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Abstract. The implementation of aviation safety regulations for aircraft design aims to minimize the occurrence of errors in the design process which ultimately can have an impact on the safety aspects of the aircraft. Aviation safety regulations for aircraft design regulate how to comply aircraft certification procedures. Civil aviation safety regulations are applied to manned aircraft and unmanned aircraft. The level of safety of this unmanned aircraft has not been much proven by the type certificate. In Indonesia there are three products certified by IMAA (Indonesian Military Airworthiness Authority). The regulations of unmanned aircraft are not declare clearly contained in CASR , the designers must be careful in choosing which regulations can be used to design. The Aeronautics Technology Center is currently developing an unmanned aircraft with a wingspan of 5.5 meters called LSU-05 NG . This series will be drafted with a design document that accommodates regulations. This paper aims to make documents complied the regulations by choosing regulations can be applied to unmanned aircraft.

INTRODUCTION

Unmanned Aerial Vehicles (UAVs) describe as drones, robot planes, pilotless aircraft, remotely piloted Vehicles (RPVs), and other terms which aircraft that fly under the control of an operator with no person aboard.[1] UAV now have a recent technological improvement and various application capabilities present challenges to flight operator, end user and aviation authorities. To minimize the risk of UAV incident, an increasing number of national and international authorities have introduced legal provision that mandate “go” or “no go” statement that allow, prohibit, or restrict flight operation. UAV regulation are still embryonic and heterogeneity of national rules and varying levels of implementation.[2] In the united states, FAA oversees both manned and unmanned aircraft operation, providing regulations and guidance on airspace restriction, pilot requirements, and equipment and performance requirements. FAA conducts a comprehensive operational and technical review, if necessary, provision or limitations may be imposed as part of the approval to ensure the UAS can operate safely with other airspace users.[3]

Certification, as the ‘legal recognition’ of the level of intended functions and other attributes of a system, is important for regulatory bodies, developers, and end-users. In the aerospace domain, formal certification has long been required and practiced for aircraft and systems that implement the aircraft functions to confirm that their design, maintenance and operation are acceptably safe.[4]

In the Australian CASA (Civil Aviation Safety Authority) FAR (Civil Aviation Safety Regulation) Part -21 based on CASA AC (advisory Circular) 21 -60 in 1998 established in 2005 called Project CS 05/01. It certification related to the design, manufacturing, and airworthiness of UAVs’ had main results of AC 21-43. In 2011 there is a new circular called AC 21-10 defining airworthiness certification procedure for Experimental Certificates dealing with airworthiness certification of the experimental aircraft, and this work has been finished[5] in 2012. The implementation of safety regulation in small aircraft in Indonesia are using Civil Aviation Safety Regulation (FAR) part 23. FAR 23

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in category Airworthiness Standard: Normal, Utility, Acrobatic, and Commuter Category Airplanes. FAR Part 23 was developed to specify the airworthiness standards for small aero-plane. For developing unmanned aircraft vehicles (UAVs) Indonesian government using FAR Part 23 amandement 64. On the basis that most UAVs will require Certificates of Airworthiness, the next task is to explore how airworthiness requirements appropriate to UAVs will be developed and administered.[6]

In this paper, a selection of regulations will be conducted in the structure, powerplant & electronic section. This study will be discussed and explains the regulation aspects that will be used on unmanned aircraft (in respect of design and construction), providing the industry with further guidance on airworthiness standards that LAPAN will apply to UAVs.

LITERATURE REVIEW

Aviation Law No. 1/2009[7]

According to Aviation Law No. 1/2009, there are explanations for several definitions regarding:

Chapter I General Provisions

Article 1

Airplane is an aircraft heavier than the air, having fixed wings, and can fly with its own power.

Airworthiness means compliance to requirements on design of aircraft type and in a safe condition for operation.

Chapter IV Aircraft Design and Production

Part One Aircraft Conceptual Design

Article 13

(1) Any aircraft, any aircraft engine, and any airplane propeller to be produced and eligible for utilization must have a conceptual design.

(2) The conceptual design of aircraft, aircraft engine, and airplane propeller as meant in item (1) must have an approval letter from the Minister after its airworthiness standard has been examined and tested.

(3) The examination and testing as meant in item (2) must fulfil airworthiness standard requirements stipulated under provisions of the law and regulations.

Article 14

Every person conducting any activity on conceptual design of an aircraft, aircraft engine, and airplane propeller as meant in Article 13 shall be obligated to obtain an approval letter.

Article 15

(1) In order to produce any aircraft, aircraft engine and airplane propeller to be made based on the conceptual design mentioned in Article 13, must possess a type certificate.

(2) The type certificate meant in item (1) shall be given by the Minister after the applicant completes demonstration of compliance with the certification basis such as an examination on conformity to initial airworthiness standard and has passed the type certification test.

FAR 21[8]

FAR 21 is a regulation that regulates the procedures for compliance certification. Then FAR 23, 25 and 27 are regulations that regulate airworthiness standards

21.021 Type certificate: normal, utility, acrobatic, commuter, and transport category aircraft; manned free balloons; special classes of aircraft; aircraft engines; propellers

An applicant is entitled to a type certificate for an aircraft (except an aircraft mentioned in regulation 21.027) in the normal, utility, acrobatic, commuter, or transport category, or for a manned free balloon, or for a special class of aircraft or an aircraft engine or propeller, if:

(a) the applicant submits the type design, test reports, and computations necessary to show that the aircraft, aircraft engine or propeller to be certificated meets the applicable requirements of this Part, the airworthiness standards mentioned in these regulations and any conditions subject to which the type certificate is to be issued; and

(b) CASA is satisfied that the type design and the aircraft, engine or propeller meet the applicable requirements of this Part and the airworthiness standards mentioned in these regulations, and any airworthiness provisions not complied with are compensated for by factors that provide an equivalent level of safety; and

(c) for an aircraft — CASA is satisfied the aircraft can reasonably be expected to be safe for its intended use when it is operated under any conditions limiting its intended use.

LSU-05

LSU-05 has requirements and objectives[9]:

1. General
   - The main design goal is to get the UAV as a utility platform
   - lightweight and can operate in the sea and near the sea.
   - The aircraft can take off and landing on the land or grass runway.
   - The aircraft can operate reliably and robustly.
   - The aircraft is prepared to operate in normal weather conditions.
   - The aircraft can be produced easily by incorporating a modular concept to simplify changing parts and aircraft parts.
   - The aircraft has a main mission, namely to support aerial photography activities by optical devices loads. In the future the aircraft will also used as a scientific platform to test communication systems satellite based developed by LAPAN and can also be use for territory control.
   - The aircraft is designed to support aerial photo missions in the dissemination program of Aeronautics Technology Center.
2. Flight Performance
   - Flying distance with camera payload system with a weight of 2 kg, to fly non-stop minimum 400 km with minimum total endurance about 5 hours.
   - Flying distance with maximum payload is 200 km with a minimum endurance about 2.5 hours.
   - The maximum cruise flight speed is not less than 40 m / s with an operational cruise flight speed of 30 m /s.
   - The maximum stall speed is 18 m /s when flap down.
   - The maximum altitude is 3,000 m with operational altitude between 150 - 1,500 m.
   - The take-off ground run distance for maximum take-off weight is 180 meters under ISA + 20ºC conditions.
   - Distance of ground run landing at maximum landing weight conditions is 180 meters under ISA + 20 ISAC conditions.
   - Maximum rate of climb in MTOW, maximum thrust and sea level conditions not less than 2.5 m / s.
3. Weight
   - The aircraft's empty weight does not exceed 45 kg. Empty weight is defined as aircraft airframe weight coupled with supporting system components, such as control systems, payload systems, and propulsion systems.
   - The maximum weight of the payload is 30 kg.
4. Payload
   - The separate module able to accommodate the optical instrument payload, instrumentation of radio wave instrument design with a modular system.

- Payload is generally used for data retrieval.

5. Avionics and Electrical System
   - Avionics systems are easy to installation (plug and play)
   - The wiring system is arranged and structured neatly.
   - The position of the components does not change when the aircraft fly and maneuvers.
   - Able to add a satellite-based aircraft communication system with an estimated weight of 5-10 kg. The dimensions of the fuselage compartment must be able to accommodate this system with the provision that this system will reduce the maximum payload that can be carried.
6. Ground Control System (GCS)
   - GCS must be able to support telecommunication aircraft in all fields with a design that is easy to carry and install.
   - GCS and aircraft can carry out data link communication within a minimum distance of 10 km.
7. Propulsion
   - The engine must be able to meet the needs of aircraft for maneuvering.
   - The maximum amount of fuel must be able to support aircraft to achieve the flight performance
   - The engine is turned on using the mobile starter.
   - Fuel status can be monitored by users in the GCS.

In the design of LSU-05 NG regulations will be chosen as compliances of FAR 23 amandement 64. Applicability and definitions FAR 23 amandement 64[10] :

a) This part prescribes airworthiness standards for the issuance of type certificates, and changes to those certificates, for airplanes in the normal category.
b) For the purposes of this part, the following definition applies:
c) Continued safe flight and landing means an airplane is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill or strength. Upon landing, some airplane damage may occur as a result of a failure condition.

However, the regulations contained in FAR 23 amandement 64 have not fully accommodated the design requirements of unmanned aircraft. In this paper, a selection of regulations will be conducted which will be applied to the design of LSU-05, which is only in the structure & powerplant section.

METHODOLOGY

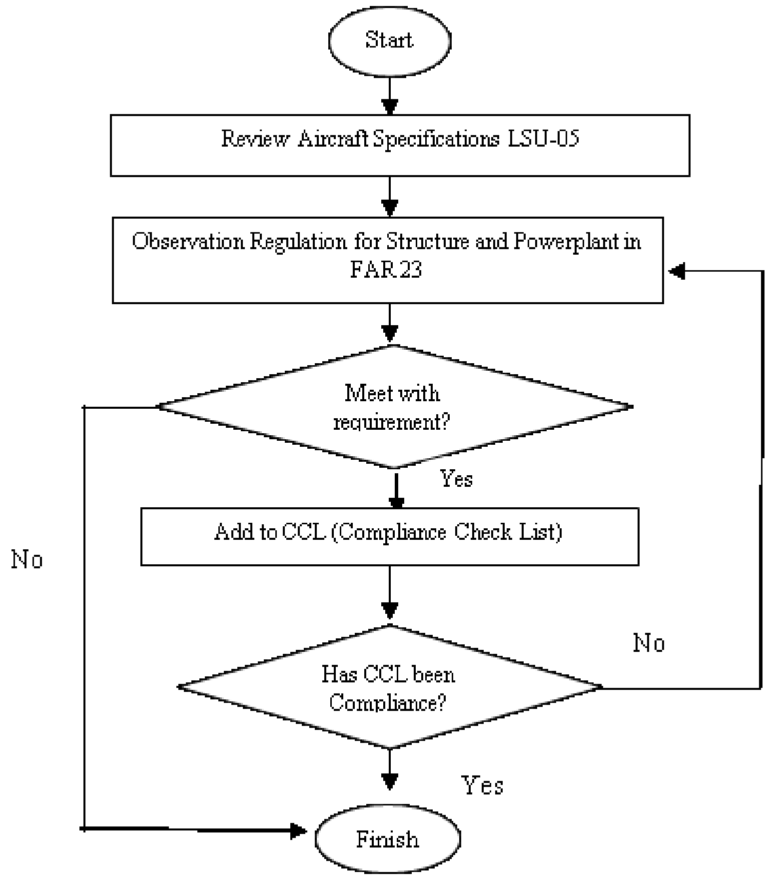

FIGURE 1. Flowchart

RESULT AND DISCUSSION

Based on the Design Requirement and Objectives from LSU-05 NG, the selection of approval from FAR 23 will be applied which will be applied to the LSU-05 NG by making a document containing the Compliance Check List (CCL) that provides information about which one to look for. These regulations are described on Table 1

TABLE 1. Subpart C – Structure and Subpart E - UAV Powerplant

Subpart C — Structure GENERAL			
23.2200	Structural design envelope	**Panel Responsible**	**MOC**
23.2200(a)	Structural design airspeeds, landing descent speeds, and any other airspeed limitation at which the applicant must show compliance to the requirements of this subpart. The structural design airspeeds must—	Str & Mech. system	2

Subpart C

GENERAL **(continued)**

23.2200(a)(1)	Be sufficiently greater than the stalling speed of the airplane to safeguard against loss of control in turbulent air; and	Str & Mech. system	2
23.2200(a)(2)	Provide sufficient margin for the establishment of practical operational limiting airspeeds.	Str & Mech. system	2
23.2200(b)	Design maneuvering load factors not less than those, which service history shows, may occur within the structural design envelope.	Str & Mech. system	2
23.2200(c)	Inertial properties including weight, center of gravity, and mass moments of inertia, accounting for—	Str & Mech. system	2
23.2200(c)(1)	Each critical weight from the airplane empty weight to the maximum weight; and	Str & Mech. system	2
23.2200(c)(2)	The weight and distribution of occupants, payload, and fuel.	Str & Mech. system	2
23.2200(d)	Characteristics of airplane control systems, including range of motion and tolerances for control surfaces, high lift devices, or	Str & Mech. system	2
23.2200(e)	Each critical altitude up to the maximum altitude.	Str & Mech. system	2
23.2210	Structural design loads		
23.2210(a)	The applicant must:	Str & Mech. system	2
23.2210(a)(1)	Determine the applicable structural design loads resulting from likely externally or internally applied pressures, forces, or moments that may occur in flight, ground and water operations, ground and water handling, and while the airplane is parked or moored.	Str & Mech. system	2
23.2210(a)(2)	Determine the loads required by paragraph (a)(1) of this section at all critical combinations of parameters, on and within the boundaries of the structural design envelope.	Str & Mech. system	2
23.2210(b)	The magnitude and distribution of the applicable structural design loads required by this section must be based on physical principles.	Str & Mech. system	2
FLIGHT LOADS			
23.2215	Flight load conditions		
23.2215(a)	Atmospheric gusts where the magnitude and gradient of these gusts are based on measured gust statistics.	Str & Mech. system	2
23.2215(b)	Symmetric and asymmetric manoeuvres.	Str & Mech. system	2
23.2215(c)	Asymmetric thrust resulting from the failure of a powerplant unit.	Str & Mech. system	2
23.2220	Ground and water load conditions		
23.2230	Limit and ultimate loads	Str & Mech. system	2
23.2230(a)	Limit loads	Str & Mech. system	2
23.2230(b)	Ultimate loads	Str & Mech. system	2
23.2235	Structural strength		
23.2235(a)	Limit loads without—	Str & Mech. system	2

FLIGHT LOADS (**continued**)			
23.2235(a)(1)	Interference with the safe operation of the airplane; and	Str & Mech. system	2
23.2235(a)(2)	Detrimental permanent deformation.	Str & Mech. system	2
23.2235(b)	Ultimate loads.	Str & Mech. system	2
23.2240	Structural durability	Str & Mech. system	2

Subpart E — UAV Powerplant			
GENERAL			
23.2400	Powerplant Installation	**Panel Responsible**	**MOC**
23.2400(a)	For the purpose of this subpart, the airplane powerplant installation must include each component necessary for propulsion, which affects propulsion safety, or provides auxiliary power to the airplane.	Eng. & Propulsion	2
23.2400(b)	Each airplane engine and propeller must be type certificated, except for engines and propellers installed on level 1 low-speed airplanes, which may be approved under the airplane type certificate in accordance with a standard accepted by the FAA that contains airworthiness criteria the Administrator has found appropriate and applicable to the specific design and intended use of the engine or propeller and provides a level of safety acceptable to the FAA.	Eng. & Propulsion	2
23.2400(c)	The applicant must construct and arrange each powerplant installation to account for—	Eng. & Propulsion	2
23.2400(c)(1)	(1) Likely operating conditions, including foreign object threats;	Eng. & Propulsion	2
23.2400(c)(2)	(2) Sufficient clearance of moving parts to other airplane parts and their surroundings;	Eng. & Propulsion	2
23.2400(c)(3)	(3) Likely hazards in operation including hazards to ground	Eng. & Propulsion	2
23.2400(c)(4)	(4) Vibration and fatigue.	Eng. & Propulsion	2
23.2400(d)	(d) Hazardous accumulations of fluids, vapors, or gases must be	Eng. & Propulsion	2
23.2400(e)	(e) Powerplant components must comply with their component limitations and installation instructions or be shown not to create a hazard.	Eng. & Propulsion	2

Subpart E			
GENERAL (**continued**)			
23.2425	Powerplant operational characteristics (a) An automatic power or thrust control system intended for in-flight use must be designed so no unsafe condition will result during normal operation of the system. (b) Any single failure or likely combination of failures of an automatic power or thrust control system must not prevent continued safe flight and landing of the airplane. (c) Inadvertent operation of an automatic power or thrust control system by the flight crew must be prevented, or if not prevented, must not result in an unsafe condition. (d) Unless the failure of an automatic power or thrust control system is extremely remote, the system must		
23.2425(1)	Provide a means for the flight crew to verify the system is in an operating condition;	Eng. & Propulsion	2
23.2425(2)	Provide a means for the flight crew to override the automatic function; and Prevent inadvertent deactivation of the system.		2
23.2430	Fuel systems		
23.2430(a)	Each fuel system must—	Eng. & Propulsion	2
23.2430(a)(1)	Be designed and arranged to provide independence between multiple fuel storage and supply systems so that failure of any one component in one system will not result in loss of fuel storage or	Eng. & Propulsion	2
23.2430(a)(2)	Be designed and arranged to prevent ignition of the fuel within the system by direct lightning strikes or swept lightning strokes to areas where such occurrences are highly probable, or by corona or	Eng. & Propulsion	2
23.2430(a)(3)	Provide the fuel necessary to ensure each powerplant and auxiliary power unit functions properly in all likely operating conditions;	Eng. & Propulsion	2
23.2430(a)(4)	Provide the flight crew with a means to determine the total useable fuel available and provide uninterrupted supply of that fuel when the system is correctly operated, accounting for likely fuel fluctuations;	Eng. & Propulsion	2
23.2430(a)(5)	Provide a means to safely remove or isolate the fuel stored in the system from the airplane;	Eng. & Propulsion	2

Subpart E

GENERAL (**continued**)

23.2430(a)(6)	Be designed to retain fuel under all likely operating conditions and minimize hazards to the occupants during any survivable emergency landing. For level 4 airplanes, failure due to overload of the landing system must be taken into account; and	Eng. & Propulsion	2
23.2430(a)(7)	Prevent hazardous contamination of the fuel supplied to each powerplant and auxiliary power unit.	Eng. & Propulsion	2
23.2430(b)	Each fuel storage system must—	Eng. & Propulsion	2
23.2430(b)(1)	Withstand the loads under likely operating conditions without	Eng. & Propulsion	2
23.2430(b)(2)	Be isolated from personnel compartments and protected from hazards due to unintended temperature influences;	Eng. & Propulsion	2
23.2430(b)(3)	Be designed to prevent significant loss of stored fuel from any vent system due to fuel transfer between fuel storage or supply systems, or under likely operating conditions;	Eng. & Propulsion	2
23.2430(b)(4)	Provide fuel for at least one-half hour of operation at maximum continuous power or thrust; and	Eng. & Propulsion	2
23.2430(b)(5)	Be capable of jettisoning fuel safely if required for landing.	Eng. & Propulsion	2
23.2430(c)	Each fuel storage refilling or recharging system must be designed	Eng. & Propulsion	2
23.2430(c)(1)	Prevent improper refilling or recharging;	Eng. & Propulsion	2
23.2430(c)(2)	Prevent contamination of the fuel stored during likely operating	Eng. & Propulsion	2
23.2430(c)(3)	Prevent the occurrence of any hazard to the airplane or to persons during refilling or recharging.	Eng. & Propulsion	2
23.2430(a)(1)	Be designed and arranged to provide independence between multiple fuel storage and supply systems so that failure of any one component in one system will not result in loss of fuel storage or	Eng. & Propulsion	2

EXHAUST SYSTEM

23.2435	Powerplant induction and exhaust systems		
23.2435(a)	The air induction system for each powerplant or auxiliary power unit and their accessories must—	Eng. & Propulsion	1
23.2435(a)(1)	Supply the air required by that powerplant or auxiliary power unit and its accessories under likely operating conditions;	Eng. & Propulsion	1

EXHAUST SYSTEM (**continued**)			
23.2435(a)(2)	Be designed to prevent likely hazards in the event of fire or backfire;	Eng. & Propulsion	1
23.2435(a)(3)	Minimize the ingestion of foreign matter; and	Eng. & Propulsion	1
23.2435(a)(4)	Provide an alternate intake if blockage of the primary intake is	Eng. & Propulsion	1
23.2435(b)	The exhaust system, including exhaust heat exchangers for each powerplant or auxiliary power unit, must—	Eng. & Propulsion	1
23.2435(b)(1)	Provide a means to safely discharge potential harmful material; and	Eng. & Propulsion	1
23.2435(b)(2)	Be designed to prevent likely hazards from heat, corrosion, or blockage.	Eng. & Propulsion	1

MOC (Means of Compliance): A Manufacture / Authority recognized identification codes on how compliance will be demonstrated:

- 0 – Statement
- 1 – Drawing / Description / Manual
- 2 – Calculation / Analysis
- 3 – Safety Assessment
- 4 – Laboratory Test
- 5 – Ground Test
- 6 – Flight Test
- 7 – Inspection
- 8 – Simulation

CONCLUSION

Based on the selection of civil aviation safety regulations chosen to be applied to the LSU-05 NG, a collection of regulations will be compiled to design the LSU-05 NG by making a CCL (Compliance Check List) document and the regulatory compliances method, namely MOC (Means of Compliance). The CCL document and the MOC method will be asked for approval to the authority that will carry out the aircraft certification process. We recommend a selection of regulations LSU-05 NG for workpackage structure, powerplant & electronic section using FAR 23 Amandemnet 64.

- Structure workpackage the regulation are include section 23.2200-23.2210 (b)
- Flight Loads workpackage the regulation are include section .2215-23.2240
- UAV Powerplant workpackage the regulation are include section 23.2400-23.2430(c)(3)
- Exhaust System workpackage the regulation are include section 23.2435-23.2435(b)(2)

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