

Evaluation on air space availability for flight operational safety at Husein Sastranegara airport

Abstract

Airport Husein Sastranegara Bandung is a plateau surrounded by mountains, with average height +791m above sea level. The highest point in the northern region with a height of +1050 m above sea level and the lowest in the south with a height of +675 m asl. Thus, it should be noted the safety of flight operations due to aircraft movement with the limited air space. Evaluated of aircraft movement pattern on topography and operation flight area of Husein Sastranegara Airport. It also evaluates the capacity and weight of each aircraft in operation, against the available air space. This evaluation gives results that in the direction of lengthwise runway; the safe area of Husein Sastranegara Airport flight operation on topography ensures the safety of flight operations. The optimum aircraft operation is at 877nm (1626.2km) mileage by consuming fuel of 10734 liters and payload of 15853kg. Boeing 737-800 aircraft operating in Husein Sastranegara Airport Bandung can extend the distance to 52nm.

Keywords: air space, flight operational safety, airport topography

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Introduction

Husein Sastranegara Airport is located in Bandung City. The airport has a capacity of 903 pax during peak hours and 500,000 passengers per year. In 2012 the number of passengers at Husein Sastranegara airport has reached ±1.8 million passengers. And in 2013 the number of passengers at Husein Sastranegara airport has reached ±2.6 million passengers. Husein Sastranegara Airport has an air side consisting of runways, taxiways and aprons. With a runway length of 2200m and a width of 45m, Husein Sastranegara Airport is only able to serve 20 destinations, with the furthest destination is Bandung-Kualanamu International Airport which is 820 nautical miles. This shows that the distance of aircraft operating in Husein Sastranegara Airport is relatively short. The largest aircraft operating at Husein Sastranegara Airport are the A320 and Boeing 737-800. Taking from the location of topography, Bandung is located at an average height of +791m above sea level. The highest point in the northern region with a height of +1050m above sea level and the lowest in the south with a height of +675m asl. Physically, the location Husein Sastranegara Airport located in the middle of dense settlements, with topography around Husein Sastranegara Airport Bandung which is a plateau surrounded by mountains.¹ Thus, it should be noted that the safety of flight operations due to aircraft movement associated with the limited air space. Therefore, the author tries to evaluate the availability of air space related to the operational safety of Husein Sastranegara Airport in order to know the suitability of the airspace requirement for the safety area of flight operation.

Results and discussion

Data analysis

In order to know the actual runway length required for the aircraft operating in Bandar Husein Sastranegara, there needs to be some correction to the elevation factor, temperature, and runway slope. To calculate the correction factor, first need to look for ARFL. The ARFL plane B 747-800 is 2256 m. Calculation of runway correction based on ARFL and runway characteristic data² is as follows:

i. Correction of Elevation (KE)

$$KE = (ARFL \times 7\% \times (\text{runway elevation}/300)) + ARFL$$

$$KE = (2256 \times 7\% \times (745.5/300)) + 2256$$

$$KE = 2648.43m$$

ii. Correction of Temperature Elevation (KET)

$$KET = [KE \times (\text{temperature} - (15 - 0.0065h))] \times 1\% + KE$$

$$KET = [2648.43 \times (23.4 - (15 - 0.0065 \times 745.5))] \times 1\% + 2648.43$$

$$KET = 2999.35m$$

iii. Correction of Temperature and Slope Elevation (KETS)

$$KETS = [KET \times \text{slope} \times 10\%] + KET$$

$$KETS = [2999.35 \times 1.6\% \times 10\%] + 2999.35 = 3004.15m \quad KETS = 3005m$$

Taking into account the safety factor and ease of work, the actual runway length, also known as TORA (Take-off Run Available) is 3005m. The existing runway length at Husein Sastranegara Airport is currently 2200m, so it is necessary to add a runway length of 805m so that aircraft with ARFL 2257 can use runway. In the upgrading design of Husein Sastranegara Airport, the critical aircraft used are Boeing 747-400 aircraft with the characteristics listed in Table 1. The critical aircraft ARC is 4C. From table 1 it can be seen that the runway width is 45m. So for the 4C group, the runway with a width of 45m is still appropriate.

Table 1 Runway width base on code number²

Code Number	Code letter					
	A	B	C	D	E	F
1a	18m	18m	23m	-	-	-
2	23m	23m	30m	-	-	-
3	30m	30m	30m	45m	-	-
4	-	-	45m	45m	45m	60m

Methodology

Figure 1.

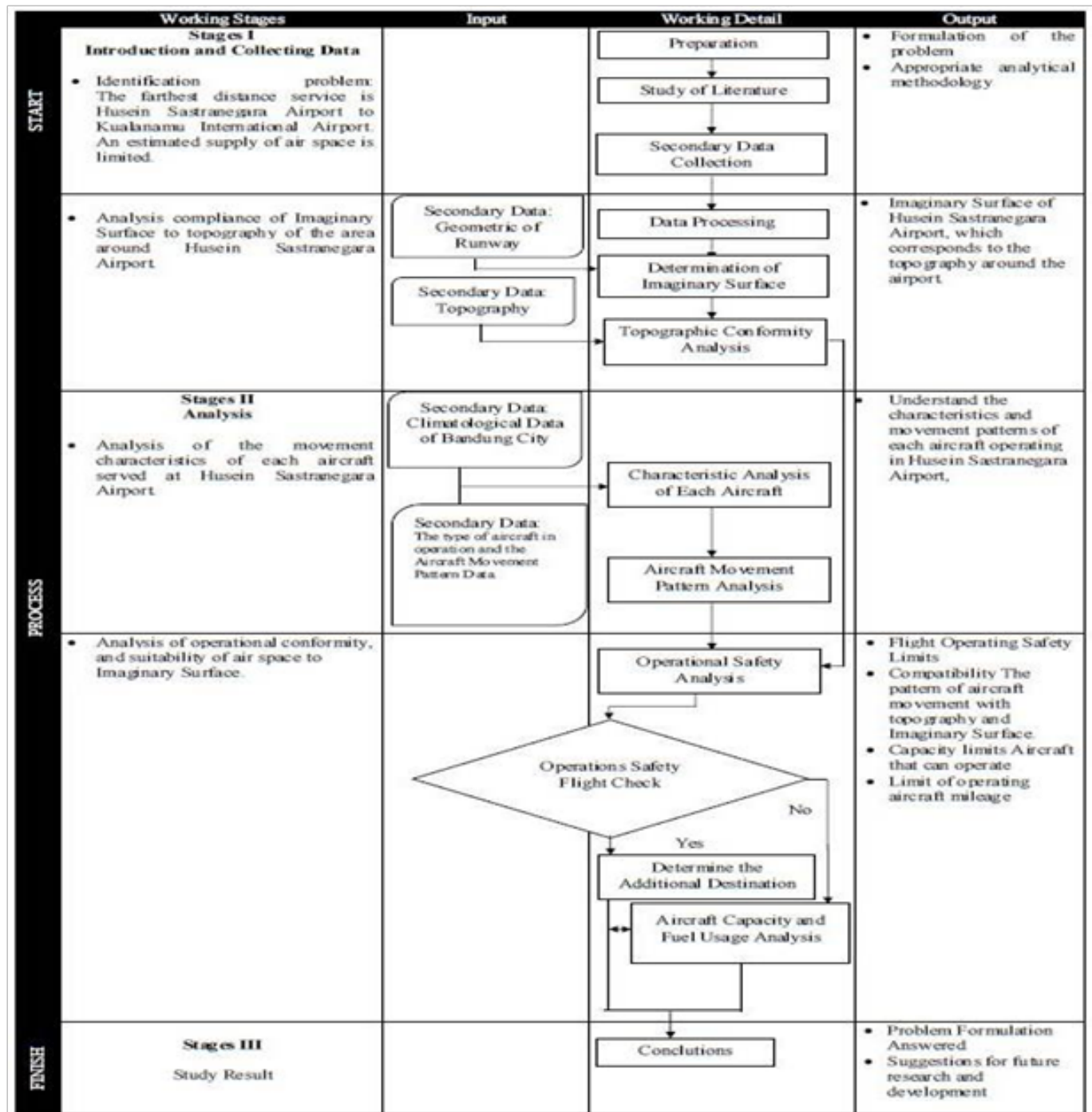


Figure 1 Flow chart of evaluation methodology.

Analysis of imaginary surface to the topography

Table 2 shows imaginary surface boundary based on the runway classification.³ The design of Husein Sastranegara Airport used Non-Precision Approach Runways with critical 4C category aircraft, Imaginary Surface specifications are adjusted to the provisions of table 4.5 above, and with the following description:

Approach area⁴: This area is bounded by an inner edge coinciding with the main surface ends 60 meters away from the end of the runway with an inner width, this area extends outwardly regularly with a 15% widening angle and the centerline of the plane is an extension of the centerline of the runway. The first horizontal distance is 3000m with the slope of the tilt of the runway is 2%, the second horizontal distance is 3600m from the first horizontal distance with a slope of 2.5%, and

the third distance is 8400 from the second horizontal distance with a slope of 2.5% so that the overall horizontal distance is 15000m with the final width of this area is 4800m. Draw from the take-off approach area as follows in Figure 2.

Table 2 Dimension of the imaginary surface based on the runway classification³

OLS & Dimensions (in meters and percentages)	Runway classification									
	Non-Instrument				Instrument					
					Non-Precision			Precision		
	Code No				Code No			Code No		
	1	2	3	4	1,5	3	4	1,2	3,4	3,4
Outer Horizontal										
Height (m)									150	150
Radius (m)									15000	15000
Conical										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height (m)	35	55	75	100	60	75	100	60	100	100
Inner Horizontal										
Height (m)	45	45	45	45	45	45	45	45	45	45
Radius (m)	2000	2500	4000	4000	3500	4000	4000	3500	4000	4000
Approach										
Length of inner edge(m)	60	80	159	150	90	150	300	150	300	300
Distance from threshold (m)	30	60	60	60	60	60	60	60	60	60
Divergence each side	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%
First section length (m)	1600	2500	3000	3000	2500	3000	3000	3000	3000	3000
Slope	5%	4%	3,33%	2,5%	3,33%	3,33%	2%	2,5%	2%	2%
Second section length (m)							3600	12000	3600	3600
Slope							2,5%	3%	2,5%	2,5%
Horizontal section length (m)							8400		8400	8400
Total length (m)	1600	2500	3000	3000	2500	15000	15000	15000	15000	15000
Inner approach										
Width (m)								90	120	120
Distance from threshold (m)								60	60	60
Length (m)								900	900	900
Slope								2,5%	2%	2%
Translational										
Slope	20%	20%	14,3%	14,3%	20%	14,3%	14,3%	14,3%	14,3%	14,3%
Inner Translational										
Slope								40%	33,3%	33,3%
Baul Ked Landing										
Length of inner edge(m)								90	120	120
Distance from threshold (m)									1800	1800
Divergence each side								10%	10%	10%
Slope								4%	3,3%	3,3%

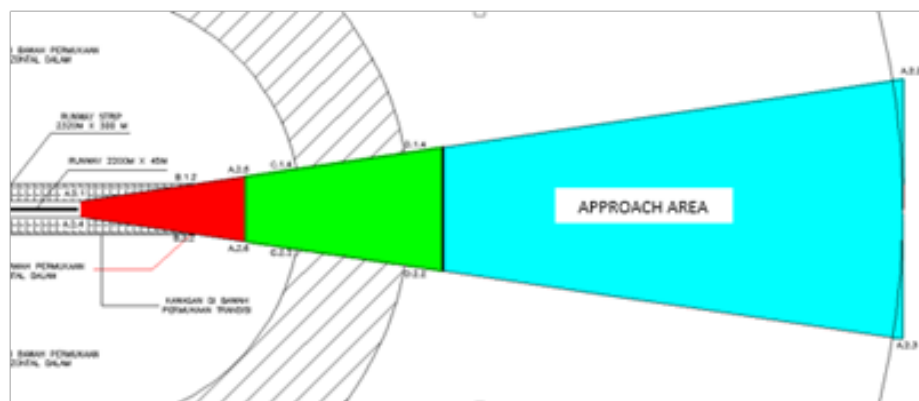


Figure 2 Approach area.

The possibility of accident hazard area: This area is bounded by a data edge coinciding with the main surface ends of a width of 300 meters, the area extends out regularly with its midline an extension

of the centerline of the runway to a width of 1200 meters and a flat distance of 3000 meters from the tip of the main surface. The possibility of accident hazard area as follows in Figure 3.

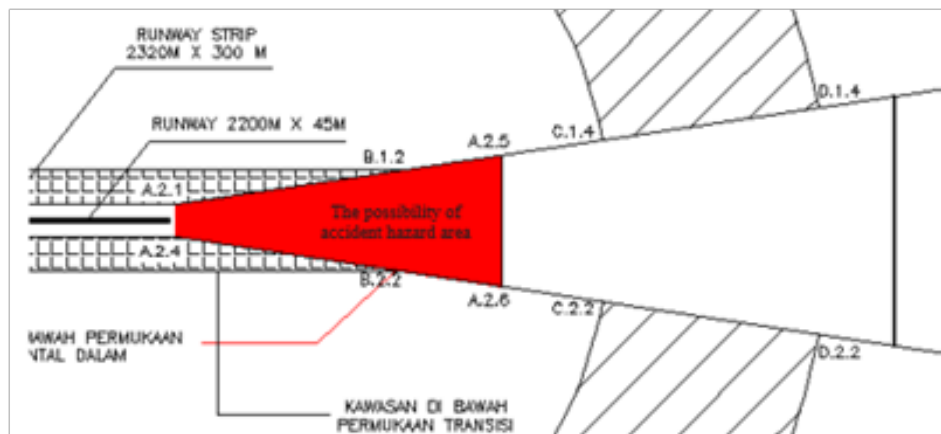


Figure 3 The possibility of accident hazard area.

Inner horizontal surface area: This area is bounded by a circle with a radius of 4000 m from the center of each end of the main surface and draws a tangent to the two adjacent circles but this area does not include the area below the transition surface of Figure 4.

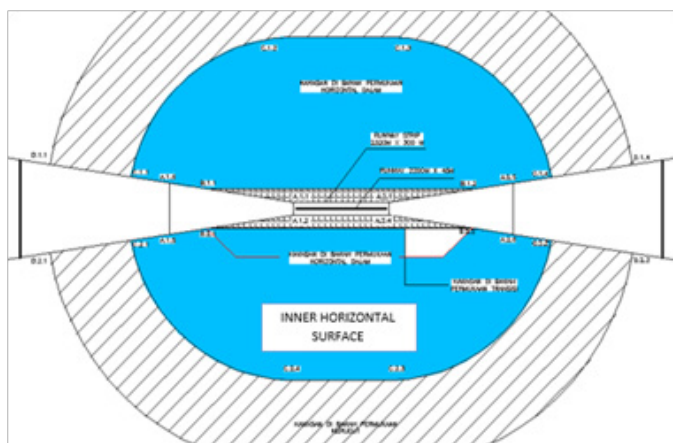


Figure 4 Inner the horizontal surface area.

Outer horizontal surface: This area is bounded by a circle with a radius of 15000 meters from the midpoint of each end of the main surface and draws a tangent on the two adjacent circles of Figure 5.

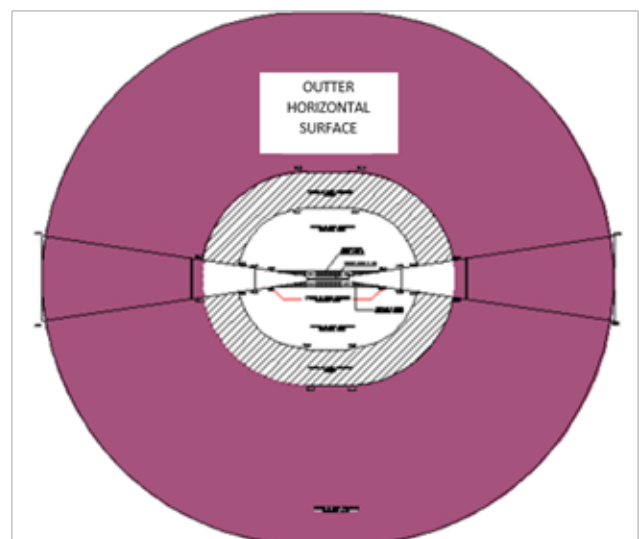


Figure 5 Outer horizontal surface.

Conical surface: The area below the conical surface as illustrated in Figure 6. Figure 6 is restricted from the outer edge of the area beneath the horizontal surface in extending with a horizontal distance of 2000 meters with a slope of 5%.

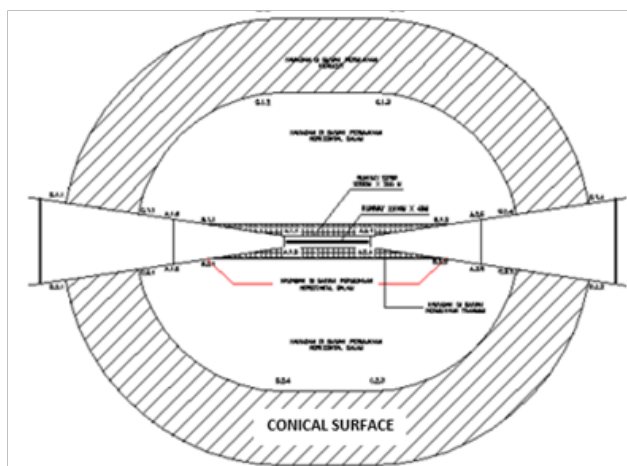


Figure 6 Conical surface.

Imaginary surface: Area safety of flight operations established/resides in the coordinate system of the airport (aerodrome Coordinate System/ACS) and the geographic coordinate system in reference Word Geodetic System 1984 (WGS'84). Flight operations area as a whole shown in Figure 7. Imaginary Surface height elevation and topographic elevation on the longitudinal and cross section of Imaginary Surface can be combined so that it can be clearly known the appearance Imaginary Surface to topography of Husein

Sastranegara Airport. In Figure 8 and Figure 9 are the longitudinal and transverse pieces illustrated by the evaluation of Imaginary Surface and topography. Figure 8 show that the topographic elevation does not exceed the height of the operating safety area of Husein Sastranegara Airport. Figure 9 show that topographic elevation exceeds operational safety area limits.

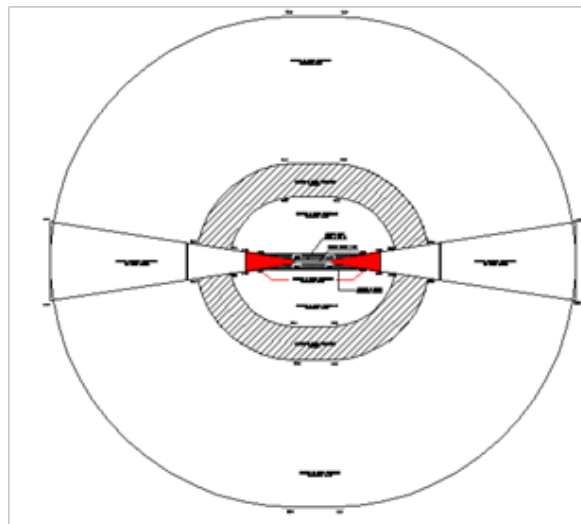


Figure 7 Imaginary surface.

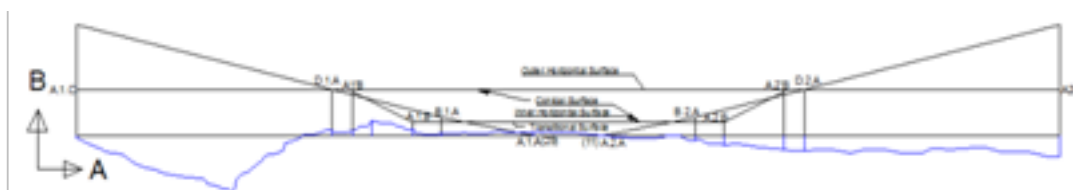


Figure 8 Lengthwise imaginary surface to the topograph.

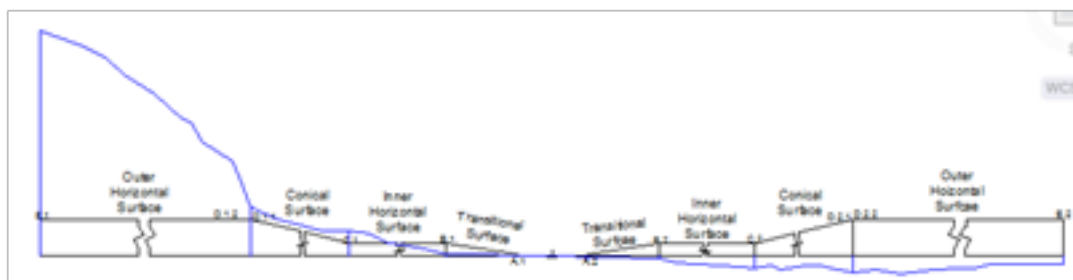


Figure 9 Transverse imaginary surfaces to the topograph.

To fulfill the safety of flight operations procedures, if any objects blocking the safety of flight operations, must be added obstacle light on the barrier. Based on SNI 03-7051-2004 about marking and lighting of obstacles around airports, topographic height of over 150m of land on the runway surface to be installed lamp type III. Type III lamp placed on a plateau above 150m to the color of white light flashing. The light intensity criticize lights between $2000 \pm 25\%$ cd and the number of blinks between 40-60 times per minute. Among the highest peaks of the horizontal surface boundary should be given a light with a maximum distance of 45m. Obstacle light (indicated by red dots) can be placed on the following areas in Figure 10.

So it can be concluded that in the direction of runway lengthening, the safety area of Husein Sastranegara Airport flight operation on topography is qualified and can guarantee the safety of flight

operations. Meanwhile, in the direction of the runway, the Husein Sastranegara Airport flight operation area on topography does not meet, because the topographic elevation is higher than the Imaginary Surface elevation. Need to add obstacle light on the barrier with white III lamp type with maximum distance of 45m between lamp and the number of flicker 40-60 times per minute.

Analysis of movement pattern of each aircraft on topography

This analysis aims to determine the movement characteristics of each aircraft operating in Husein Sastranegara Airport. By knowing the characteristics of aircraft movement during takeoff, lift off, climb out, and cruise, can know the height and angle and distance of each aircraft movement, and then can be done correction to topography

height and limit of KKOP. In conducting the evaluation, the basic data required is imaginary surface for safety operation / flash of each aircraft. Here is a picture of 10 is a flash on Boeing 737-800 aircraft

(Figure 11). Dari flash above we get pattern with characteristic as the Table 3 below.

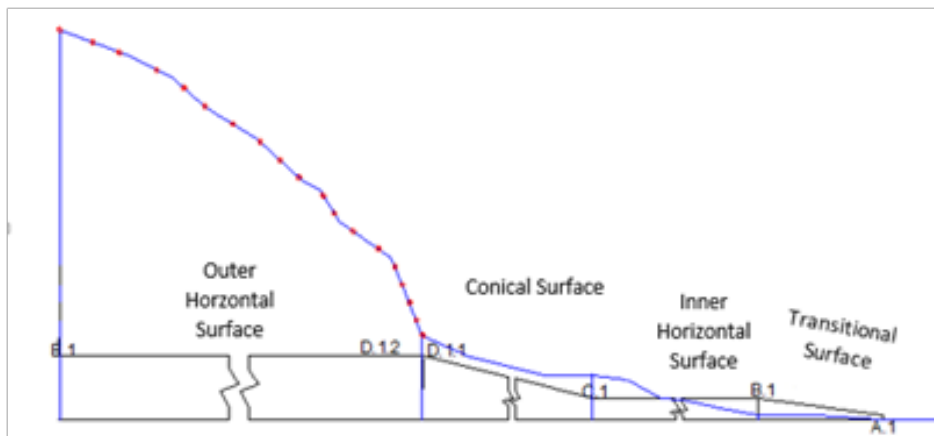


Figure 10 Installation of obstacle light.

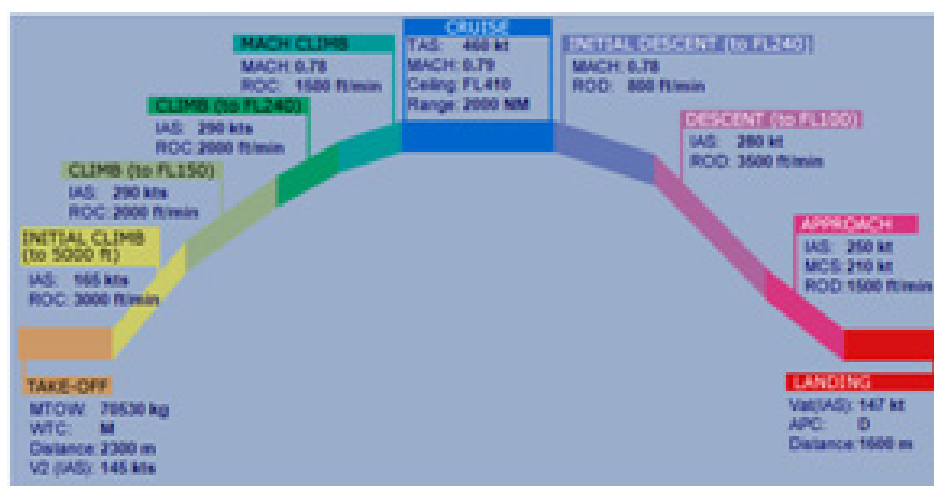


Figure 11 Flash of aircraft Boeing 737-800.⁵

Table 3 The result of calculation of aircraft movement pattern

	Tinggi	Beda Tinggi	IAS	ROC	jarak	sudut
Boeing 737-800	1	2	3	4	5	6
	ft	ft	ft/min	ft/min	m	degree
Takeoff	0	0	14684.2		2300	
Initial climb	5000	5000	16709.6	3000	8354.67	10.18
Climb	15000	10000	29368.3	2000	44051.87	3.90
	24000	9000	29368.3	2000	39646.68	3.90
Mach climb	41000	17000	52665.4	1500	179062.24	1.63
Cruise	41000	0	52665.4	460	3704000.00	180.00
Initial descent	24000	17000	52665.4	800	335741.71	0.87
Descent	10000	14000	29368.3	3500	35241.50	6.80
Approach		10000	21266.7	1500	42532.84	4.03
Landing	0	0	14177.8		1600.00	0.00

Analysis of individual movement patterns to topography

Topographic analysis in this evaluation was observed at topographic sighting in the direction of approach runway which then will be evaluated against pattern of aircraft movement. Figure 12 below is a topographic shape taken from the middle of the runway towards the 29th along the 18.1km and toward the 11th along the 18.1km. After knowing the topographic elevation of the airport area, evaluation of movement patterns on topography was conducted. Evaluated the height of the aircraft when the lift off first. If the elevation of the ground level coupled with the altitude distance (10.7m) between the surface of the ground and the aircraft is eligible, then for the next

higher pattern of aircraft movement, it will not interfere with flight safety. Exemplified the type of 737-800 Boeing aircraft with takeoff distance of 2300 meters and experience the lift off to a height of 35ft (10.7m) toward the runway 29-11. Once calculated and get the TOR along 2189.21 meters with a lift angle off 5.5° then can be described as follows Figure 13. From Figure 13, blue is the topography of the ground surface, black is the horizontal line parallel to the airport runway, and red is the flight line of the aircraft after the lift off (gradient of climb). So it can be concluded that the aircraft did not experience safety interruption when off the elevator. So for the patterns of subsequent aircraft movement, it will not interfere with operational safety.

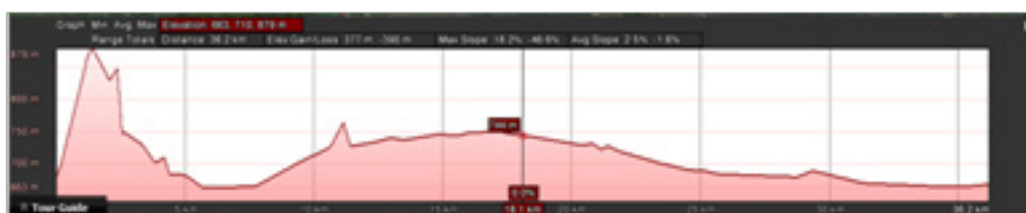


Figure 12 Airport topograph to the runway 11-29.⁶

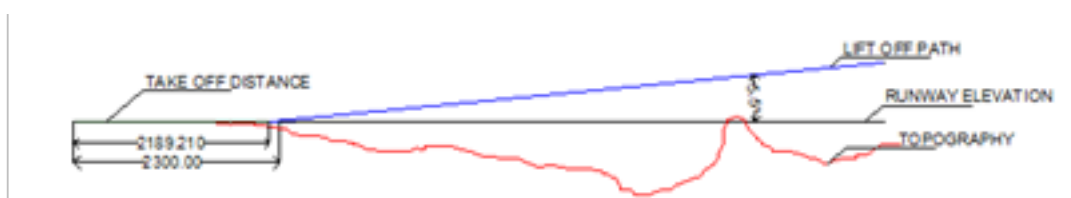


Figure 13 Aircraft lift off.

Aircraft heavy effect analysis on airspace

The critical aircraft operating in Husein Sastra Airport is Boeing 737-800. The maximum distance traveled by aircraft is Husein Sastranegara Airport Bandung-Kualanamu Airport Medan with distance of 820 nautical miles. The range/distance that has been studied is inserted into the graph of Figure 14. From the graph of Figure 14 with the range of 820nm obtained OWE plus payload is 62000kg with Brake Release Gross Weight is 70307kg. OEW boeing 737-800 is 41413kg. So the payload on this flight is as follows.

- Payload = OEW plus payload on the graph – OEW
- Payload = 62000 – 41413 kg
- Payload = 20507 kg

Also done calculation of fuel consumption of aircraft boeing 737-800 on Bandung-Medan destinations as follows:

- Fuel Consumption = Brake Release Gross Weight – Zero Fuel Consumption = 70307 kg – 62000 kg
- Fuel Consumption = 8307 kg = 10130 liter
- (Density of Avtur = 0.820 kg/liter (6.84 lb/US gal))

With Takeoff distance of 2189.2m, it can be seen in Figure 15 that with 733m runway elevation above sea level, Operational Takeoff Weight should be 68000kg. However, based on the classification, in this flight route the weight of the plane reaches 70307kg. So the maximum payload on this flight as follows.

- Max Payload = AGW – fuel – OWE

b. Max Payload = (68000 – 10130 – 41413) kg

c. Max Payload = 16457 kg

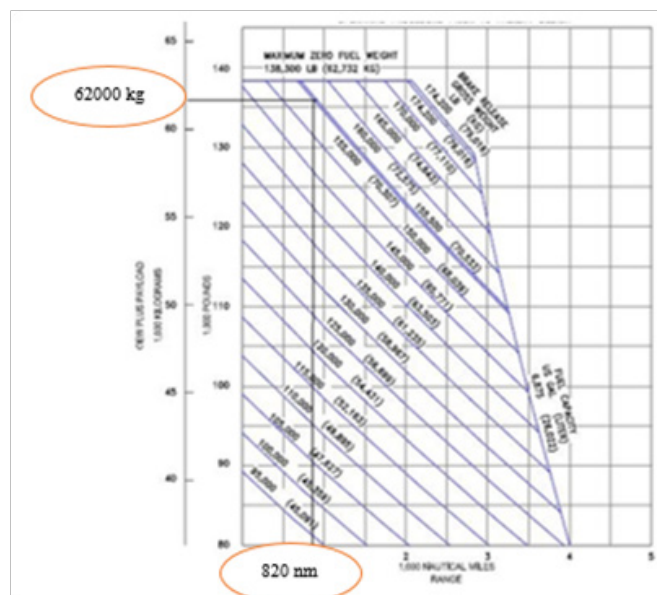


Figure 14 The graph of the range and payload of the aircraft boeing 737-800.⁷

The flight destination from Husein Sastranegara Airport to Kualanamu Airport takes 8400s (2 hours 20 minutes) with Boeing 737-800 so that the average speed of the aircraft is 5.9nm/min. Within a radius of destinations 820 nm aircraft can spend fuel for 10130

liters, so the fuel consumption of aircraft per destination length yag is 15 liters/nautical miles. Fuel reserve on aircraft based on CASR (Civil Aviation Safety Regulation) part 91 is 30 minutes with normal speed. So the fuel reserve required by the aircraft is 2655 liters. In this evaluation, we need to know the optimum destinations with the best fuel and payload compositions in the operational of the 737-800 Boeing aircraft. The further the destination of an aircraft, the greater the fuel consumed and the reduced payload in the aircraft. So we made the payload graph, fuel, and the distance as shown in Figure 16.

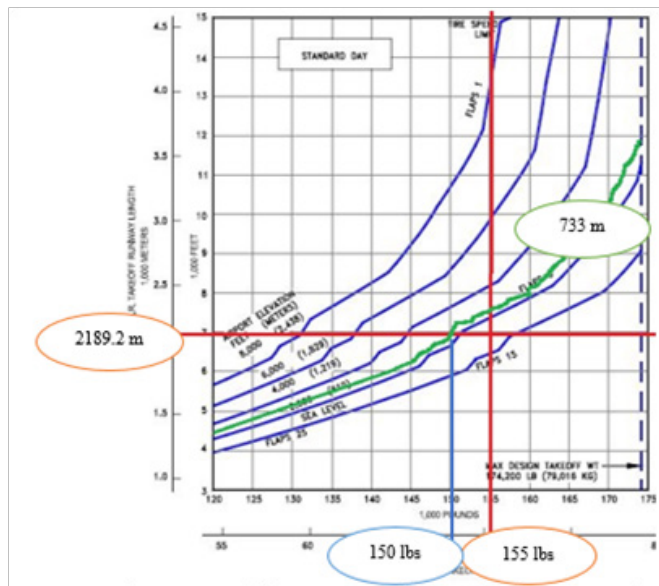


Figure 15 The operating weight of the 737-800 Boeing aircraft graph.⁸

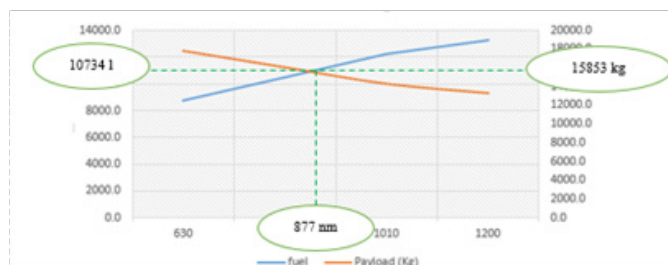


Figure 16 Payload graph, fuel, and the distance operation of Boeing 737-800.

Figure 16 shows that the operation of the aircraft is at optimum equilibrium at 877nm (1624.2km) distance by consuming fuel of 10734 liters and payload of 15853kg. The Boeing 737-800 aircraft destinations can be added not only to the radius of 820nm (Husein Sastranegara Airport Bandung-Kuala Namu Airport Medan) but can add destinations up to 877nm and can add destinations to several airports as follows.

1. Pearl Airport (Kalimantan)
2. Lawas Airport (Kalimantan)
3. Bolaang Airport (Sulawesi)
4. Baubau Airport (Sulawesi)
5. Soa airport (Nusa Tenggara)
6. Teuku Cut Ali Airport (Aceh)
7. Brunei Darussalam Airport (Brunei Darussalam)

8. Sultan Ismail Petra (Malaysia)

9. Antar Bangsa Airport Penang (Malaysia)

It can be concluded that the 737-800 Boeing aircraft operating at Husein Sastranegara Airport Bandung, can extend the distance of 57 nautical miles.

Conclusion and recommendations

This evaluation is an evaluation of air space availability in relation to operational safety carried out by evaluating the safety area of flight operations on the Airport runway Husein Sastranegara which is projected on the topography of the Banadara Husein Sastranegara region. Operational safety is also determined by the movement of aircraft that is not disturbed by topography. Runway length, topography, and aircraft movement patterns are very influential in the evaluation of air space availability in relation to the operational safety of Husein Sastranegara Airport.

From the analysis that has been done, obtained the following results:

1. The results of the analysis of the Aviation Safety Operation Area with the topography of the area around Husein Sastranegara airport shows that:
 - a. In the direction of runway lengthening, the safety area of Husein Sastranegara Airport flight operation on topography can ensure the safety of flight operations.
 - b. In the direction of the runway, the Husein Sastranegara Airport flight operation area on topography does not meet, because the topographic elevation is higher than the aerodrome elevation.
 - c. Need to add obstacle light on the barrier (higher topographic elevation of aerodrome outer horizontal area) with white III lamp type with maximum distance of 45m between lamp and 40-60 times per minute flicker.
2. Analysis of aircraft weight to air space, indicating that:
 - a. The lift angle off is determined by using angle of attack to get take off run.
 - b. With take off distance of 2300 meters and experience the lift off to a height of 35ft (10.7 m) toward the runway 29-11. Once calculated and get the TOR along 2189.21 meters with a lift angle off 5.5°.
 - c. At a distance of 9.5 km from the runway end, the ground elevation reaches 782 m from sea level, and at that distance, based on the pattern of aircraft movement, the plane is at an altitude of 1056 m above sea level. It can be concluded that the aircraft is not subject to operational safety disturbances and meets the aircraft's permit distance to topography.
3. Flight destination from Husein Sastranegara Airport to Kualanamu Airport takes 8400s (2 hours 20 minutes) with Boeing 737-800 so that the average speed of the aircraft is 5.9 nm / min. Within a radius of destinations 820 nm aircraft can spend fuel for 10130 liters, so the fuel consumption of aircraft per destination length yag is 15 liters / nautical miles.
 - a. The operation of the aircraft is in optimum equilibrium at 877 nm (1624.2 km) with fuel consumption of 10734 liters and payload of 15853 kg.

- b. Boeing 737-800 aircraft operating at Husein Sastranegara Airport Bandung, can extend the distance of 52 nautical miles from the distance of the farthest flight 820 nm to 877 nm.
- c. Boeing 737-800 aircraft operating at Husein Sastranegara Airport can add destinations to several airports to optimize flight operations. New destinations that can be taken by Boeing 737-800 aircraft from Husein Sastranegara Airport are:
 1. Pearl Airport (Kalimantan)
 2. Lawas Airport (Kalimantan)
 3. Bolaang Airport (Sulawesi)
 4. Baubau Airport (Sulawesi)
 5. Soa airport (Nusa Tenggara)
 6. Teuku Cut Ali Airport (Aceh)
 7. Brunei Darussalam Airport (Brunei Darrussalam)
 8. Sultan sultan Ismail Petra (Malaysia)
 9. Antar Bangsa Airport Penang (Malaysia)

Acknowledgments

None.

Conflicts of interest

Authors declare that there is no conflicts of interest.

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