Assessment Analysis Based on SORA on IA-25 Drones for Cargo Delivery

Rafika Arum Sari[1], Hisar M Pasaribu[2]

{rafika@unsurya..ac.id[1], hmpasaribu@ae.itb.ac.id[2]}

Faculty of Aerospace Technology, Air Marshal Suryadarma University, Jakarta, Indonesia[1]
Mechanical and Aerospace Engineering, Institut Teknologi Bandung, Bandung, Indonesia[2]

Abstract. With increasingly advanced developments, the military generally uses cargo drones. Cargo drones are used for goods delivery services for civil society. The IA-25 drone is the drone that will carry out the mission of shipping goods from Jakarta to Bandung. This delivery mission is a specific operation, so it is necessary to carry out a risk assessment to ensure that the aircraft can fly safely. Risk assessment begins using the instructions and methods in the SAEARP-4761 explains the safety assessment process for civil aircraft. Obtained risk from the safety assessment process becomes the basis for carrying out Specific Operation Risk Assessment (SORA) on the mission of delivering goods with operations BVLOS on the IA-25 Drone obtained the result that the aircraft can fly safely but has a relatively high risk. Hence, it needs to be ascertained level safety when the aircraft performs operations.

Keywords: SORA, Cargo Drone, Risk Assessment

1 Introduction

Technology development is increasingly advanced, especially in aviation which affects human life. Unmanned Aerial Vehicles (UAVs) are one example of growing technology. UAVs have increasingly evaluated missions from milter to logistics in shipping—general shipping goods using transportation such as motorcycles, cars, and trucks for land routes on shipments between cities and for inter-island shipping generally using ships or aircraft. Such transportation has many obstacles, such as congestion, slow delivery, and overload in the delivery process. UAVs supply solutions to problems that occur in the delivery process. Utilizing UAV technology can ship goods to densely populated areas to minimize the delay in goods. The use of UAVs in the delivery of goods needs to follow the rules applicable to flights on CASR 107, 91, 21, and 22. On freight forwarding missions, it is necessary to review the UAV to minimize the risks that may occur when the UAV is in operation and to find out if it is safe while operating. Performing risk analysis allows, on the one hand, the improvement of the safety of the process, enabling a quick response if an error or failure and cooperation with

AVINER 2023, November 08-09, Jakarta, Indonesia

DOI 10.4108/eai.8-11-2023.2346010

manned aviation, and on the other hand, reduction in the risk of failure or an operator's error. Safety risk assessment is one way to analyze the hazards that can occur in drones.

2. Materials and Methods

2.1 Flight operations

Flight Operations are the guidelines used to make flights. Flight operations are divided into the operating profile and the type of operation. The active profile is a process during flight. Type of operation In a variety of Operations used in aviation operations, there are types of procedures for UAVs, as follows:

a. VLOS (Visual Line of Sight)
   VLOS is an operation where the remote pilot can operate the UAV in its visibility at 500 m horizontally from the remote pilot [1].
b. BVLOS (Beyond Visual Line of Sight)
   BVLOS is a UAV operation without visual contact with a UAV without vision aids, including pilots and observers [2].
c. EVLOS (Extended Visual Line of Sight)
   EVLOS is a remote operation pilot not performing visual contact and without visual aids, but using a visual observer can monitor the flight path [2].

2.2 Unmanned Aerial Vehicle (UAV)

A UAV or drone is an unmanned vehicle using a remote as a control field with a mission in every operation. EASA creates category levels based on their risks, as follows [3]:

a. Open Category
   This category has the lowest risk and has almost no specific regulation.
b. Specific Category
   This type of category is at an intermediate risk level, providing maximum length and weight.
c. Certified Category

This category has a direct risk to humans compared to other types of traditional aviation.

UAVs have various models, such as fixed-wing, tilt-wing, unmanned helicopters, and multi-copter. The four most widely used UAV models are fixed-wing and multi-copter. These two types give rise to a new type of UAV that is combined, called the VTOL hybrid so that the ability of two UAV models becomes one.

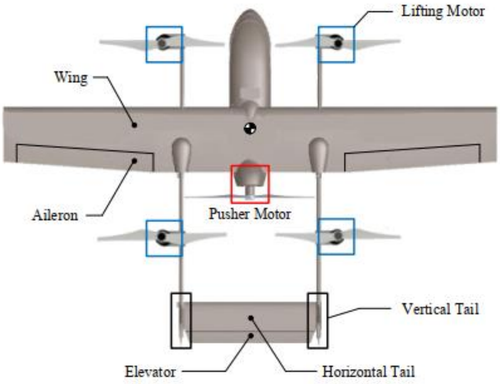

Figure 1. Fixed-Wing Hybrid VTOL [4]

2.2.1 Cargo drone

Cargo drones usually referred to as delivery drones are a cost-effective and time-effective solution for sending packages in densely populated environments or hard-to-reach areas.

2.3 UAV Regulations

UAV operations have three certifications and regulations: CASR 22, CASR 91, and CASR 107. CASR 22 describes the airworthiness standards for sailplanes, power sailplanes, and aerobatic maneuvers. CASR 91 describes general operating, flight regulations, and operating limitations for aircraft that have experimental certificates. Moreover, CASR 107 describes the system for small Unmanned Aircraft. Namely, the speed limit should not exceed 100 miles/hour, visibility from the observation site should be less than 4.8 km, and the minimum distance from the cloud should be less than 150 m below the cloud, 600 m horizontally away from the cloud, and the weight limit cannot be more than 25 kg [1], [2], [5].

2.4 Safety Risk Assessment

The UAV safety risk assessment identifies and assesses active and latent safety hazards for drone operations . To carry out a risk assessment, one of the methods used is safety operation. Safety risk assessment includes mitigation measures to predict the likelihood and severity of operational risks [6].

2.5 SORA (Specific Operation Risk Assessment)[7]

SORA aims to assist in the creation, evaluation, and safe conduct of UAS, and provide a level of confidence that certain operations can be conducted safely. The use of SORA is used for the assessment of operations outside of existing regulations. The IA-25 aircraft uses SORA, as it is a special case (special class). Although the IA-25 is in the process of obtaining a type certificate from the Directorate of Airworthiness and Operation of Aircraft (DKPPU), not all operating capabilities can be applied due to infrastructure limitations and operating limitations applied by the Directorate of Flight Navigation (DNP). Therefore, the IA-25 aircraft will temporarily be operated with a specific operating pattern. Thus, requiring a safety assessment and risk mitigation based on operations. SORA can also be used for waiving applicable regulatory requirements if the operations performed demonstrate an acceptable level of safety. of acceptable safety.

The risk assessment not only considers the risk to the operation but also the operator responsible for the performance and characteristics of the UAS. responsible operators with the performance and characteristics of the UAS itself. itself. One way to comply with this is by using the SORA methodology suggested by JARUS.

The risk mitigation methods themselves can be classified differently, so SORA distinguishes into several groups based on the type of UAS operations performed and the place called operational safety objectives (OSO), as follows:

- UAS with technical problems
- Damage to external systems supporting UAS operations.
- Human resource errors
- Adverse operating conditions

In the SORA process, it is important to understand the concept of robustness. Robustness means that any given risk mitigation can be demonstrated at different levels. SORA proposes that there are three different levels of robustness, namely Low/None, Medium, and High with corresponding risks. SORA provides a process for analyzing proposed ConOps (Concept of Operation) and establishing sufficient confidence that the operation can be performed with acceptable risk data.

Phase One of the SORA process contains the technical, operational, and system aircraft information required to assess the risks associated with the operation. Subsequently, the UAS information and characteristics are used to perform the subsequent risk assessment stage. In the SORA process, chances are divided into ground and air risks. The ground risk process is a qualitative estimation of the risk to people and infrastructure on the ground that will be exposed to UAS. This risk is divided into two methods: determining the Ground Risk Class (GRC) and determining the result of the GRC. Choosing the GRC in the SORA process is in the second stage. At this phase, analyze to determine the initial value of GRC. The analysis begins by defining the characteristic dimensions of the UAS, generally represented by the wingspan or rotor diameter of the UAS. Next, by determining the kinetic energy value UAS must decide the energy that is generated if the aircraft falls, using the equation,

$$\boldsymbol{E_k = \frac{mv^2}{2}} \quad (1)$$

Table 1. Ground Risk Class [7]

Intrinsic UAS Ground Risk Class				
Max UAS Characteristic	1 m/ approx. 3ft	3 m/ approx. 10ft	8 m/ approx. 25 ft	>8 m/ approx. 25 ft
Typical kinetic energy expected	<700J (approx. 529 ft Lb)	<34 KJ (approx. 25000 ft Lb)	<1084 KJ (approx. 800000 ft Lb)	>1084 KJ (approx. 800000 ft Lb)
Operational scenarios				
VLOS/BVLOS over the controlled ground area	1	2	3	4

VLOS is a sparsely populated environment	2	3	4	5
BVLOS in sparsely populated	3	4	5	6
VLOS in a populated environment	4	5	6	8
BVLOS in a populated environment	5	6	8	10
VLOS over a gathering of people	7			
BVLOS over the gathering of people	8			

Table 2. Mitigation of Ground Risk [7]

		Robustness		
Mitigation Sequence	**Mitigation of Ground Risk**	**Low/none**	**Medium**	**High**
1	M1 - Strategic mitigation for ground risk	0: None -1: Low	-2	-4
2	M2 - Effect of ground impact is reduced	0	-1	-2
3	M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	1	0	-1

The type of operation to be performed is determined after determining the characteristic dimensions and energy generated in the UAS. This type of operation is obtained from the information in the first phase. The third phase determines the final value of the GRC. At this phase, ground risk will be analyzed based on its mitigation.

$$\mathbf{FINAL\ GRC = Intrinsic\ GRC + GRC_{M1} + GRC_{M2} + GRC_{M3}}$$

The results at this phase are considered necessary as they determine whether the SORA process continues. If the final GRC result exceeds 7, the aircraft cannot use the SORA process. Furthermore, the Air risk process describes the qualitative risk of experiencing a mid-air collision with a civil aircraft. Competent authorities in the field of space service provision can directly map the risk by studying the characteristics of the airspace. This process falls into the fourth stage of the SORA process. The results of the ARC are analyzed to assess whether the ARC value set is appropriate or too high. Appropriate or too high, if the results obtained are appropriate, then the ARC value that has been determined will become the residual ARC. The value will become the residual ARC. Residual ARC in the SORA process goes into the Fifth phase. The sixth stage is the Tactical Mitigation Performance Requirement (TMPR) and Robustness Level. This stage determines the mitigation that will be carried out based on the results of the ARC. Based on the results of the ARC. This process is only used if the aircraft uses operations other than VLOS.
Furthermore, from the SORA process, namely the Seventh stage, determining the value of the Specific Assurance and Integrity Level (SAIL).

Table 3. SAIL [7]

SAIL Determination				
	Residual ARC			
Final GRC	**a**	**b**	**c**	**d**
≤2	I	II	IV	VI
3	II	II	IV	VI
4	III	III	IV	VI
5	IV	IV	IV	VI
6	V	V	V	VI
7	VI	VI	VI	VI
>7	Category C operation			

The SAIL classification evaluates safety in operations in the eighth phase, namely operational safety objectives (OSO). The OSOs are divided into four sections based on the mitigation. Each OSO will determine the level of robustness based on the results of SAIL, where O is optional, L is the level of optional, L is the Low Robustness level, M is the Medium Robustness level, and H is the High Robustness level.
The OSO results will be mitigated following the operations and missions to be carried out by the aircraft. Next, the Ninth stage is to determine the area of operation to reduce violations that may occur in airspace and land areas. Finally, the Tenth stage is to analyze all the stages in SORA to determine whether the aircraft can operate safely and follow applicable regulations.

3. Result and Discussion

Stage One of the SORA process contains the technical, operational, and system aircraft information required to assess the risks associated with the operation. The operation that will be carried out on the IA-25 aircraft is the delivery of goods from the JNE Warehouse in Jakarta to the JNE Center in Bandung 108.91 km. The type of UAS used is hybrid UAS VTOL, which is a combination of two types of UAS, namely a combination of fixed-wing and multi-copter with a VTOL system. This operation uses BVLOS (Beyond Visual Light of Sight), which is a type of UAS operation without direct contact with the aircraft. UAS operation without direct contact with the aircraft and visual aids, including remote pilot and visual including remote pilots and visual observers.

This stage explains the primary risks of UAS related to a person's risk of developing UAS. First, the dimensional characteristics of the UAS, namely the longest distance between the front and rear rotors. Second, the kinetic energy value of the IA-25 aircraft. Finally, it determines the operation scenario that will be carried out on the IA-25 aircraft, in this case, the delivery of goods. The first stage determines the dimensional characteristics of the UAS; on the IA-25 aircraft, the longest distance between the rotors is 1489 mm or 1.489 m .

After obtaining the characteristic value, they continued in the second stage to determine the kinetic energy with the result of 6050 Joules or 6.05 KJ. The last stage determines the desired operating scenario adjusted to the mission to be carried out. Operations tailored to the mission will be carried out on the UAS. on the UAS. In this case, the IA-25 aircraft will carry cargo from JNE Kokesma ITB, Bandung, to JNE Warehouse, Jakarta using BVLOS operation. Using BVLOS operations, it was decided that the operating scenario was a flight in a densely populated area. The scenario is a flight in a densely populated area with BVLOS operations.

Third stage, after obtaining the intrinsic value of GRC, an analysis is carried out to determine the number of mitigations at ground risk and provide the right level of robustness. The first mitigation value, or M1, is mitigation to reduce the number of people at risk. The IA-25 aircraft has a mission to deliver goods with an operation scenario flying over a densely populated area. Thus, the robustness level used in the operation scenario is medium. The second mitigation, or M2, explains reducing the effect of a collision on the ground when the UAS control is lost. In this mitigation, the robustness level used is medium, based on the integrity and assurance levels, by considering failures in UAS manufacturing and function. The last mitigation, or M3, is a plan that must be established when there is a loss of control during operation, known as an Emergency Response Plan (ERP). In the last mitigation, the appropriate robustness level is medium, considering the management plan. The class is medium, considering the management plan for UAS.

Table 4. Robustness

		Robustness		
Mitigation Sequence	**Mitigation of Ground Risk**	Low/none	Medium	High
1	M1 - Strategic mitigation for ground risk	0: None -1: Low	-2	-4
2	M2 - Effect of ground impact is reduced	0	-1	-2
3	M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	1	0	-1

$$\text{FINAL GRC} = \text{Intrinsic GRC} + \text{GRC}_{M1} + \text{GRC}_{M2} + \text{GRC}_{M3}$$
$$\text{FINAL GRC} = 6 + (-2) + (-1) + 0$$
$$\mathbf{FINAL\ \ GRC = 3}$$

In the fourth stage, the Air Risk Class determines the risk of collision with other aircraft due to using the same air space. The ARC process of the IA-25 aircraft flies more than 500 ft AGL but less than FL600 and operates in uncontrollable areas above urban areas, so the ARC-c result is obtained, which means that the risk of collision with passenger aircraft is quite considerable. This fifth stage ensures that the value assigned to ARC is correct. In this case, the ARC assigned in phase 4 is appropriate based on the analysis that has been done, so the residual ARC value remains the same, namely ARC-c. At this stage, TMPR aims to reduce the risk of residual mid-air collisions so that the safety of the applicable region can be achieved. TMPR can help pilots detect crewed aircraft and avoid aircraft traffic in BVLOS operations, by combining the results of the residual ARC carried out in stage 4 and stage 5, the TMPR result is medium, and the TMPR level of robustness is medium. The greater the residual ARC value, the greater the TMPR. Medium TMPR helps pilots perform operations because it is supported by a system for detecting civil aircraft or a system designed to support flights at a high level. Support flight with an appropriate level of robustness.

At this stage, SAIL parameterizes the combined analysis of ground and air risk to keep drone operations under control. Risk and air risk so that drone operations remain under control. At stage 3, the final GRC value of 3, and at stage 5, the value of the residual ARC is ARC-c, so SAIL is obtained at level IV. The final stage of SORA creation is identifying OSOs based on the SAIL results. The ninth stage addresses the risks of uncontrollable operations that result in ground or airspace violations. Some of the risks that result in airspace or ground violations are as follows: Loss of aircraft and operator communication signals, GPS signal interference, GPS reception failure, poor flight plan, and GCS failure. On the IA-25 aircraft, the geofencing function is used, strengthening the signal transmitter and receiver to be more vital to avoid signal blocking from foreign objects, such as tall buildings.

4. Conclusion

Based on the results of the risk assessment analysis on the IA-25 aircraft using SORA, SORA is considered to have a high risk, with a medium level. Relatively high, with a medium level. The results of this assessment are considered quite dangerous for goods delivery missions using BVLOS operations. The analysis results with SORA obtained a GRC value of 3 and an ARC value with ARC-c. This condition is a reference to get a SAIL value of IV. The OSO results are used to mitigate the risk of operations on the IA-25 aircraft, such as conducting training on the crew, conducting inspections before and after the aircraft operates, conducting inspections in the form of documentation, creating an operation module for emergencies, and having a monitoring station.

References

[1] DKPPU, "Easy Access Rules for Sailplanes and Powered Sailplanes (CS-22) (Amendment 2)," 2018.

[2] DKPPU, "Peraturan Keselamatan Penerbangan Sipil Bagian 107 (Civil Aviation Safety Regulations Part 107: Small Unmanned Aircraft SYSTEM)," 2015.

[3] EASA, "UAS Prototype Regulation final," *'Prototype' Commission Regulation on Unmanned Aircraft Operations*, pp. 1–72, 2016.

[4] H. Gu, X. Lyu, Z. Li, S. Shen, and F. Zhang, "Development and experimental verification of a hybrid vertical take-off and landing (VTOL) unmanned aerial vehicle(UAV)," in *2017 International Conference on Unmanned Aircraft Systems (ICUAS)*, IEEE, Jun. 2017, pp. 160–169. doi: 10.1109/ICUAS.2017.7991420.

[5] DKPPU, "PART 91 General Operating And Flight Rules Republic Of Indonesia Ministry Of Transportation," 2010.

[6] SAE, "SAE ARP4761 Guidelines And Methods For Conducting The Safety Assessment Process On Civil Airborne Systems And Equipment," U.S.A, 1996.

[7] JARUS, "Joint Authorities for Rulemaking of Unmanned Systems JARUS guidelines on Specific Operations Risk Assessment (SORA)," 2019. [Online]. Available: http://jarus-UAS.org