Chapter 2

Small to Medium UAVs for Civilian Applications in Indonesia

Fuad Surastyo Pranoto, Ari Sugeng Budiyanta and
Gunawan Setyo Prabowo

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.76426

Abstract

Indonesian government needs a well-built, easy to operate unmanned aircraft systems (UAS) to perform various civilian missions as UAS are a well-known platform for dirty, dull, and dangerous missions. Hence, the Indonesian government has an organization that performs research and development of UAS, named as Aeronautic Technology Center. This organization is placed underneath Indonesian National Institute of Aeronautics and Space. The UAS developments in this institute are primarily driven by civilian uses; therefore, the UAS size, sensor types, and mission payload are optimized for civilian missions. In order to produce the decent to the best quality of the aerial image, which is the essential product for various civilian missions, the UAS regularly flies under the cloud. For this reason, the Aeronautic Technology Center is only developing the LASE (low altitude, short-endurance) and the LALE (low altitude, long endurance) UAS type as of now. The UAS development was begun with LSU-01, followed by LSU-02, LSU-03, and LSU-05. The LSU-01, LSU-02, and LSU-03 are in the operational phase, while the LSU-05 is in the experimental Phase. In this chapter, the specification of the platforms and the sensor capabilities that are relevant with the demands of users in the civilian sector are described.

Keywords: unmanned aerial system, low altitude, long endurance, civilian missions, sensor capabilities

1. Introduction

Indonesia is a beautiful country and has a lot of volcanoes, beaches, and some beautiful landscapes. Furthermore, Indonesia located in the equatorial area where only two seasons available, summer and rainy. In summer, the beautiful landscapes are enjoyable by many tourists. Contrary to the summer season, rainy season is the unfavorable time for traveling to Indonesia. The reason is, during the rainy season, the rainfall could be increasingly high. The rainfall characteristics over Indonesia are known to have seasonal and inter-annual variability primarily related to the monsoon and El Niño/Southern Oscillation (ENSO) [1]. The East Monsoon, from June to September, brings in dry weather, whereas the West Monsoon, from December to March, brings in the rain. The heaviest rainfall is usually recorded in December and January [2]. The average annual rainfall for Indonesia's Main Islands is ranging between 1200 and 3190 mm/year. The fourth highest rainfall is recorded in Papua (3190 mm/year), Kalimantan (2990 mm/year), Sumatra (2820 mm/year), and Java Island (2680 mm/year) [3]. The high rainfall is committed to flooding disaster. Especially in Java, where the population density is the highest (Java-Bali has estimated for among 58.7 and 59.6% of the national population average between 1993 and 2007 [4]), the flooding disaster could lead to the severe consequence. One of the flood disaster examples is the Jakarta flood on 2 February 2007 that inundated 70,000 houses, displaced 420,440 people and killed 69 people with losses of IDR. 4.1 trillion (US$ 450 million) [5].

Despite the flooding disaster, Indonesia is susceptible to the earthquake and volcanic eruption disasters. The reason why the earthquake frequently happens is the Indonesian location. Placed in one of the most active seismic zones in the world, Indonesia also lies on five active tectonic plates geologically. Hence, the earthquakes occurred daily in the region, with a magnitude of five in Richter scale or larger happened weekly [6]. In order to recognize the greatness of earthquake destruction, look at the following case. On March 2007, a powerful earthquake hit the Indonesian island of Sumatra and resulted in 66 fatalities, 500 injured, and severe damage or destruction of nearly 15,000 buildings. The total loss from the earthquake is estimated at US$180 million [7].

The mountainous terrain of Indonesia is the hideout of some disasters. The mountainous terrain plus Indonesian location in Pacific Rim ring of fire is a good recipe for volcanic eruptions. The mountainous terrain and wet soil could lead to the landslide. Both of the disasters happen frequently in Indonesia.

The natural disaster such as the earthquakes, the floods, the volcanic eruptions and the landslide are one of the problems that confronted by the government. Other problems such as forest fire, illegal fishing, border protection, and terrorism are demand to be fixed too. The government needs an adequate field data to be examined before performing the remedial action.

One of the methods to obtain necessary field data is the aerial photography where the aerial photo is the output of this method. The aerial photo is useful to determine the level of destruction of the disasters and the affected area. Both parameters are necessary for post-disaster management, such as creating the evacuation route for search and rescue team. The aerial photo could be used to validate the hot spot location in the forest fire. That information is useful for firefighting team to control and extinguish the fire. Other interesting functions of the aerial photo are discovering the terrorist hideout in counter-terrorism mission, spotting the illegal fishing operation and protecting the border from smugglers.

The aerial photo, indeed, needs a camera and a platform that capable for carrying the camera into the air. The camera and the platform selection are highly dependent on the mission requirement. A lot of camera is already available in the market for aerial photography. However, the platform shall be built specifically according to the requirement defined by Indonesian government. The Indonesian government needs a well-built, easy to operate unmanned aircraft systems (UAS) platform to perform coastline and borderline surveillance, disaster management and mitigation missions as a UAS are a well-known platform for dirty, dull, and dangerous missions.

For that purposes, the Indonesian government has an organization that performs research and development of UAS platform, named as Aeronautic Technology Center. This organization is placed underneath Indonesian National Institute of Aeronautics and Space. The UAS developments in this institute are primarily driven by civilian uses; therefore, the UAS size, performance, and mission payload are optimized for civilian missions.

However, because Indonesia positioned in the equator area, the sky is cloudy almost every day. In order to produce the decent to the best quality of the aerial photo, the platform (UAS) regularly flies under the cloud. For this reason, the Aeronautic Technology Center only developing The LASE (Low Altitude, Short-Endurance) and the LALE (Low Altitude, Long Endurance) UAS type for now.

The UAS development was begun with LSU-01, followed by LSU-02, LSU-03, LSU-04 and LSU-05. The LSU-01, LSU-02, and LSU-03 are in the operational phase while the LSU-04 and LSU-05 are in the experimental phase. Hence, all three UAS are frequently used for various civilian missions.

In this chapter, the specification of the platforms is described, as well as sensor capabilities, and advantages of each as relevant to the demands of users in the civilian sector. We also briefly discuss the field experience that obtained during the UAS operation.

2. LAPAN surveillance UAS specification

The LAPAN Surveillance UAS, abbreviated as LSU, is the UAS platform developed by Aeronautic Technology Center for the civilian purposes. The design of the UAS and the payload system are utilized mainly for aerial photography missions. The payload system usually uses a small format digital camera. The UAS platform categorized as The LASE (Low Altitude, Short-Endurance) and the LALE (Low Altitude, Long Endurance) class. The LSU family consists of five types such as LSU-01, LSU-02, LSU-03, LSU-04, and LSU-05. **Figure 1** shows the UAS size comparison.

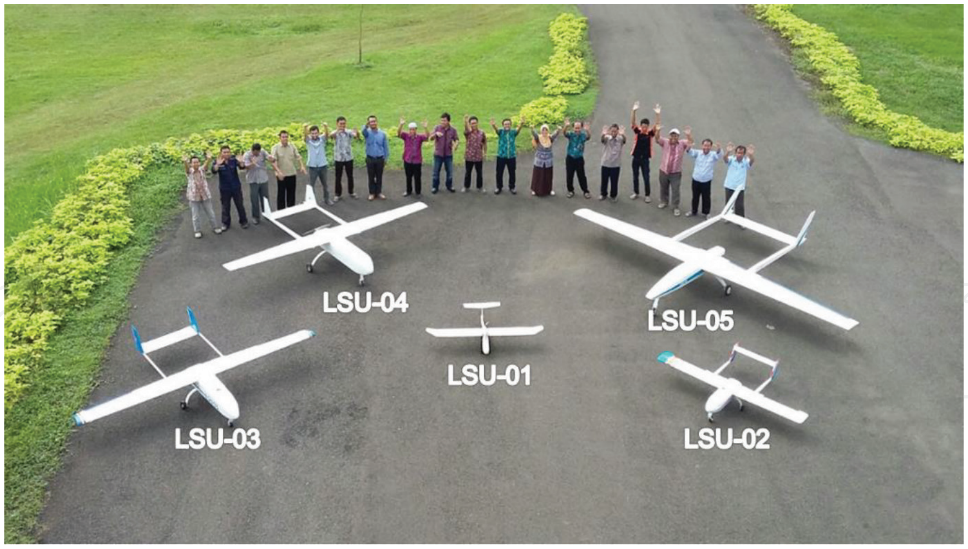

Figure 1. LSU family.

The LSU UAS platform requires an additional system for autonomous flight. The system consists of RC transmitter, RC receiver, autopilot, and servo actuator. During the autonomous flight, the UAS position shall be monitored by ground control segment in real-time. Therefore, a telemetry and ground control station shall be available too. The UAS pilot handles the take-off and landing operation manually. **Figure 2** shows the correlation between the UAS and ground control segment.

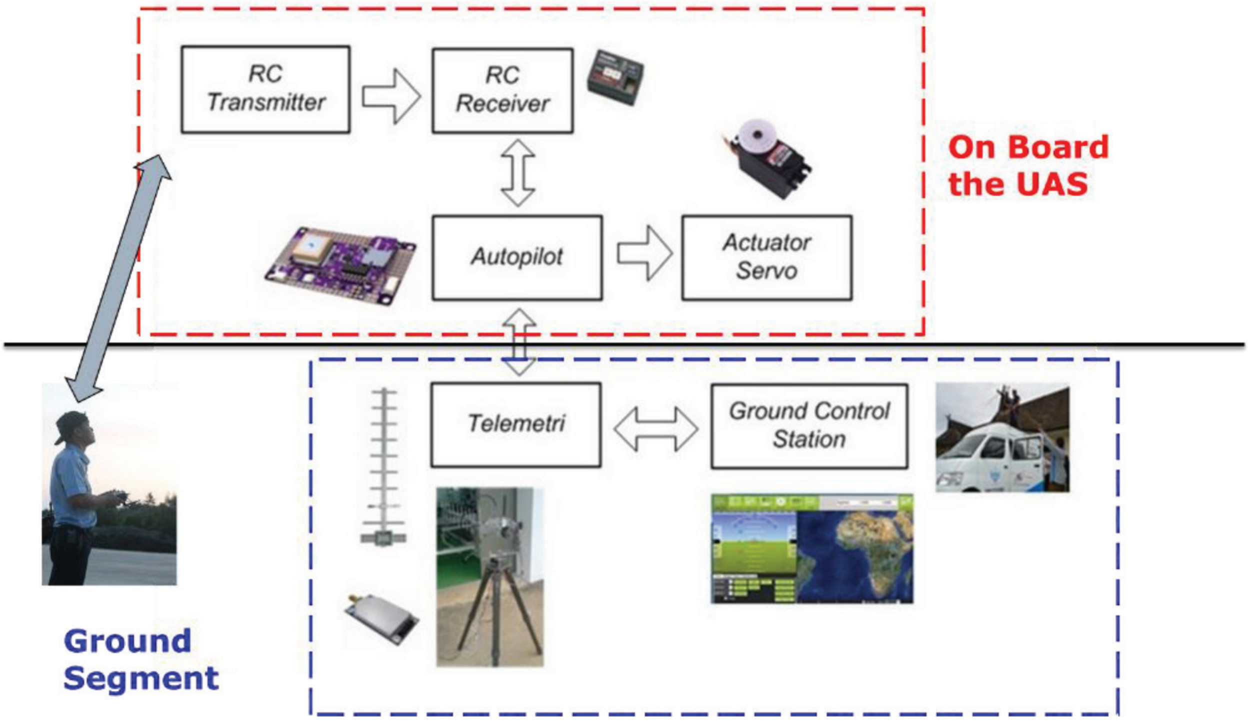

Figure 2. The LSU family avionic system and ground segment.

The autopilot system uses commercially out of the self (COTs) product. There are a lot of alternatives for the UAS autopilot, such as Ardu Pilot Mega (APM), Pixhawk, Feuyu Tech Autopilot Panda, Micro Pilot, and Piccolo Autopilots. However, we use only the Ardu Pilot Mega (APM), Pixhawk, Feuyu Tech Autopilot Panda for our UAS platform.

The ground control segment uses open source software for the flight planning, commanding the UAV, and receiving telemetry data. We use Ardu Pilot Mission Planner if the autopilots are Ardu Pilot Mega (APM) and Pixhawk.

The telemetry system to extend the UAS communication ranges up to 47 km is developed. Without the telemetry system, the UAS communication ranges only 2 km. The telemetry system capable of receiving data (flight data, real-time video, and picture) from the UAS to the ground control segment as well as sending autopilot command to the UAS. The telemetry system located on the ground segment; utilize the Yagi antenna for tracking the UAS while on board the UAS use the omnidirectional antenna. The Yagi antenna is capable of tracking the UAS manually (with the GPS assist) or automatically. **Figure 3** shows the telemetry system of the UAS.

The remote control system is necessary for take-off and landing operation of the LSU family. The LSU family normally take off and climb to the cruise altitude manually, then, change to the automatic mode during the aerial photography mission. After completing the mission, the UAS descending to the commanded altitude automatically and the UAS pilot will take over the control and land the UAS manually. The remote control utilizes the 72 and 2400 MHz frequency for interacted with the UAS operation mode. There are three operation modes: manual, stable, and fully autonomous mode. The maximum operating range of the radio control is 5 km and the typical operating range is 2 km.

Figure 3. The LSU family telemetry system.

2.1. UAS specification

This chapter describes the LSU family technical specification.

2.1.1. LSU-01

The LSU-01 is the smallest UAS platform in the LSU family. This platform is the only one who uses the electric engine. The platform design is based on the Skywalker UAS family. However, there are some modifications applied to the platform in order to make the platform perform better in the field, such as:

1. Additional fiber lamination to enhance the structural strength of the UAS. The UAS structure is made from the Styrofoam which is known as sturdy and light material. However, in the field, we learned that the material is not sturdy enough when the UAS shall perform the hard landing. The additional fiber lamination helps to protect the UAS structure from destruction when hard landing

2. Special camera bay for housing the small format digital camera. The camera bay is outfitted with structural support and rubber to prevent the camera from shaking. When the shake is minimized, the aerial photo quality is increased (**Figure 4**).

The LSU-01 is used for an aerial photography mission. The mission shall have the following requirement, such as the survey area is within 0–1000 hectares, no proper takeoff and landing place near the mission location, and the survey location has a calm wind condition (the wind speed below 10 m/s). The LSU-01 is capable to finish 250 hectares survey area in one flight with Canon S100 camera. The average speed in flight is 15 m/s, the flight altitude is 300 m above ground level, the flight time is within 30–50 min (highly dependent on the wind condition). **Table 1** shows the detailed specification of LSU-01.

2.1.2. LSU-02

The LSU-02 is the second UAS platform in the LSU family. This platform uses a gasoline engine in push configuration. The platform design is inspired by skyhunter UAS family. The longitudinal section of LSU-02 fuselage is nearly square and has an advantage of the big payload bay.

Figure 4. Left: LSU-01 final configuration; right: LSU-01 during operation with the camera bay shown under the fuselage.

Parameter	Unit	Value
Physical specification		
Wingspan	mm	1830
Wing area	dm^2	41.17
Wing aspect ratio	—	8.133
Wing taper ratio	—	0.885
Fuselage length	mm	1270
Weight specification		
Empty weight	g	1400
Payload weight	g	1600
Maximum takeoff weight	g	3000
Flight performance		
Endurance	min	30–50
Cruise speed	m/s	15
Maximum speed	m/s	25
Service ceiling	m	1500
Payload configuration		
Engine	—	2820KV850–900
Engine type	—	Electric
Electronic speed controller	A	60
Propeller	in.	13
Battery capacity	mAH	2 × 4S 5000
Servo	—	4 × 12 g
Autopilot	—	3DR Pixhawk Mini
Camera	—	Canon S100
Takeoff method	—	Hand cast manual/full auto
Landing method	—	Manual/full auto/parachute

Table 1. LSU-1 technical specification.

The LSU-02 has a landing gear; therefore, the takeoff and landing operation need a runway. However, there are some modifications applied to the platform in order to extend the LSU-02 takeoff and landing capabilities such as implementation of catapult launch for takeoff and parachute or landing net for landing operation. The catapult launch of LSU-02 was successfully tested while the parachute landing still needs some improvements. **Figure 5** shows the LSU-02 during operation.

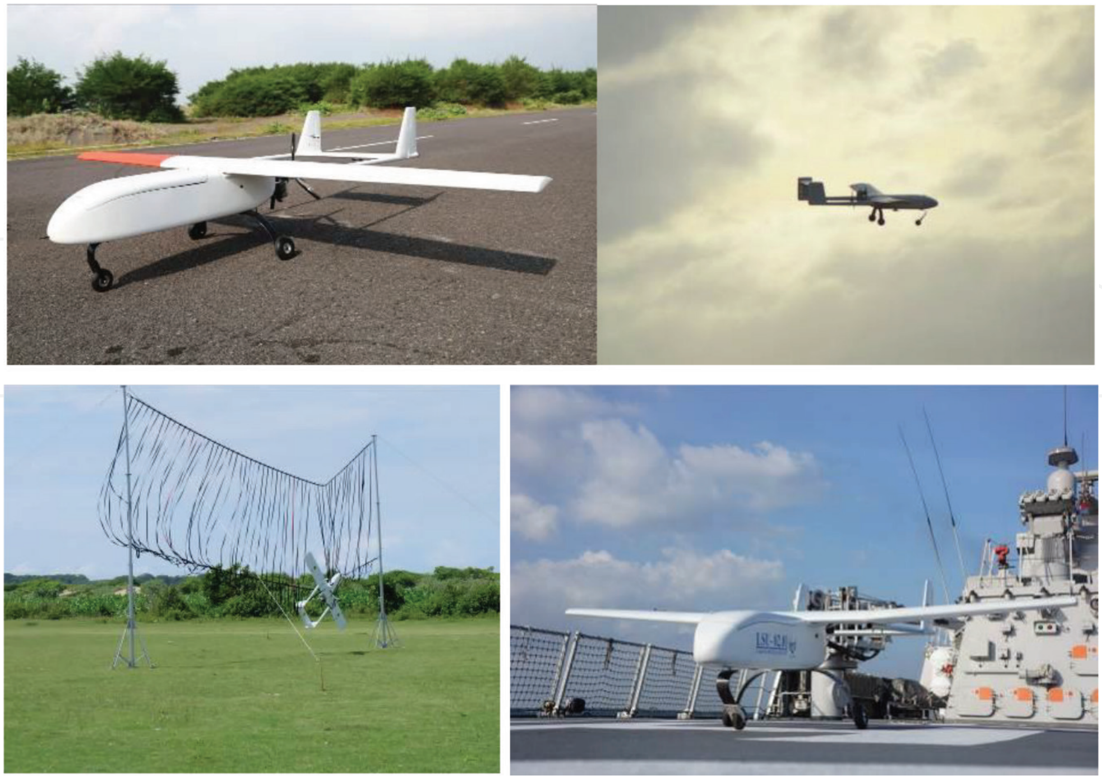

Figure 5. Top-left: LSU-02 final configuration shortly before takeoff; top-right: LSU-02 during aerial photography mission; bottom-left: landing operation with net; bottom-right: takeoff preparation from Indonesian Hasanudin class corvette warship.

The LSU-02 is used for an aerial photography mission. The LSU-02 has an endurance of 4 h with the average ground speed of 27 m/s. The LSU-02 is capable to finish 2500 hectares survey area in one flight with Sony A6000 camera. In one sortie of flight, the LSU-02 flies at 27 m/s ground speed, 60–80 min flight time and 300 m flight altitude. The LSU-02 has more resistant to the wind disturbance due to powerful gasoline engine installed on this aircraft. The LSU-02 is capable to maintain the 27 m/s groundspeed under 10 m/s headwinds. The LSU-02 is suitable for aerial photography mission that have 10,000–15,000 hectares survey area and has a grass runway for normal takeoff and landing operations. **Table 2** shows the detailed specification of LSU-02.

2.1.3. LSU-03

The LSU-03 is the third UAS platform in the LSU family. This platform is developed from LSU-02; therefore, it uses a gasoline engine in push configuration. The LSU-03 has bigger wing and bigger fuselage compared to the LSU-02 (**Figure 6**). The advantages of LSU-03 over LSU-02 such as longer endurance due to increase fuel capacity and heavier payload capability, it means the LSU-03 is capable to lift up the medium format camera for aerial photography.

The LSU-03 has endurance up to 6 h with the average ground speed of 30 m/s. The LSU-03 is capable to finish 7500 hectares survey area in one flight with Sony A6000 camera. In one sortie of flight, the LSU-03 flies at 30 m/s ground speed, 120–150 min flight time and 300 m flight

Parameter	Unit	Value
Physical specification		
Wingspan	mm	2400
Wing area	dm^2	66.5
Wing dihedral	°	2
Wing swept angle	°	0
Fuselage length	mm	1700
Weight specification		
Empty weight	g	9700
Payload weight (exclude fuel)	g	2000
Fuel weight	g	3300
Maximum takeoff weight	g	15,000
Flight performance		
Endurance	h	3.5–4.0
Cruise speed	m/s	27.3
Maximum speed	m/s	41.6
Service ceiling	m	2000
Payload configuration		
Engine	—	Gasoline
Engine capacity	cc	33
Engine fuel system	—	Carburetor
Propeller	in.	16 × 10
Battery capacity	mAH	3 × 4S 5500
Servo	kg.cm	7.7
Autopilot	—	3DR Pixhawk/Feuyu Tech Autopilot Panda
Flight mode	—	Manually, stable, autonomous
Camera	—	Sony A6000
Gimbal	—	1 axis (roll axis)
Takeoff method	—	Normal, launcher
Landing method	—	Normal, parachute

Table 2. LSU-2 technical specification.

altitude. The LSU-03 is suitable for aerial photography mission that have 20,000–30,000 hectares survey area and has a grass runway for normal takeoff and landing operations. **Table 3** shows the detailed specification of LSU-03.

Figure 6. Left: LSU-03 final configuration shortly before takeoff; right: LSU-03 test flight.

2.2. Payload specification

The payload for the LSU UAS family is mainly a small format digital camera. The aerial photography mission, which uses small format digital camera, is called as small format aerial photography (SFAP). Small-format aerial photography (SFAP) is based on lightweight cameras with 35- or 70-mm film format as well as equivalent digital cameras and other electronic imaging devices. For the most part, these are "popular" cameras designed for hand-held or tripod use by amateur and professional photographers. Such cameras lack the geometric fidelity and exceptional spatial resolution of aerial mapping cameras. Low-cost, availability of cameras and lifting platforms is a combination that renders SFAP desirable for many people and organizations. The SFAP is self-made remote sensing system design, technical implementation, and image analysis may be in the hands of a single person, granting utmost flexibility and specialization [8].

The SFAP may be classified according to the camera attitude (angle of photography) and the type of film used. Depending on the camera angle, the SFAP may be vertical or oblique classification. A vertical SFAP is taken with the axis of the camera at right angles to the horizontal. This yields an image which may be unfamiliar in format but which is relatively easy to manipulate photogrammetrically [9]. Almost all-modern SFAP, including SFAP missions that done by the LSU family is vertical in orientation.

Other interesting parameter in the SFAP is spatial resolution. The spatial resolution for digital camera sensor is known as ground sampling distance (GSD). If the GSD is specified too high (high GSD means small pixel size on the ground), more flight lines will be required and the amount of data per area will increase. It is recommended to specify both a target GSD and a minimum GSD to allow some flexibility because of terrain variation [10]. The very high-resolution satellite like worldview 1, 2, and 3 normally has 50, 46, and 31 cm of GSD, respectively, while manned and unmanned aircraft usually have 3–65 cm of GSD [11]. The smaller GSD value means more detail in the photograph. The GSD is calculated by using Eq. (1) from literature ([8], p. 22), where H_g is flight altitude above ground level and f is camera focal length.

$$GSD = (camera\ pixel\ element\ size) \times H_g / f \tag{1}$$

Parameter	Unit	Value
Physical specification		
Wingspan	mm	3500
Wing area	dm^2	127
Wing dihedral	°	2
Wing swept angle	°	0
Fuselage length	mm	2500
Weight specification		
Empty weight	g	18,000
Payload weight (exclude fuel)	g	5000
Fuel weight	g	7000
Maximum takeoff weight	g	30,000
Flight performance		
Endurance	h	4.0–6.0
Cruise speed	m/s	30
Maximum speed	m/s	45
Service ceiling	m	2000
Payload configuration		
Engine	—	Gasoline
Engine capacity	cc	60
Engine fuel system	—	Carburetor
Propeller	in.	14 × 12
Battery capacity	mAH	3 × 4S 5500
Servo	kg.cm	7.7
Autopilot	—	3DR Pixhawk
Flight mode	—	Manually, stable, autonomous
Camera	—	Sony A6000
Gimbal	—	1 axis (roll axis)
Takeoff method	—	Normal, launcher
Landing method	—	Normal, parachute

Table 3. LSU-03 technical specification.

The "camera pixel element size" depends on the digital camera sensor size and the camera resolution. For example, a full frame digital camera Canon EOS 1D X mark II capable to record picture in various resolutions, such as 20.0 megapixels (5472 × 3648), 12.7 megapixels (4368 × 2912), 8.9 megapixels (3648 × 2432) and 5.0 megapixels (2736 × 1824) [12]. The full frame sensor has 36 by 24 mm dimensions and an effective area of 864 mm^2. The value of "camera pixel element size" for each camera picture resolution is shown in **Table 4**. **Table 4** shows higher camera resolution has more information inside 1 mm of sensor length. Assuming $H_g = 1000$ mm and $f = 1$ mm, the GSD at the highest resolution is 0.65 cm while at the lowest resolution is 1.31 cm. It means the picture at the highest resolution contains the detail twice as much as the picture at the lowest resolution.

For the aerial photography mission, the LSU-01 equipped with Canon S100 camera, while the LSU-02 and LSU-03 equipped with Sony A6000 camera. The canon S100 has 7.6 by 5.7 mm sensor size and the maximum resolution of 4000 by 3000 pixels. The focal length is variate between 5.2 and 26.0 mm (35 mm equivalent: 24–120 mm) [13]. On the other hand, the Sony Alpha A6000 has bigger sensor size and higher maximum picture resolution. The Sony Alpha A6000 sensor size measured at 23.5 by 15.6 mm and the maximum resolution of 6000 by 4000 pixels. The focal length of Sony Alpha A6000 camera is depends on the installed lenses. The lens of Sony Alpha A6000 is interchangeable because this camera belongs to the mirrorless camera type. The standard lens kit for Sony Alpha A6000 has variable focal length between 16 and 50 mm (35 mm equivalent, 24–75 mm) [14]. The LSU family usually flies at 300 m altitude during the aerial photography missions. Based on this information, the GSD for the Canon S100 and Sony Alpha A6000 at the longest and shortest focal length can be calculated. **Table 5** shows the GSD value for both camera at $H_g = 300$ m.

Unlike the LSU-01, the Sony Alpha A6000 that mounted in the LSU-02 and LSU-03 is equipped with a-axis gimbal. The gimbal compensates the aircraft roll movement and keeps the camera

Camera resolution (pix)	No. of pixels (Mpix)	Pixel element size (mm/pix)	No. of pixels per mm (pix/mm)
2736 × 1824	5.0	0.013157895	76
3648 × 2432	8.9	0.009868421	101
4368 × 2912	12.7	0.008241758	121
5472 × 3648	20	0.006578947	152

Table 4. Digital "camera pixel element size" for canon EOS 1D X mark II.

Camera resolution (pix)	Pixel element size (mm/pix)	Focal length (mm)	GSD (cm)
Canon S100			
4000 × 3000	0.0019	5.2	11
		26.0	2.2
Sony Alpha A6000 + 16–50 mm kit lens			
6000 × 4000	0.003916667	16.0	7.3
		50.0	2.35

Table 5. The GSD value of canon S100 and Sony Alpha A6000 at $Hg = 300$ m.

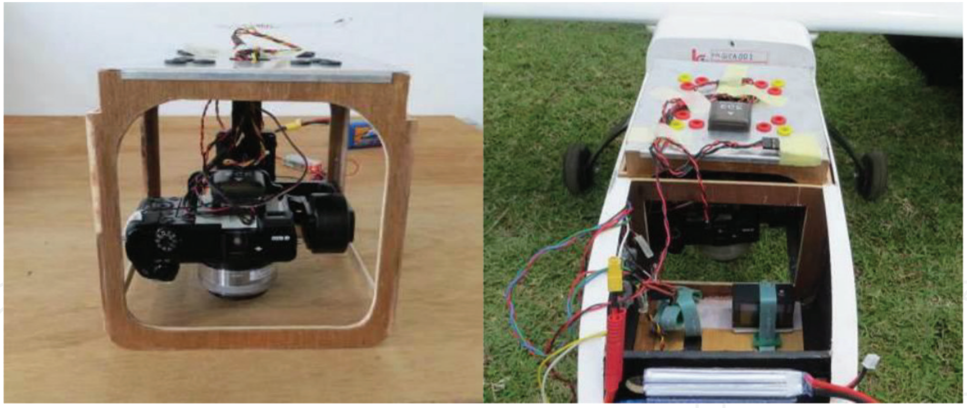

Figure 7. Left: the Sony Alpha A6000 attached in the gimbal. The gimbal is installed in the payload cage; right: the payload cage location at the LSU-02 fuselage.

for pointing downward. With the gimbal, the photograph is guaranteed to have a vertical orientation. The gimbal is attached to the payload cage that also has a rubber for damp the vibration for engine as shown in **Figure 7**. With the gimbal and the damper, the aerial photograph results of LSU-02 and LSU-03 are better compared with the LSU-01.

3. Lapan surveillance UAS mission

3.1. Aerial photography for volcanic mountain mapping

On 17 October 2014, the LSU-01 performed an aerial photography mission for creating 3-D photography of mount Merapi peak. Mount Merapi is the most active volcano mountains in the Java Island. The customer of this mission is Pusat Studi Bencana Alam (PSBA) Gadjah Mada University. The PSBA uses the data for post-disaster management. They analyze the scale of destruction if the mount Merapi erupts again based on the current crater condition. The new crater was created since the last mount Merapi eruption in 2010.

Before performing the mission, some preparations shall be done such as selection of the UAS, flight planning, camera selection, and image processing technique for creating 3-D photography.

The UAS selection shall examine the environment condition before making a decision. The environment is an active volcano and constantly vomiting the volcanic ash. The volcanic ash is one of the threats to the internal combustion engine; therefore, utilizing the LSU families with an internal combustion engine are not reasonable for this mission. The mission uses the LSU-01 because only the LSU-01 utilizes an electrical engine as primary thrust generator.

In order to capture the Mount Merapi, the LSU-01 shall fly 300 m above the mountain, meaning the UAS flies at 3200 m above mean sea level. However, the highest terrain (base camp) that reachable by the team has an altitude of 1050 m above mean sea level as shown in **Figure 8**. Consequently, the LSU-01 shall climb 2150 m to enter the mission altitude. The slant range from the base camp to the mountain peak is 4 km. The LSU-01 takeoff and landing from the base

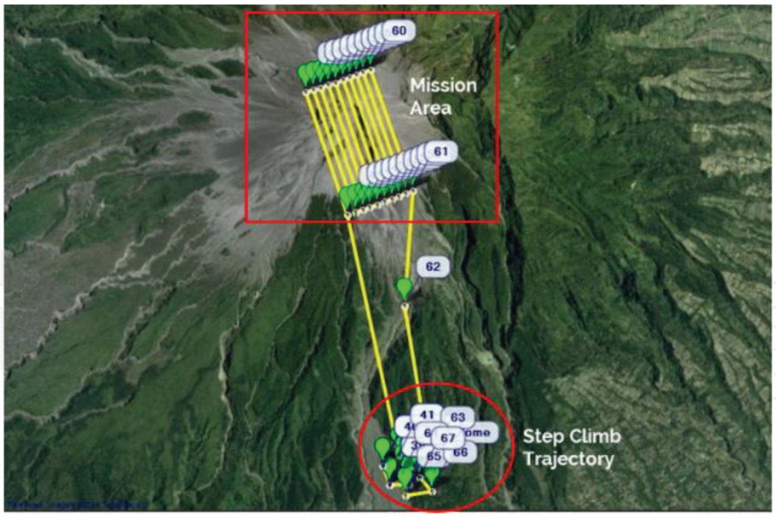

Figure 8. Flight planning for the mount Merapi mission. The red circle shows the waypoint for step climb from 1050 to 3000 m, while the red square shows the mission area at altitude 3200 m.

camp. The LSU-01 take off and climb to the 3000 m altitude using step climb method in circle trajectory. After reaching the 3000 m altitude, the LSU-01 flies 3.5 km and 200 m altitude to enter the mission altitude. At the mission altitude, a strong headwind cause the LSU-01 cannot move forward; hence, the team decides to change the waypoint on demand using telemetry system.

The mission uses Canon S100 camera mounted in the LSU-01 camera bay and equipped with the gimbal and vibration damper. The camera shutter speed is 3 s and the total flight time is 46 min. During this mission, the camera captures 275 raw aerial photos. The Agisoft PhotoScan software was used to process the raw aerial photos. **Figure 9** shows the result of this mission.

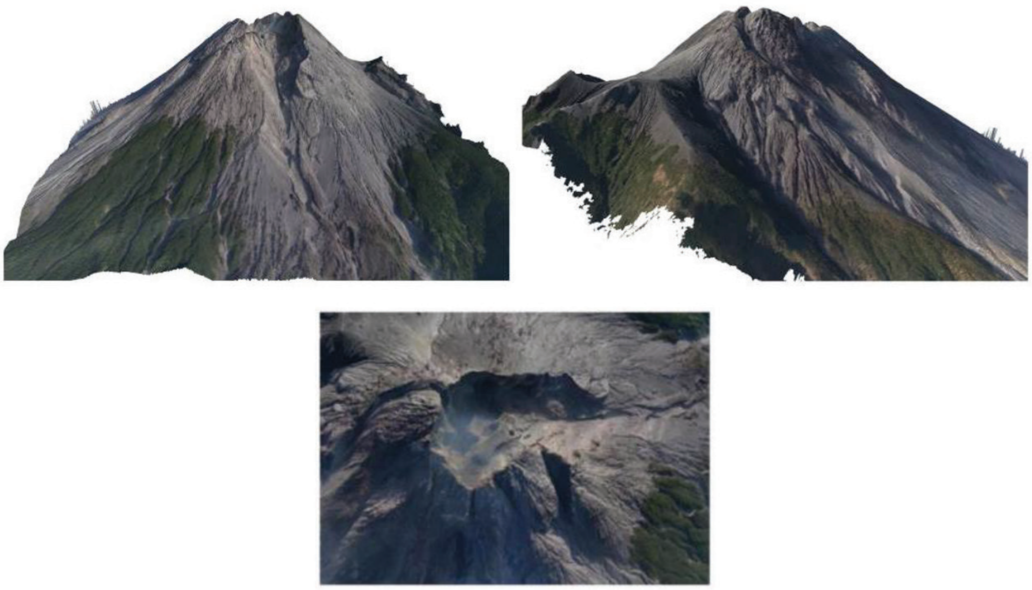

Figure 9. Top left and right: isometric view of mount Merapi peak, bottom: top view of mount Merapi peak shows the crater area.

3.2. Aerial photography for landslide disaster

The landslide is happening in Indonesia infrequently. However, once it is happening, the number of victims is quite high. One of the examples is the landslide disaster at Banjarnegara on 18 December 2014. Based on the information from the search and rescue team, there are three known locations of the landslide. The first location classified as the major landslide, the second classified as imminent landslide due to earth crack occurrence, and the third classified as the potential landslide. **Figure 10** shows the relative position between basecamp and the landslide area. The distance between the basecamp and the landslide location is around 2 km, while the altitude of the basecamp is 1023 m MSL. The aerial photography mission shall produce aerial photo that covers the major landslide, imminent landslide, and potential landslide location. The aerial photography is needed by Indonesian National Board for Disaster Management to identify the greatness of the disaster and planning the evacuation scheme for the search and rescue team.

The basecamp does not have any appropriate runway. As shown in **Figure 11** (top-left), the only grass field is available. Therefore, the LSU without landing gear is preferable for this mission. The LSU-01 is the only one who does not have a landing gear hence, the team selects the LSU-01 for this mission. After analyzing the landslide area, the LSU-01 is capable of taking the required aerial photography in one flight. The mission uses Canon S100 camera mounted in the LSU-01 camera bay and equipped with the gimbal and vibration damper. **Figure 11** shows the flight plan for this mission.

In order to capture the landslide area, the LSU-01 shall fly 300 m above ground level (AGL). We assume the altitude at landslide area is equal to the basecamp altitude. It means the LSU-01

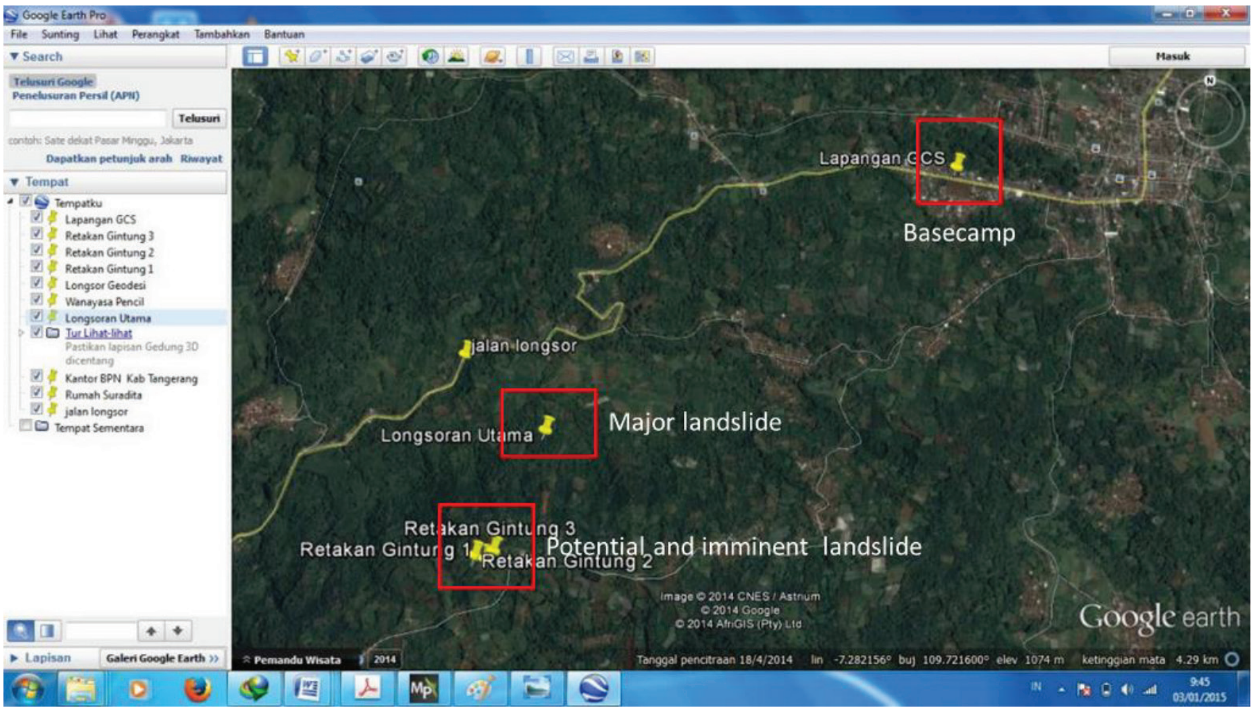

Figure 10. Relative position between the basecamp and the landslide position.

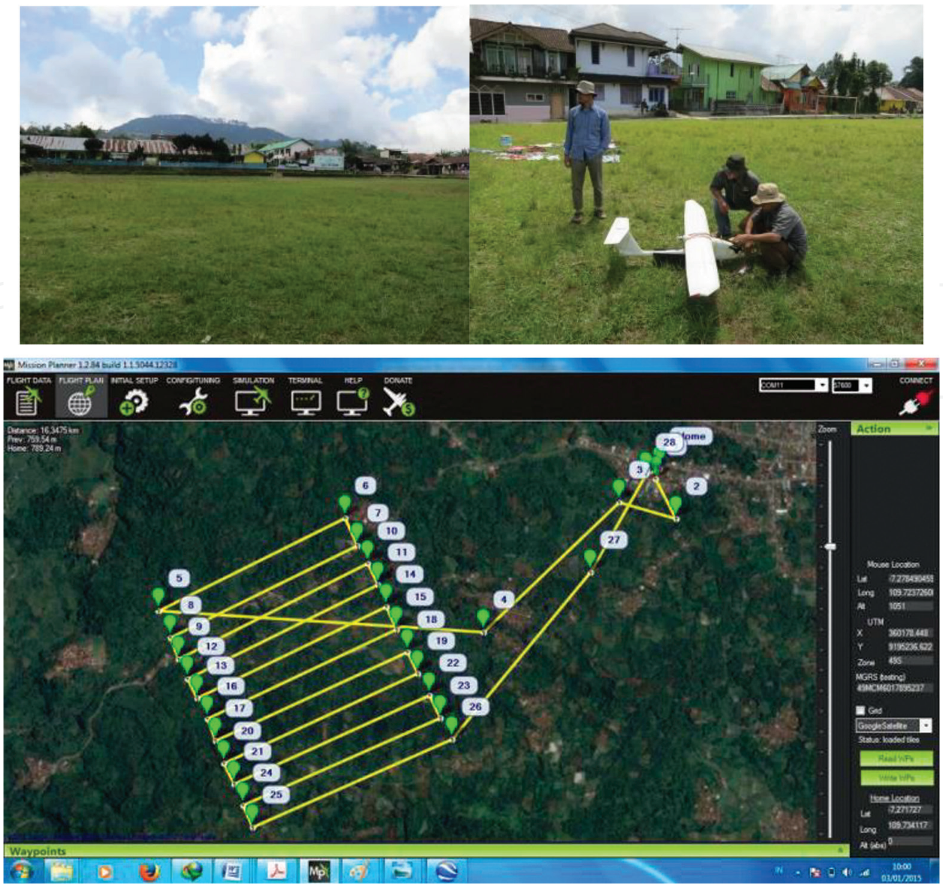

Figure 11. Top left: basecamp condition shows no appropriate runway for takeoff and landing of the LSU, top-right: pre-flight inspection, bottom: flight plan of the landslide mission shows 28 waypoints in total.

shall climb from altitude 1023 m MSL to the 1323 m MSL. The climb phase uses the step climb method from altitude 0 to 80 m AGL (waypoint 2), 80 to 200 m AGL (waypoint 3), 200 to 250 m AGL (waypoint 4) and finally 250 to 300 m AGL (waypoint 5). After reaching the mission altitude, the LSU-01 captures the aerial photography in 11 photographic path (waypoint 5–26). Using this scenario, the LSU-01 able to produce aerial photo that cover the major landslide, imminent landslide, and potential landslide location. **Figure 12** shows the result of this mission. The affected area of the landslide is large. The landslide hit the roads, buried 35 houses and more than 100 peoples [15].

3.3. Aerial photography for mapping the Indonesian army exercise zone

The Indonesian armed force has many exercise zones to train their soldier. One of the exercise zones located in the North Sumatra is called as "daerah latihan tempur Negeri Dolok Kodam I Bukit Barisan." The Indonesian armed force needs the topography map of the exercise zone. The map shall have good quality and good accuracy. Therefore, Indonesian armed force asks the aeronautic technology center for support.

The initial survey indicated that the total mission area is 12,200 hectares. The takeoff and landing place is available too. However, the farthest distance from takeoff and landing place to the mission area is 30 km, while the shortest is 15 km. The UAS shall fly 30 km to the mission area

http://dx.doi.org/10.5772/intechopen.76426

Figure 12. The landslide in Banjarnegara, 18 December 2014.

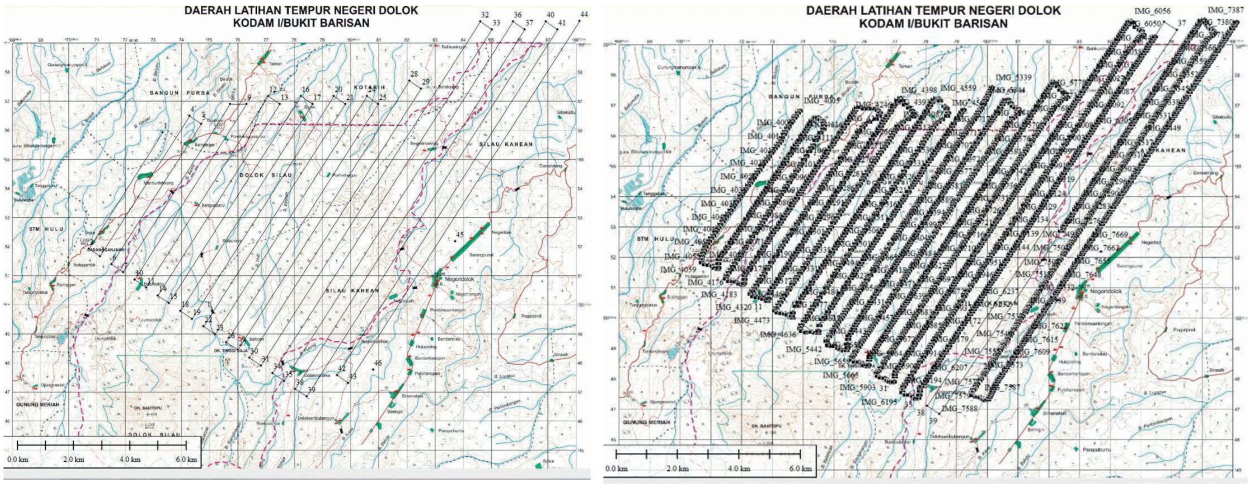

Figure 13. Left: the flight planning of the LSU-02 aerial photography mission show 44 waypoints in total; right: the photography data that captured during this mission.

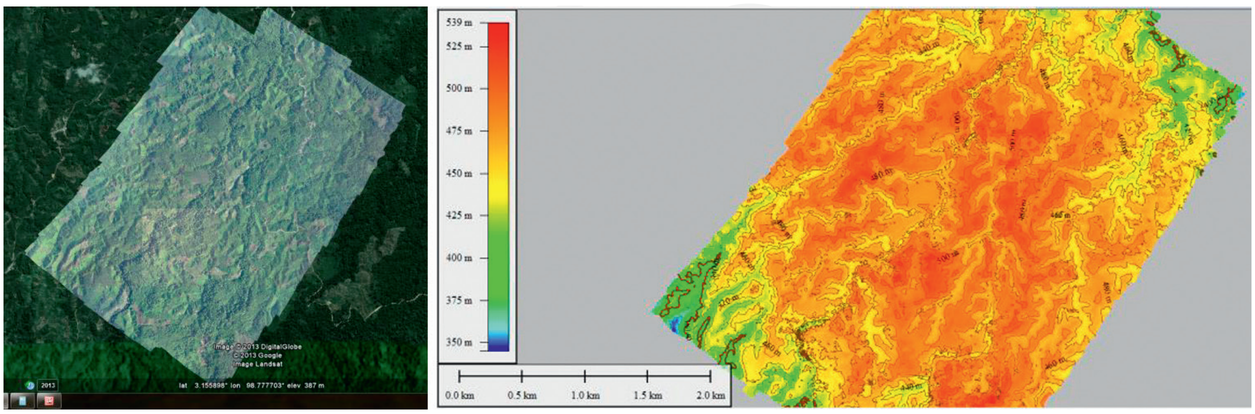

Figure 14. Left: the topography map of the exercise zone; right: the contour map of the exercise zone.

and starting the mission. Based on this situation, The LSU-02 is the best option for handling the mission due to its ability to cover 2500–3000 hectares mission area within one sortie of flight (**Figures 13** and **14**).

Flight sortie	Flight endurance (min)	Fuel available (L)	Total fuel consumption (L)	Flight distance (km)	Fuel consumption / 100 km (L)
First	112	2.5	2.25	126	1.78
Second	84	3.5	1.05	126	0.83
Third	100	3.5	1.80	137	1.31
Fourth	62	2.5	1.30	102	1.27

Table 6. The fuel consumption and flight distance for each flight sortie.

The LSU-02 flies four times to cover the whole mission area at the flight altitude of 300 m. The Sony Alpha A6000 is installed inside the LSU-02 payload bay during this mission. The fuel consumption for each mission sortie is recorded too. **Table 6** shows the fuel consumption as well as flight duration for each mission sortie.

In total, there are 44 waypoints that divided into four flight sortie during this mission. The numbers of photographs are 3348. **Figure 14** shows the result of this mission.

4. Conclusion

With the increase of UAS usage in civilian world, the Aeronautics Technology Center has the important role to keep the contribution in these sectors. The contributions such as the research and development of UAS platform, as well as the dissemination of the research product to the civil world are continuously performed. The capability of LSU family will be improved and upgraded proportioned with the trend and need in civilian world. This chapter only shows a little part of LSU family research, development and dissemination activity that was done by the Aeronautics Technology Center.

Acknowledgements

The authors would like to thank the National Institute of Aeronautics and Space (LAPAN) for the financial support.

Conflict of interest

The authors whose names are listed in this chapter certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Appendices and nomenclature

AGL	above ground level
APM	Ardu Pilot Mega
COTs	commercially out of the self
ENSO	El Niño/southern oscillation
GPS	global positioning system
GSD	ground sampling distance
LALE	low altitude, long endurance
LASE	low altitude, short endurance
LSU	LAPAN surveillance UAS
MHz	megahertz
MSL	mean sea level
PSBA	Pusat Studi Bencana Alam
RC	radio control
SFAP	small-format aerial photography
UAS	unmanned aircraft systems

Author details

Fuad Surastyo Pranoto*, Ari Sugeng Budiyanta and Gunawan Setyo Prabowo

*Address all correspondence to: fuad.pranoto@lapan.go.id

Indonesian National Institute of Aeronautics and Space (LAPAN), Aeronautic Technology Center, Bogor, Indonesia

References

[1] Lee HS. General rainfall patterns in Indonesia and the potential impacts of local seas on rainfall intensity. Water. 2015;**7**:1751-1768. DOI: 10.3390/w7041751

[2] Asian Development Bank. Indonesia Country Water Assessment. Manila: ADB; 2016. pp. 3-5. E-ISBN: 978-92-9257-361-4

[3] Ministry of Environment. Status Lingkungan Hidup Indonesia 2012. Jakarta: Ministry of Environment; 2013

[4] The World Bank. Indonesia, the Rise of Metropolitan Regions: Towards Inclusive and Sustainable Regional Development. Jakarta: National Development Planning Agency; 2013. pp. 10-12

[5] Case M, Ardiansyah F, Spector E. Indonesia, Climate Change in Indonesia. Jakarta: WWF. pp. 01-13

[6] Pribadi KS, Kusumastuti D, Rildove. Learning from recent Indonesian earthquakes: An overview to improve structural performance. In: Proceedings of the 14th World Conference on Earthquake Engineering; 12-17 October 2008; China, Beijing: WCEE; 2014. pp. 1-8

[7] Miyamoto HK, Gilani AS. Recent earthquakes in Indonesia and Japan: Observed damage and retrofit solutions. In: Proceedings of the 14th World Conference on Earthquake Engineering; 12-17 October 2008; China, Beijing: WCEE; 2014. pp. 1-8

[8] Aber JB, Marzolff I, Ries JB. Small-Format Aerial Photography: Principles, Techniques, and Geoscience Applications. 1st ed. Oxford: Elsevier; 2010. pp. 15-25. ISBN: 978-0-444-53260-2Ch2

[9] Hickin EJ. Maps and Mapping. A Cartographic Manual. Burnaby: R.S. Graphics and Printing; 2014. pp. 74-76. Ch7

[10] Neumann KJ. Digital Aerial Camera [Report]. Aalen: Deutchland Integraph Z/I GmbH; 2006

[11] Pranoto FP, Prabowo GS. Economic analysis of small format aerial photography mission utilizing the LSA-01 UAV. International Journal of Unmanned Systems Engineering. 2015;**3**:31-39. DOI: 10.14323/ijuseng.2015.11

[12] Canon EOS-1D X Mark II [Internet]. Available from: https://downloads.canon.com/nw/camera/products/eos/1d-x-mark-ii/specifications/canon-eos-1dx-mkii-specification-chart.pdf [Accessed: May 03, 2018]

[13] Canon PowerShot S100 [Internet]. Available from: https://en.wikipedia.org/wiki/Canon_PowerShot_S100 [Accessed: May 03, 2018]

[14] ILCE-6000 [Internet]. Available from: https://www.sony.com/electronics/interchangeable-lens-cameras/ilce-6000-body-kit/specifications [Accessed: May 03, 2018]

[15] Satu Dusun Tertimbun Tanah Longsor di Banjarnegara, Jawa Tengah [Internet]. 2014. Available from: https://www.voaindonesia.com/a/satu-dusun-tertimbun-di-banjarnegara-jawa-tengah/2557623.html [Accessed: January 03, 2018]