limitations to flying long distance compare to the take-off/landing horizontal forms systems such as the case of LUAV's. At the same time, the cons of the take-off/landing horizontal style systems present many difficulties too, especially in the departure and arrival process. The pros of the take-off/landing horizontal style systems can fly more long distances. In the case of the aerial video filming and photography by the take-off/landing, horizontal style systems can take better videos and photos according to the altitude, angle, stability, and coverage. For the take-off/landing, vertical style systems cannot take pictures and videos for its limitation of the angle, stability, and coverage.

According to this research also Quadcopters, Drones, Smart-Platforms (SP) and LUAV's can be classified by size and weight: Nano-Size, Mini-Size, Medium size, Large size and Giant size. This research paper focuses on the application of Quadcopters, Drones, Smart-Platforms (SP) [2, 3, 4, 5, 6] and LUAV's, and UAV's Robots. This research would like to clarify that a Smart-Platform (SP) is the mix of the take-off/landing horizontal style systems and the take-off/landing vertical style systems together. The primary objective of any Smart-Platform (SP) is to offer an alternative system of aviation support with different applications.

In our case, we suggest two models of Smart-Platforms (SP) such as a firefighter Smart Platform and the natural disasters cargo express smart platform that can supply necessary provisions to the survivors: water, food, medicines, lights, communication systems (radios). We need to build an individual infrastructure deposits to keep a primary storage (e.g. food, water, and medicines) that we can supply anytime and anywhere to survivors in different places simultaneously. At the same time, any Quadcopter, Drone, Smart-Platforms (SP) and LUAV requests the construction of unique platforms that can facilitate the departure and landing faster and safely in case of a natural disaster or national security issue (War or Terrorism). These Drones or platforms will be called Droneports or Smart-Platforms that can facilitate the uses of Quadcopters, Drones, Smart-Platforms (SP) and LUAV's efficiently.

Hence, any Quadcopter, Drone, Smart-Platforms (SP) and LUAV request the uses of Droneports or Smart-Platforms to generate an efficient and systematic logistic coordination. In fact, we need to have a computing system and excellent facilities in the maintenance of Quadcopters, Drones, Smart-Platforms (SP) and LUAV's activities in any case of a huge and destructive and massive natural disaster. The Droneports or Smart-Platform request five essential elements. These five elements are: kept large storage deposits; efficient electricity plants, and faster charger systems; large stock of parts and accessories; the strategic geographical location of Droneports or Smart Platforms according to the high population density; the design of particular routes for flying Quadcopters, Drones, Smart-Platforms (SP) and LUAV's anytime and anywhere. Another important issue is to include the users of Quadcopters, Drones, Smart-Platforms (SP) and LUAV's is necessary to design different prototypes according to the natural disaster hazard.

The creation of various types of Quadcopters, Drones, Smart-Platforms (SP) and LUAV's is according to the natural disaster hazard category. Basically, in the process of departure and landing facilities, but more focus on the equipment we request to help survivors in the critical moments for any natural disasters case. In fact, the advantages to using the Quadcopters, Drones, Smart-Platforms (SP) and LUAV's is according to its effectiveness and efficiency in support aid for a massive natural disasters devastation. The principal objective is to give enough support to download any cargo just in time for the post-natural disaster critical timing and the fast return to the Droneports or Smart-Platforms as soon as possible again:

- This research proposes that a Quadcopter, Drone, Smart-Platforms (SP) and LUAV's has three core missions in any natural disasters event: (i) the aerial monitoring post-natural disaster damage evaluation; (ii) the natural disaster logistic and cargo delivery; (iii) the post-natural disaster aerial assessment. Firstly, the aerial monitoring post-natural disaster damage evaluation by using Quadcopters can help us to evaluate the real situation and magnitude of the damage in any natural disaster
- Secondly, the natural disaster logistic and cargo delivery role depends on the Smart-Platforms (SP). The Smart-Platforms (SP) mission is to bring essential provisions such as water, food, lights, radios with massive coverage, medicines, and communication systems as primary internet connectivity systems as soon as possible
- Thirdly, we have the post-natural disaster aerial evaluation that can help in evaluating the final human damage and infrastructure destruction magnitude of any natural disaster hazard

These three core missions of the Quadcopters, Drones, Smart-Platforms (SP) and LUAV's can give us a precise natural disasters response and relief humanitarian aid framework in case of natural disasters shortly. Finally, the uses of Quadcopters, Drones, Smart-Platforms (SP) and LUAV's request pilots with appropriate training and abilities to manage to fly this new type of technology and also the survivor's request to learn how to offload all provisions from the Drone or Smart-Platform (SP) or LUAV's. In the closed future, we can observe that the Quadcopters, Drones, Smart-Platforms (SP) and LUAV’s are moving to transform itself into UAV’s robots that can help in the informal interaction between survivors and rescue agencies.

Also, the UAV's robots are going to facilitate the easy and fast distribution of necessary provisions in more short time to help all survivors. Especially in the critical post-natural disaster timing, the efficiency of UAV's robots depends on the advanced computer systems (artificial intelligence), large antennas coverage, sophisticated GPS systems, better mapping systems details.

2. How to evaluate quadcopters, drones, smart-platforms (SP), and LUAV’s efficiency in case of natural disasters?

Firstly, this particular section of this paper introduces the technical part to evaluate Quadcopters, Drones, Smart-Platforms (SP) and LUAV’s in a case of natural disasters response and humanitarian relief aid. The first section is the Quadcopters, Drones, Smart-Platforms (SP) and LUAV’s (SP) technical analysis to use in case of natural catastrophes response and humanitarian relief aid. The second section is the different type of missions for Quadcopters, Drones Smart-Platforms (SP) and LUAV’s for each natural disasters response and humanitarian relief aid.

2.1. The quadcopters, drones, smart-platforms (SP) and LUAV’s technical analysis and evaluation for natural disasters response and relief humanitarian aid

In the Quadcopters, Drones, and Smart-Platforms (SP) and LUAV’s technical evaluation for natural disasters response and relief humanitarian aid. We have to evaluate nine main factors to find the best Quadcopters, Drones, and Smart-Platforms (SP) and LUAV’s:

- The first technical factor is that any Quadcopters, Drones, Smart-Platforms (SP) and LUAV’s design involve size (space) and capacity (weight) by the uses of light materials in saving battery energy and generate a better performance in the electric engines
- The Second technical factor is the batteries voltage plays a crucial to flying long distances. In our days, many companies are considering the uses of solar energy to keep a larger range of operating for any Quadcopters, Drones, Smart-Platforms (SP), and LUAV’s respectively. Together with efficient charging systems for batteries to cut time and help faster the survivors in different geographical areas at the same time
- The third technical factor is about the electric engines size and power to generate more speed and carry heavy weights for long distances without any problem to a significantly damaged place by a natural disaster urgently
- The fourth technical factor is the antenna coverage and GPS systems to keep a large reception for a better location in the departure or landing from any Droneports or Smart-Platforms. At the same time, we need large stock parts such as a large set of propellers, batteries, motors or ESC’s
- The fifth technical factor depends on the pilot’s experience to keep a stable flying and high precision to deliver any cargo in particular areas affected by any natural hazard
- The sixth technical factor is the geographical location of Droneports or Smart Platforms (KM^2) to generate the perfect coordination of logistic in the area of disasters
- The seventh factor is to find suitable electronic speed control (ESC) to keep a good connection between the batteries and electric engines always, but especially in the propulsion system aspect
- The eight technical factor is the role of the propellers design and material quality to generate a better propulsion and stability in the air
- Finally, the ninth technical factor is the camera systems for a better videos quality and photos with better resolution respectively

Additionally, we propose to have a particular table to evaluate these nine technical factors in Quadcopters, Drones, Smart-Platforms (SP), and LUAV's performance in case of any natural disasters. This table is entitled "The Quadcopters, Drones, Smart-Platforms (SP), and LUAV's Technical Check Evaluation Table (QDSPLTCE-Table)." The QDSPLTCE-Table is based on the uses of a binary system (1 or 0) to facilitate the evaluation of each technical factor in the analysis, in the analysis of the nine technical factor depend directly on nine different parameters were established for each technical factor respectively. If our technical factor had located in our setting was created before, then we have a result equal to 1 (excellent performance) and vice versa (see Table 1). Additionally, this table is going to help build a new indicator to evaluate the final technical performance of any Quadcopter, Drone, Smart-Platforms (SP) and LUAV's. This new index is called "Quadcopters, Drones, Smart-Platforms (SP) and LUAV's Technical Performance in Case of Natural Disasters Response (Ψ)" (1). This indicator is possible to be used by any natural disasters rescue agencies, governments, and NGO's to evaluate different Quadcopters, Drones, Smart-Platforms (SP), and LUAV's technical performance [7, 8].

$$\Psi = \sum \text{Total Results from QDSPLTCE} - \text{Table} \,/\, 9 \text{ (total variables in analysis)} \tag{1}$$

$$\text{If } \Psi = [0,1] \text{ then } \Psi = 0 \wedge \Psi \leq 1 \tag{2}$$

The results of the Quadcopters, Drones, Smart-Platforms (SP) and LUAV's Technical Performance in Case of Natural Disasters response (Ψ) is evaluating four levels of efficiency:

Level-1: 0.00-0.25 (Out of performance)
Level-2: 0.26-0.50 (Poor Performance)
Level-3: 0.51-0.75 (Good Performance)
Level-4: 0.76-1.00 (High Performance) (3)

Table 1. The quadcopter, drones, smart platforms (SP), and LUAV's technical check evaluation table (QDSPLTCE-Table).

Variable	Parameters	Drone-1	Drone-2	…..	Drone-n
Drone design	Light =1 or Heavy =0				
Batteries Power	Long duration = 1 or Low duration = 0				
The Electric Engines Size and Power	High power = 1 or Low power = 0				
GPS Systems	Large reception = 1 or Short reception = 0				
Pilots Experience	Long hours =1 or Few hours experience = 0				
Droneports Location	Short distances = 1 or Long distances = 0				
ESC Systems	High resistance =1 or Low resistance = 0				
Propellers Design	Light =1 or Heavy = 0				
Camera System	High Resolution = 1 or Low Resolution =0				
Total (Y*)		∑Vt/9	∑Vt/9	∑Vt/9	∑Vt/9

The next step, we need to evaluate a large number of Quadcopters, Drones, Smart-Platforms (SP) and LUAV's performance to help in case of a massive natural disasters response based on the final results from Ψ (see Table 1). We can observe that a high (Ψ) can help in generating a better planning and enforce natural disasters response plans with bringing heavyweight cargo to long distances in the short run.

Therefore, the efficiency of Quadcopters, Drones, Smart-Platforms (SP), and LUAV's depend directly on the technological advances (software and hardware) and the number of pilots able to flying anytime and anywhere. The experience of pilots requests to start from a young age. According to few research papers, the ability and skill of pilots start from an early age to manoeuvre and control any Quadcopter, Drone, Smart-Platform (SP), and LUAV in any situation of emergency.

3. Type of stages in any mission for quadcopters, drones, smart-platforms (SP), and LUAV's in case of natural disasters

In the evaluation of Quadcopters, Drones, and Smart Platforms (SP) in the case of natural disasters, we have to consider three type of mission stages:

Mission Stage-1 is named the aerial monitoring post-natural disasters damage magnitude evaluation. The Mission Stage-1 focus on the uses of Quadcopters with high-quality resolution cameras in real time. The primary objective of mission stage-1is to evaluate the infrastructure devastation preliminarily after of any natural disaster quickly. However, we evaluate a significant number of Quadcopters according to QDSPLTCE-Table and Ψ in the large market of Quadcopters, Drones, and Smart Platforms and LUAV's can help in case of any natural hazard. According to this research, after an exhausted evaluation of Quadcopter by Quadcopter. We find five Quadcopters branches in order can be used in case of Mission Stage-1: (i) Phantom 4 Advanced ($\Psi = 0.91$); (ii) Mavic Pro ($\Psi = 0.90$); (iii) DJI Inspire 2 ($\Psi = 0.88$); (iv) H920 PLUS Yuneec ($\Psi = 0.85$); (v) Parrot BEBOP 2 FPV ($\Psi = 0.80$) (see Figure 3). These five quadcopters show a high performance according to its (Ψ) standards. These five type of Quadcopters can fit perfectly for any mission for observation in any post-natural disasters evaluation. These five Quadcopters can fly a perimeter of 7 kilometers without any problem during an average of 25-30 minutes in the air with an average maximum speed of 60 Km/Hr with an average altitude of 3500 Mts. The evaluation of Quadcopters for this particular type of mission depends highly on the altitude, battery duration, and camera quality.

Phantom 4 Advanced

Mavic Pro

DJI Inspire 2

H920 PLUS Yuneec

Parrot BEBOP 2 FPV

Fig. 1. Quadcopters [9, 10, 11, 12, 13].

Two countries are pioneers in using quadcopters in the case of natural disasters are referring to large earthquakes and tsunamis in China and Japan respectively. In China, Quadcopters have already proven their value in evaluating the damage of earthquakes such as the case of the 2008 Sichuan earthquake (69,000 killed and 18,000 missing people). The uses if Quadcopters by the Chinese government and rescue agencies were able to detect and evaluate the highways, buildings, schools, hospitals, electric plants, bridges and tunnels conditions, and other population-dense locations [14].

In another hand, Japan the uses of Quadcopters in the earthquake and Tsunami in the year 2011 was to evaluate the damage to the nuclear plant of Fukushima Daiichi [14]. Finally, the case of the massive earthquake in Nepal in the year 2015 and again Quadcopters probe its effectiveness to evaluate the damages and reconstruction of Nepal based on aerial video and photos in different places [15].

The Mission Stage-2 focus on the channels of distribution or logistic of light cargo by Smart Platforms (SP) systems can help in the critical post-natural disaster period. This research finds five key provisions to supply survivors in any natural disaster such as water and food in light packing, essential medicines and equipment, LEDs lamps, and radios to establish a fast communication in remote areas were affected by any natural hazard. Actually, the Smart Platforms (SP) are in the experimental stage under the design and experimental prototypes such as the Airbus Group and Local Motors ZELATOR-28 ($\Psi = 0.95$), LUV ($\Psi = 0.70$), the APSARA Glider Drone ($\Psi = 0.75$), Incredible Heavy Lift Quadcopter ($\Psi = 0.65$), Mantarraya Negra Smart-Platform (SP) @ Firefighter Version 5 ($\Psi = 0.65$), Mantarraya Negra Smart-Platform (SP) Version 8 P-6 ($\Psi = 0.60$), Mantarraya Negra Smart Platform Version 7 and 8 ($\Psi = 0.55$) (see Fig. 2). These five Smart Platforms (SP) show different levels of according to our final evaluation.

However, these five Smart Platforms (SP) prototypes show different shapes and levels of cargo capacity. The biggest problem that Smart Platforms (SP) for Mission Stage-2 is to find reliable electric engines or gasoline engines to keep in the air longer time and carry heavy cargo for long distances. According to this research, we need to find the perfect balance of light and durable materials to build the Smart Platforms (SP). Additionally, we need to find suitable engines to save energy with powerful batteries with high voltage to facilitate long flying hours. At the same time, the easy way to charging the set of cells and the fast loading of provisions. However, this Smart Platforms (SP) requests a camera with high resolution, together with a large antenna coverage with a good GPS system with high precision for take-off and landing to the Droneports or Smart Platforms to get more provisions many times.

The Mission Stage-3 focus on the post-aerial evaluation of any natural disasters. This particular type of stage suggests that each natural disaster requests different treatment and type of Quadcopters, Drones, Smart-Platforms (SP), and LUAV's for a different kind of natural disasters such as a Tsunami, earthquake, flooding, landslide, etc. Each natural disasters demand to build different structures and shapes, together with various powerful engines and batteries. The crucial future of Quadcopter, Drones, Smart Platforms (SP), and LUAV's support for natural disasters is to find the perfect balance between the software (programming and networks) and the hardware (structures, battery power, and engines) together.

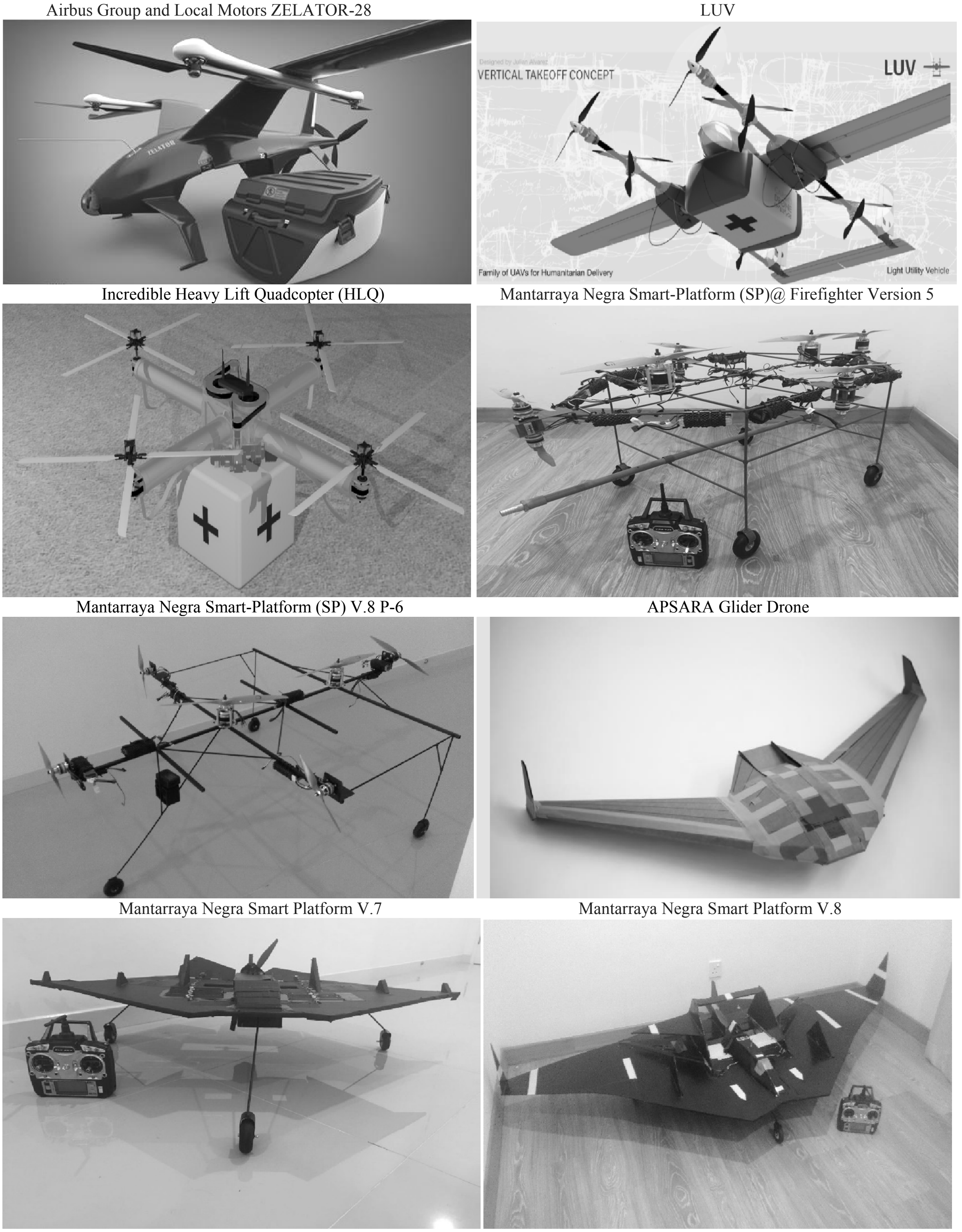

Fig. 2. Smart platforms (SP) [2, 3, 4, 5, 6, 16, 17, 18, 19].

4. Conclusion

This paper concludes that the effectiveness of Quadcopters, Drones, Smart Platforms (SP), and LUAV's in the case of natural disasters highly depend on the perfect balance between the technology development of software and hardware together. Additionally, the professional training for future pilots (human capital) to generate efficient and effective missions in different stages. These three steps in any mission are firstly the aerial monitoring post-natural disasters impact. Secondly, the channels of distribution or logistic with a light cargo.

The third stage is the post-aerial evaluation of any natural disasters. Therefore, at any stage depends on the fast development of new materials, powerful engines (electric or mechanical), powerful batteries with high voltage or alternative energy resources for electric or mechanical engines (electricity, gasoline, solar), and powerful antennas with advanced GPS systems respectively. This paper remarks that Quadcopter, Drones, Smart Platforms (SP), and LUAV's are going to play a crucial role in our days and closed future in releasing any natural disasters emergency anywhere and anytime.

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