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Flight Safety Case Study: Adi Sucipto Airport Jogjakarta - Indonesia

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Abstract: Adi Sucipto Airport-Jogyakarta is an airport with enclave civil status or as TNI-AU airbase (civilian airport within the military area) has limited infrastructure with Azimuth Runway 09-27, has no RESA (Runway End Safety Area). The calculation results using Acceptable Safety Level (ASL) standard 1 x 10-7 shows that the probability of accident risk at wet runway condition is greater than in dry condition. Runway Excursion occurs at the airport, especially when the runway is wet and overrun due to hydroplaning and the plane deviates from the center of runway as well as the aircraft wheels are in contact with ground or obstacle surface outside the runway. It means the thicker layer of water above the runway will cause increased risk of accidents on the runway. This is why standing water should be immediately removed from the runway as quickly as possible.
Mitigation efforts need to be done simultaneously with recovery by adding RESA and other preventive efforts in order to water patch and standing water does not exceed 2 mm and apply the mandatory of SOP consistently at the airport.

Keywords: Risk assessment of runway safety area.

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I. INTRODUCTION

Flight safety is a top priority in the world of aviation, there is no compromise and tolerance in safety. The government is committed to "Safety is Number One", but in fact, aircraft accidents are still occurring, especially on runways in time of takeoff and landing, many aircraft are slipping on the runway. This is strongly influenced by the provision of airport infrastructure such as runways, Runway Strip, and Runway End Safety Area (RESA). Adi Sucipto Airport-Jogjakarta is an airport with enclave civil status or as TNI-AU airbase (civilian airport within the military area) has a limited infrastructure with Azimuth Runway 09-27 dimension of 2,200 mx 45 m runway, PCN 55/ F/C/X/T, with 3 taxiways 105 mx 30 m, 120 mx 23 m, 380 x 23 m, has no RESA (Runway End Safety Area).

In serving flights during the years 1992 - 2017 there are several incidents and accidents that have occurred in the airport namely:

- On 13/1/1995 an accident happened to operator PT.Garuda Indonesia with flight number GA358, PK-GWF registration and Jakarta-Jogyakarta flight route crashed During landing on RW 09 the A/C was overrun and went out of R / W about 50 meters from the end of R/W 09 (the runway was wet due to rain).
- On 7/3/2007 an accident happened to PT.Garuda Indonesia with flight number GA258, PK-GZC registration and Jakarta-Jogyakarta flight route crashed During landing and overrun, complete data Report issued by KNKT that is Aircraft Accident Investigation Report
- On 20/12/2012 an accident occurred at the operator to PT. Sriwijaya Air with flight number SJ-230, PK-CKM registration and Jakarta-Jogyakarta flight route had an accident and over run, complete data report issued by KNKT that is Aircraft Accident Investigation Report.
- On 23/1/2013 there was an accident of PT. Garuda Indonesia with flight number GA-207, PK-GEH registration with Jogyakarta-Jakarta flight route having an RTA accident due to damage of wing body overheat.
- On 22/11/2013 PT. Batik Air & PT. Air Asia with flight numbers BTK-6360 & AWQ8441, PK-LBH & PK-AXA register with route JKT-JOG & JOG-JKT had runway incursion accident, complete report data issued KNKT namely Aircraft Accident Investigation Report KNKT 12.11.29.04.
- On 6/11/2015. Batik Air with flight number ID 6380, JKT-JOG route had an overshoot during landing at the end of runway RW 27.

- On February 1, 2017, PT.Garuda Indonesia has an accident with flight number GA258, registration PK.GNK type of aircraft B-737.800 NG with the route CGK-JOG. plane slipped and overshoot while landing from RW 09 with rainy weather conditions (due to weather).

In mitigating and preventing future aviation hazards, it is necessary to supervise the operators of airlines, airport operators and regulators on the implementation of safety standards on aviation.

The objective of this research is to evaluate prevention efforts of aviation accident due to not fulfilled standards of runway, strip and RESA at airports. The problem is the factor causing the flight accident due to not fulfilled standards of runway, strip and RESA at the airport. So it needs to overcome at operational aspects of runway infrastructure, runway strip and RESA at the airport.

II. LITERATURE REVIEW

In Law of Act Number 1 Year 2009 on Aviation in Article 1 point 48 states that flight safety is a condition of fulfillment of safety requirements in the utilization of airspace, aircraft, airport, air transport, flight navigation, as well as supporting facilities and other general facilities. In Chapter XIII Law no. 1 Year 2009 on Aviation states Aviation Safety, which consists of a discussion of the National Aviation Safety Program. There are three elements that contribute to aviation safety: first: the aircraft itself, how the aircraft was designed, manufactured and cared for; Second: country flight system, airport, air traffic, and air traffic controls; Third: airlines flight operations deals with the control and operation of aircraft in airlines.

According to Law Number 24 Year 2007 on Adaptation and Disaster Mitigation, Definition of mitigation is a series of efforts to reduce the risk of disaster / accident, either through physical development or awareness and increased ability to face disaster threat. Anticipation and mitigation of aviation safety is critical to reducing the risk of aircraft crashed on runways when taking off and landing. According to the investigation results of the National Safety Transportation Committee (KNKT), transport accidents from 2007 to 2015 caused by human error factor of 60.38%, technical 31.45%, and environment by 8.18%.The accident risk factor according to Ayres et al (2011) states that human error and airport condition affect aviation safety.

According to Fortes and Correaia (2012) states that condition of airport capacities and facilities that affect aviation safety are called non conformities. Non conformities are situations or conditions of deviations from the standard requirements in regulations. Examples of non conformities and runway circumstances that affecting aviation safety at airports.

Basic analysis Risk Assessment of Runway Safety Area

The danger of accidents create a risk. Accident occurring conditions, events, objects or environments that may affect or contribute to unplanned or undesirable events. Risk is uncertainty caused or caused by danger. The magnitude of risk is probable and depends on the probability occurrence and its consequences, so it can not be eliminated (Fortes and Correaia, 2012, after Canale et al., 2005).

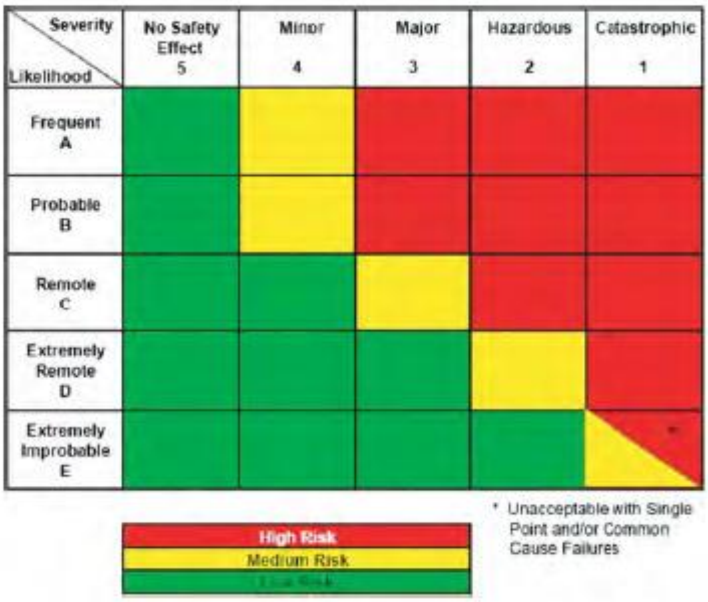


Table 1. Classification of Accident Risk

Source: Ayres et al, 2011 after FAA, 2010

Model Risk Assessment of Runway Safety Area Consists of four parts as follows:

1. Frequency probability model.
2. Location model.
3. hazard severity.
4. Classification of accident risk
5.

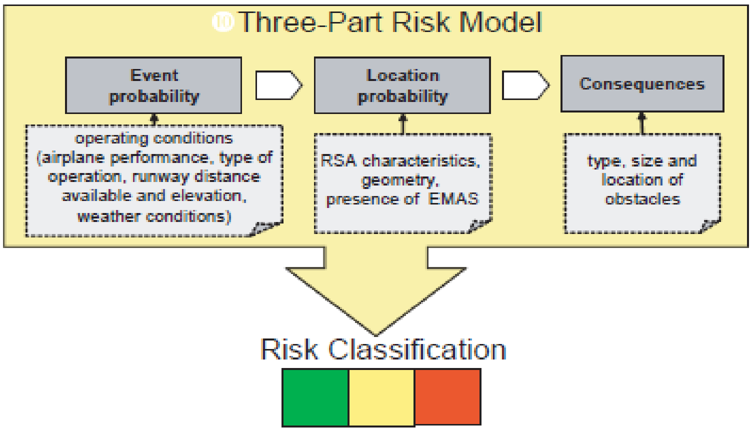


Figure 1. Three stages on Risk Assessment of Runway Safety Area
(Source: Ayres et al, 2011)

Equation 1 The frequency model or the probability of an accident or incident

$$P\{Accident\_Occurence\} = \frac{1}{1 + e^{b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots}}$$

P{Accident_Occurence} : The possibility or probability of accident occurring under certain operational conditions.
X_i : Independent variable..
b_i : Regression constant.

There are three types of accidents that are accommodated in Equation 1 that is :

1. Landing overrun (LDOR).
2. Landing undershot (LDUS).
3. Takeoff overrun (TOOR).

Table 2. Constants for each type of accident

Accident	**Variable b**
Landing Overrun	b = – 15.456 + 0.551(Heavy Acft) – 2.113(Commuter Acft) – 1.064(Medium Acft) – 0.876(Small Acft) + 0.445(TurboProp Acft) – 0.857(International Origin/Destination) + 1.832(Ceiling Height < 1000 pés) + 1.639(Ceiling Height 1001 – 2500 pés) + 2.428(Visibility < 2SM) + 1.186(Visibility 2 - 4SM) + 1.741(Visibility 4 - 6SM) + 0.322(Visibility 6 - 8SM) – 0.532(Crosswind 2 – 5 knots) + 1.566(Crosswind 5 – 12 knots) + 1.518(Crosswind > 12 knots) + 0.986(Electric Storm) + 1.926(Icing Conditions) + 1.499(Snow) – 1.009(Temperature< 5C) – 0.631(Temperature 5 – 15C) + 0.265(Temperature > 25C) + 1.006(Nonhub Airport) + 0.924(Significant Terrain)
Taking off Overrun	b = – 16.6515 + 0.721(Heavy Acft) – 0.619(Commuter Acft) – 0.009(Medium Acft) + 1.669(Small Acft) + 1.336(User Class1) + 1.052 (User Class 2) + 1.225(Ceiling Height < 1000 pés) + 1.497(Ceiling Height 1001 – 2500 pés) + 0.201(Visibility < 2SM) – 1.941(Visibility 2 - 4SM) – 0.366(Visibility 4 - 6SM) + 0.317(Visibility 6 - 8SM) + 1.660(Fog) – 0.292(Crosswind 2 – 5 knots) + 1.598(Crosswind 5 – 12 knots) + 1.781(Crosswind > 12 knots) – 0.536(Temperature < 5C) – 0.507(Temperature 5 – 15C) + 0.502(Temperature > 25C) + 1.805(Icing Conditions) + 2.567(Snow)
Landing Undershoot	b = – 14.9642 + 0.036(Heavy Acft) – 1.699(Commuter Acft) – 0.427(Medium Acft) + 1.760(Small Acft) + 0.288(User Class1) + 0.908 (User Class 2) –1.042(International Origin/Destination) + 0.199(Ceiling Height < 1000 pés) + 1.463(Ceiling Height 1001 – 2500 pés) + 2.074(Visibility < 2SM) + 0.069(Visibility 2 - 4SM) – 0.185(Visibility 4 - 6SM) – 0.295(Visibility 6 - 8SM) + 1.830(Fog) – 1.705(Rain) – 0.505(Temperature < 5C) – 0.874(Temperature 5 – 15C) – 0.446(Temperature > 25C) + 2.815(Icing Conditions) + 2.412(Snow)

Source: Ayres et al, 2011 after FAA, 2010

Equations 2 and 3.:The general model of location possibilities as follows.

$$P\{Location > x\} = e^{-ax^n}$$

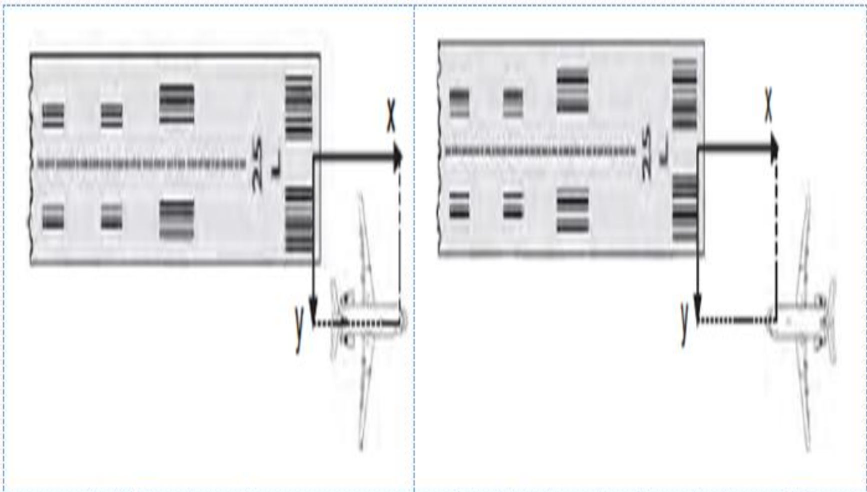
$$P\{Location > y\} = e^{-by^m}$$

X : The longitudinal distance of an obstacle measured from the end of the runway (feet).
Y : The transverse distance of an obstacle measured perpendicular to the axis of the runway (feet)

Table 3. Equations of possible model locations for each type of accident

Type of Accident	Type of Data	Model	R^2	# of Points
LDOR	X	$P\{d > x\} = e^{-0.00321x^{0.984941}}$	99.8%	305
	Y	$P\{d > y\} = e^{-0.20983y^{0.4862}}$	93.9%	225
LDUS	X	$P\{d > x\} = e^{-0.0148x^{0.751499}}$	98.7%	83
	Y	$P\{d > y\} = e^{-0.02159y^{0.773896}}$	98.6%	86
		$P\{d > x\} = e$		
	Y	$P\{d > y\} = e^{-0.04282y0.659566}$	98.7%	90
TOOR	X	$P\{d > x\} = e^{-0.00109x^{1.06764}}$	99.2%	89
	Y	$P\{d > y\} = e^{-0.04282y0.659566}$	98.7%	90

Source: Ayres et al, 2011 after FAA, 2010



a. Definition of x - y On overrun condition

b. Definition of x-y On undershot condition

Figure 2. Definition of x and y in overrun and under shoot conditions

If the obstacle is regarded as a thin field, then x has one value; whereas y has two values i.e. the nearest value (y1 or yc) and the furthest value (y2 or yf) of the axis of the runway end. Figure 4 presents the definitions y1 or yc and y2 or yf.

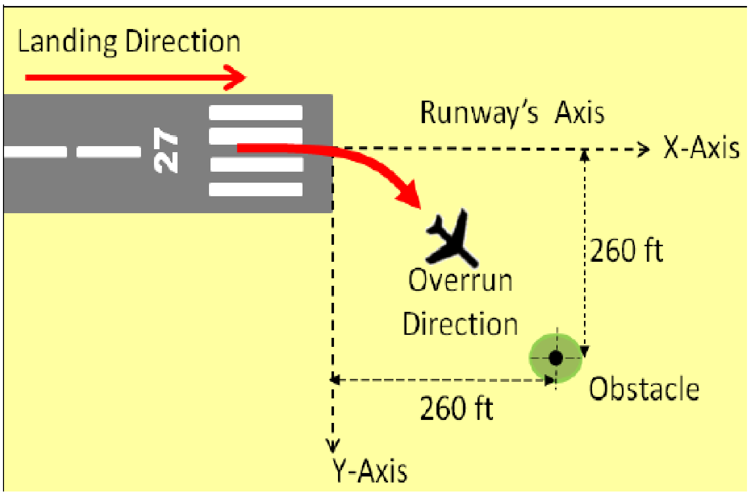


Figure 3. The determination of the values of x and y if the obstacle is regarded as a point and which has coordinates (260 feet, 260 feet) of the axis of the runway

If the obstacle is considered a thin field, then x has one value; Where y has two values ie the nearest value (y1 or yc) and the furthest value (y2 or yf) of the runway axis. Figure 4 presents the definition of y1 or yc and y2 or yf.

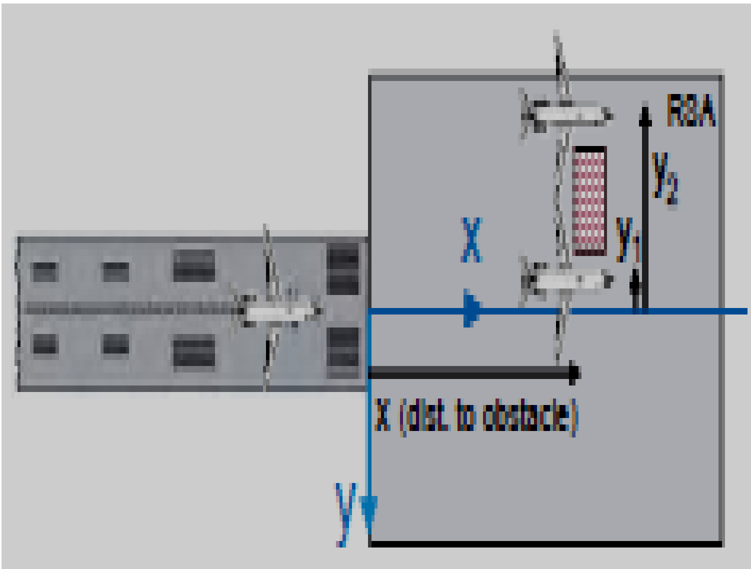


Figure 4. The definition of y1 or yc and y2 or yf

If the obstacle is regarded as a thin field, the value of P {Location> y} is symbolized as P_{sc} and calculated using the following Equation 4

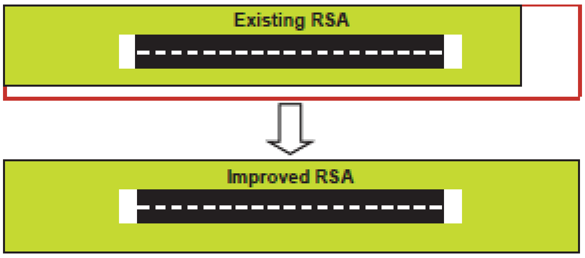
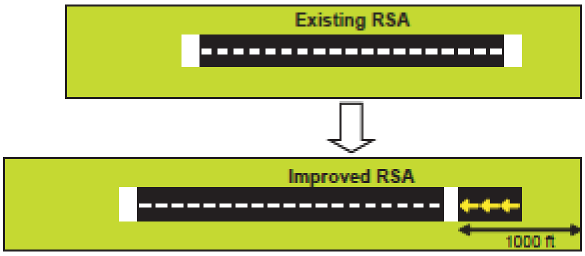
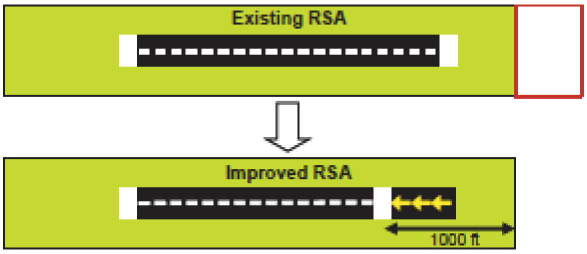
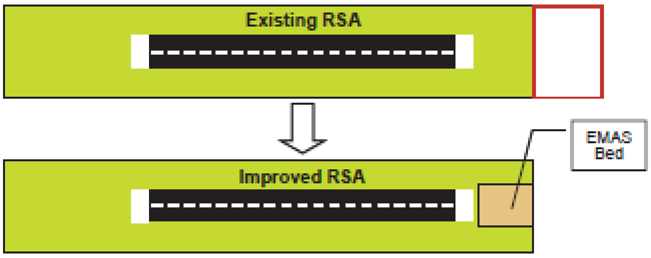
$$P_{sc} = \frac{e^{-by_c^m} - e^{-by_f^m}}{2}$$

Values b and m: regression coefficients according to the type of accident being analyzed.
The Probability Value {final} is obtained by Equation:
After P {Accident_Occurence}, P {Location> x}, and P {Location> y} are then calculated the final value of probability (or P {final}).

The P value {final} is obtained with the following Equation 5.
P {final} = P {Accident_Occurence} × P {Location> x} × P {Location> y}
The P value {final} is then converted to the probability of occurrence frequency or P (x) as shown in Table 1.

Accident Risk Mitigation at Runway Safety Area (RSA)

Table 4. Four main alternatives within efforts to reduce the risk of accidents in RSA

No	Alternative	Illustration
1	RSA extension either longitudinally or laterally	
2	Runway relocation to extend RSA	
3	Use the declared distance, by shortening the runway and extending the RSA	
4	Repair RSA using (Engineering Material Arresting ystem).EMAS is usually a lightweight concrete stretch	

Source: Ayres et al, 2011

A. Model Risk Safety Assesment

The risk of accidents (on) runways consists of three categories:

1. Runway Excursion (RE).
2. Runway Incursion (RI).
3. Runway Confusion (RC).

Hazard events in the runway are divided into two, namely accident and accident. Accident incurs losses. Incident has potentially caused an accident, so it has not to cause losses yet. The highest accident frequency is RE. RI incident frequency is higher than RC.

Runway Excursion (RE).

Runway excursion is an event in which an aircraft has deviated (veer off) from or exceeded the runway either on takeoff or landing. RE is categorized into three namely:

a. Overrun.
b. Undershoot.
c. Veer-offs

Overrun is the failure of the aircraft to make a landing or take-off so that the plane keeps on and off the runway. Veer-offs occur when the pilot fails to control the plane, so that the movement of the plane when landing or take off deviates from the runway. Undershoot occurs when the landing gear is in contact with the ground or obstacle before the runway.

The Flight Safety Foundation (2009) states that there are five factors that cause safety risks: flight operations, air traffic management, airports, aircraft manufacturing, and regulators.

According to Leonardi (2013) previous studies by stating that the four factors that cause risk of aviation accidents is "environmental conditions characteristics of aircraft performance, runway conditions and human factors"

Table 5. Factors Affecting Flight Accidents

.No.	Classification of Factor	Factor Details
1	Environment	heavy rain side wind bird attacks fog fortex shadding
2	Airplane performance	Engine failure landing gear damage loss of hydraulic power loss of electrical power anti skid system failure high speed flap failure brake failure outbrake of pneumatic.
3	Runway condition	runway markers are not eligible loss of runway lights failure of Instrument Landing System (ILS) Absence of the Visual Aproach Slope Indicator (VASI) A large slope runway slope Foreign Object Damage (FOD) No friction aqua/hydro planning
4	Human condition	An incompetent aircraft crew Inadequate ATC services Unqualified treatment incorrect loading of aircraft

Source: Ayres et al, 2011

Assessment of the weighted contribution of factors number causing simultaneously of Runway Excursion (RE) occurrence (Page et al, 2010). States that the main cause of RE due to wet runway and / or contaminated as well as associated with straying and drainage quality of runway construction does not meet the requirements. In table 6.

Table 6. Some factors causing Runway Excursion (RE) and its weight

No	Causative factor	LDOR*	LDVO*	TOOR*	TOVO*
1	wet or contaminated Runway	58,8%	36,9%	14,2%	41,3%
2	Long landing	38,9%	-	-	-
3	The speed is too high	19,9%	-	-	-
4	Incorrect decision to land	16,3%	-	-	-
5	Aquaplaning	13,8%	-	-	-
6	Tailwind	13,6%	-	-	-
7	Late/incorrect use of brakes	11,3%	-	4,2%	-
8	Late/incorrect use of reverse thrust	11,1%	-	-	-
9	Too high on approach	6,1%	-	-	-
10	Crosswind	-	26,2%	-	18,3%
11	Aircraft directional control not maintained	-	13,9%	-	33,9%
12	Hard landing	-	12,1%	-	-
13	Nose wheel steering issues	-	10.1%	-	17,4%
14	Tire failure	-	6,4%	-	12,5%
15	Landing gear collapsed	-	6,2%	-	-
16	Cancellation takes off after the plane reaches speed V1**	-	-	40,8%	-
17	Takeoff mass too high/incorrect	-	-	10,8%	-
18	Asymmetric power	-	-	-	9,2%

Source : Ayres et al, 2011

Information
LDOR:Overrun during landing,
LDVO: Veer-off during landing,
TOOR: Overrun during take-off,
TOVO: Veer-off during take-off

Runway conditions and other air side facilities that do not meet the requirements are called Non conformities associated regulation/regulation of design. There are probably two causes some airports have non conformities associated regulation/regulation of design , namely the construction is carried out when the needs of aviation safety has not been as high as current and / or the beginning of its existence as a military airport that is not fully in accordance with the standards of safety of civil airport operations.

According to Flight Safety Foundation FSF (2009) states that some types of non conformities at airports that have the potentially cause RE are as follows

1. Less precise evaluation of the obstacle.
2. Runway marking error
3. Insufficient RESA.

Some examples of non conformities related to design regulation are:

1. There are obstacles entering the transition surface.
2. Obstacles enter the surface of approach and take off.
3. There are obstacles at the runway strip.
4. There are obstacles at the taxiway strip.
5. Runway strip is uneven.
6. RESA does not exist.
7. There is a drainage channel in the runway strip.
8. Vertical signs are incomplete.
9. Horizontal signs are incomplete.
10. Road service using runway.
11. There is a wall or building structure in the runway strip area.
12. Taxiway inside the runway strip.
13. Distance of runway and centerline taxiway is relatively close.
14. Distance of runway and taxiway edge of apron is relatively close.

Runway Incursion

FAA formulates the definition of runway incursion as follows:
"Any occurrence in the airport runway environment involving aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land".

Runway incursion is also defined as the incorrect presence of aircraft, people, or vehicles in the area for landing or take-off. Based on these two formulations, runway incursion is a runway incident involving an aircraft with another aircraft, vehicle, human, or object on the surface as it should not be on the runway or taxiway, causing a collision / impact hazard due to the distance that is relatively close to the plane Which is or will take off; Or a plane that is or will take off.
The three main factors causing Runway incursion (RI) are:
1. Crew does not meet direction from ATC,
2. Crew does not recognize well the situation of the airport, and
3. SOP is not obeyed.

Runway Confusion

Runway confusion is the incident of an aircraft that unintentional use of the wrong runway, or a taxiway, for landing or take-off.

III. RESULT AND DISCUSSION

Adi Sucipto Airport-Jogyakarta is class 1 airport with enclave civil status or as a TNI-AU air base airport (civilian airport within military area). Specification of airport profile and runway conditions and other air side facilities that have not fully complied with the provisions (Non conformities) related to the design regulations. This is due to the design regulations, namely: the construction is carried out when the needs of aviation safety has not been as high as current and / or the beginning of its existence as a military airport that is not fully in accordance with the standards of safety of civil airport operations. It is clearly can be seen in table 7,8,9

Table 7. Profile and Operational Specification of Adi Sucipto Airport-Jogyakarta

Operator	**: Pt. Angkasa Pura I (Persero)**
Airport Airport Airport Status Airport Code	: Kelas I : Enclave Civil : Iata: Jog Icao :Wahh
Location Distance From The City Elevation Operating Hours Navigation Aids	: 07^0.47’12’s/110^0.25’55’e : 9 Km From The City Of Yogyakarta : 350 Ft/106 M : 15 Hours (06.00 - 21.00 Wib/23.00 - 14.00 Utc) : Ndb, Dvor, Dme, Ils, Radar
Runwaydimensi (P X L) Azimuth Runway The Value Of Pcn Platform Transverse Slope Slope Lengthwise Year Of The Last Overlay Skid Resistance Value Thickness Of Pavement Structure **Runway Strip**(P X L) Runway Strip Materials Type Of Runway Strip Layer Construction Runway Strip **Runway End Safety Area** Dimensi (P X L) Material Resa Obstacle (Kkop) Water Ponding Taxiway Apron	: 2.200 M X 45 M : R09 – R27 : Pcn 55/F/C/X/T : 1,5 % : 1 % : 2005/2006 : Average 0,59 : Ac=50,2 Cm, Atb=5 Cm, Broken Stone =35 Cm, Sirtu= 5 Cm : 2285 M X 150 M : Soil Solid : Grass : Land And Sandstone : Resa 1 (Rw 27): 77m X 66 M : Broken Stone 2/3” : Obstacle Mount Boko : - : Tw N2 : 105 M X 30 M (Pcn 41/F/B/X/T) Tw N2 : 120 M X 23 M (Pcn 59/F/C/X/T) Tw North Paralel : 380 X 23 M (Pcn 59/F/C/X/T) : Parking Stand : 9 = 28.055 M² (Pcn 40/F/B/X/T - Flexible Apron : 12.409 M² - Rigid Apron : 16.114 M² Parking Stand : 9
Passenger Terminal Cargo Terminal Parking Land	: International : Terminal B : 450 M² (240 Seat) : Domestik : Terminal A : 1.366 M² (838 Seat) Terminal B : 810 M² (310 Seat) : International : 384 M² Domestic : 342 M² : North Parking : 20.628 M² Cip Parking : 469 M²
Rescue & Fire Fighting Services Communication Supply Electricity Imigrations Counter Bea Customer Counter Trolley	: Category Vii - 1 Unit Type I @ 9000l Water & 900l Foam - 2 Unit Type Ii @ 4000l Water & 400l Foam - 1 Unit Rescue Multi Purpose Car - 2 Unit Ambulance - 1 Unit Commando Car - 1 Unit Rescue Car : Vhf (Adc/App), Hf (Ssb), Amsc, Direct Speech, Atis, Vsat : Pln : 20.628 M² Genset : 469 M² : Departure : 4 Unit Arrival : Voa & Non Voa : 4 Unit Voa Room (Bri Bank) : 1 Unit : Arrival 2 Unit : 231 Unit
Data Operations Flight: A. Operating Airlines B. The Type Of Aircraft That Operates C. The Largest Type Of Aircraft	 : Gia, Citilink, Lion, Wings, Batik, Sriwijaya, Nam, Airasia, Silkair, Express Air : B737series, B738/9, A320, Atr72, Crj1000 Bombardier : B737-900
Air Side Drainage Conditions A. Main Drainage Channel	

B. Runoff C. The Cause Of Standing Water In The Runway	: Exist : Go To Kali Kuning River Flow : Runway Slope Is Too Flat

Source :The data Airport Adi Sucipto Airport, Th. 2016

Table 8. Development of Air Transportation at Adi Sucipto Airport-Yogyakarta

No.	PRODUCTS	YEAR					
		2010	**2011**	**2012**	**2013**	**2014**	**2015**
1.	**Aircraft** Domestic International	 27.356 -	 30.417 -	 35.156 -	 39.146 -	 43.466 -	 27.443 -
2.	Passenger Domestic International	 3.356.490 -	 4.045.619 -	 4.733.686 -	 5.094.269 -	 8.085.925 -	 3.503.560 -
3.	**Cargo (Kg)** Domestic International	 11.648.168 -	 12.472.396 -	 14.019.920 -	 12.498.611 -	 16.028.649 -	 10.477.826 -

Source : Directorate General of Air Transport, Th. 2016

Table 9.. Results Of Data Collection Of Adi Sucipto Airport Operators

No.	**Question**	**Answer**
1.	Air traffic management at Adi Sucipto Airport-Yogyakarta?	Air traffic management refers to ICAO rules, operational standards pursuant to Annex as well as current documents, civilian and military aircrafts have the same civilian treatment (ICAO) including: - Separate vertical minima: 1,000 feet, - Horizontal Separation: 5 Nm
2.	Problems faced by PT. Airnav Indonesia Adi Sucipto Airport in air traffic management?	- Frequent occurrence of airprox / Teasra (Break Down of Separation) between civilian and military aircraft; - Differences in aircraft speed (type) so that is problem in air traffic management; - The absence of cooperation agreement between Military aiport Adi Sucipto and Airnav Yogyakarta so that problem is legality.
3.	The cooperation agreement between Airnav Indonesia district Adi Sucipto Airport with the TNI-AU (Air Force) in terms of air traffic management?	Not yet, waiting for the result of cooperation agreement (PKS) at the central Airnav office is still under discussion
4.	The challenge faced by Airnav Indonesia Adi Sucipto Airport district in the operation of the enclave civil airport?	- Frequent occurrence of aircraft holding of departures and arrivals waiting for the queue exceeds the existing capacity; - Determination of Operating must be unilateral by TNI-AU; - Maintenance of tower asset is often delegated fully Airnav while asset belongs to TNI-AU; - Slot time is determined by TNI-AU, Airnav and AP I.
5.	Improvement and development in air traffic management at Adi Sucipto Airport-Yogyakarta as an enclave civil airport?	- Local military procedures to be amended according to current traffic development (LLU); - Immediately made PKS as a legal law of Air Navigation; - Military training to determine the number of TPCs per hour and there is propose time in the PPL; - Training students of each flight must fill out flight plan. -

Source :The Airport Adi SuciptoYogyakarta, Th. 2016.

Figure 5. Map Runways The Airport Adi Sucipto. Joyakarta

Risk Assessment of Accident In Runway Area

The risk assessment of accidents at the airport runway area uses the comparison of safety risk (R) value and acceptable safety level (ASL). Frequency analysis models used include: based on historical data and predicted probability events. Historically based model, R is the frequency of accident or incident occurring at airport. The probability prediction model, R is the predicted chance occurrence using the model, According to the European Aviation Safety Agency (EASA, 2011) or FAA (2011). ASL is determined by reference to the recommendation of a particular aviation authority or expert opinion.

Table 10. Safety risk recommendations by aviation authorities and Experts.

Authority and / or Expert	Tipe RE	ASL
ICAO (1974)	Veer-offs	$6{,}6\times10^{-7}$
Ashford (1977), Norwegian CAA (2001), Ayres, M. Jr. et al, (2011)	Overrun	1×10^{-7}
CAA UK (1997)	Overrun	4×10^{-7}

The accident risk analysis using EASA 2011 model consists of two sub models, namely:

1. Model of opportunity occurrence.
2. Location opportunity model.

EASA 2011 uses the following equation to calculate the chance of a safety risk event (p1).

$$p_1 = \frac{1}{1+e^{-C}}$$

Table 11. The equation for calculating the value of C in the probability event model

Risk of accidents	C*
TOOR (small aircraft)	–14.0819 + 0.3513 (wet runway) + 1.5687 (contaminatedrunway) + 0.7807 (tailwind < -5 knots) – 0.2708 (Headwind ≥0 kts) + 0.9792 (Elevation ≥ 500 m) +1.9339 (Runway slopeless than -1%) + 1.1329 (Take-off distance margin ≤ 100 m)
TOOR (large aircraft)	–16.1786 + 0.0296 (wet runway) + 1.5983 (contaminatedrunway) + 0.3678 (tailwind < -5 knots) – 0.0262 (Headwind ≥0 kts) + 0.4107 (Elevation ≥ 500 m) + 1.2993 (Take-offdistance margin ≤ 100 m).
LDOR (small aircraft)	–14.1677 + 1.3326 (Non Precision Approach) + 2.057(Visual approach) + 0.8397 (Wet runway) + 1.6583(Contaminated runway) + 2.2575 (Tailwind < -5 knots) –0.2726 (Headwind ≥ 0 kts) +0.9700 (Elevation ≥ 500 m) +0.5469 (IMC conditions) + 1.2720 (Visibility < 1500 m) –1.628 (Glidepath – visual system installed) + 1.4471 (Runway slope < -1%) + 1.0655 (Landing distance margin ≤100 m).
LDOR (large aircraft)	–15.5004 + 0.5336 (Non Precision Approach) + 1.1924(Visual approach) + 2.0366 (Wet runway) + 2.9468(Contaminated runway) + 2.5239 (Tailwind < -5 knots) –0.3187 (Headwind ≥ 0 kts) + 0.6692 (Elevation ≥ 500 m) +1.0883 (IMC conditions) + 1.4280 (Visibility < 1500 m) –0.8002 (Glidepath – visual system installed) + 1.9539 (Runway slope < -1%) + 0.1716 (Landing distance margin ≤100 m).
LDUS (small aircraft)	–14.0655 + 0.3448 (Non precision approach) + 1.6982(Visual approach) – 0.1713 (Daylight) + 1.0921 (Elevation ≥500 m) + 0.7932 (IMC conditions) + 0.9635 (Visibility < 1500m) – 0.8535 (Glidepath – visual system installed).
LDUS (large aircraft)	–17.1955 + 0.734 (Non precision approach) + 1.4649 (Visual approach) – 0.4418 (Daylight) + 0.952 (Elevation ≥ 500 m) +

	1.1944 (IMC conditions) + 2.5386 (Visibility < 1500 m) – 0.1206 (Glidepath – visual system installed).

* **Source :** Ayres et al, 2011

The equations apply to take off maneuvers or landing ≥ 800 per year

T**he location opportunity model calculates the probability of events based on RESA data**. **Table 12**. presents the equations for calculating them

Table 12. The equations in the location opportunity model

Scenario	Longitudinal cumulative probability distribution	Lateral cumulative probability distribution
Takeoff overrun (small and large aircraft)	$e^{-0.0022450x^{1.1268}}$	$e^{-0.279545\|y\|^{0.4666}}$
Landing overrun (small and large aircraft)	$e^{-0.007572x^{1.10006}}$	$e^{-0.318647\|y\|^{0.4802}}$
Landing undershoot small aircraft	a= 0.6170 and b=1.1218, see footnote	$e^{-0.111593\|y\|^{0.558}}$
Landing undershoot large aircraft	a= 0.5331 and b=1.4913, see footnote	$e^{-0.627182\|y\|^{0.3176}}$

*Coefficients of the Beta cumulative distribution function.

Stages of calculating safety risks for mixed traffic are as follows.
1. Collect data on runway size and RESA airport.
2. Collect the baseline data required for TOOR, LDOR and LDUS calculations, for each landing and take-off plane to be analyzed.
3. Calculate safety risks (p1) TOOR, LDOR and LDUS using the equations Table 5.6.
4. If there is more than one value of TOOR, LDOR and LDUS, it is necessary to calculate the p1 value of the mean.
5. Calculate the probability of occurrence using the probability model of the location in Table 5.7.
6. Calculate the probability of a plane occurring out of RESA using the following equation.

Analysis of equation calculation for wet runway condition and dry runway condition

Analysis results of safety risk calculation (P) Adi Sucipto Airport to be compared with Acceptable Safety Level (ASL). The calculation is done for wet runway condition and dry runway condition. The results of the analysis from each survey location can be presented in the following table

The calculation is carried out for wet runway condition and dry runway condition.

Table 13. Analysis results for Adi Sucipto Airport, Yogyakarta

Airport	Event	Single Probility		Mised Probality	
		Wet	Dry	Wet	Dry
Yogyakarta	LDUS SA	3, 28E -07	3, 28E -07	3,80554E-07	2, 36218E-07
	LDUS LA	3, 37E -08	3, 37E -08		
	LDUS SA	2, 07E -06	2, 07E -06		
	LDUS LA	2, 78E -07	2, 78E -07		
	LDUS SA	7, 01E -06	7, 01E -06		
	LDUS LA	6, 3E -08	6, 3E -08		

Source : Result Analysis

Larger probability indicates a greater potential safety risk. If using ASL standard as much as 4 x 10-7. Then the surveyed airport meets the ASL standard on wet conditions. If ASL standard of 1 x 10-7 is used then the surveyed airport does not meet the safety risk requirement. Until now there is no provisions standard on the ASL standard, so for each country there are different trends. The calculation result shows that the probability of occurrence of accident risk on wet runway condition is greater than in dry condition. It means that the thicker layer of standing water above the runway will cause an increased risk of accidents on the runway. This is why standing water must be removed from the runway as soon as possible.

Qualitatively, mitigation measures to overcome non conformities runway through preventive action and remedial action. In this continuing analysis effort will be simulated with the provision of RESA that meets the standards at both ends of runway 27 - 09 as part of the recovery action.

Table 14. Simulation Results at Adi Sucipto Airport, Yogyakarta

Airport	Event	Single Probility		Mised Probality	
		Wet	Dry	Wet	Dry
Yogyakarta	LDUS SA	3,19934E-07	3,19934E-07	1, 42446E-07	1, 03411E-07
	LDUS LA	3,34969E-08	3,34969E-08		
	LDUS SA	1,22969E-06	1,22969E-06		
	LDUS LA	1,65194E-07	1,65194E-07		
	LDUS SA	2,44319E-06	2,44319E-06		
	LDUS LA	2,19655E-08	2,19655E-08		

Source : Result Analysis

The results of the two comparison scenarios are: a. Probability Existing &With RESA (wet) and 2. Probability Existing & With RESA (Dry)

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

From the analysis and evaluation of several things we can conclude as follows:

1. Adi Sucipto airport that is surveyed generally meets ASL standard 4 x 10-7 on dry runway and wet runway. But if using the Acceptable Safety Level ASL standard 1 x 10-7 then the airport has a greater risk of accident probability.

2. Runway Excursion takes place at the airport when the runway is wet and the aircraft rides out of the runway (overrun) due to hydroplaning and the plane deviates from the runway as well as the aircraft's wheels are in contact with ground or obstacle surface outside the runway.

3. In general, the addition of RESA in accordance with the standards may lower the probability of accident risk.

4. There is no information of braking action should be submitted to the pilot about uneven runway surface ondulation during landing and take off

RECOMMENDATIONS

Suggestions or recommendations that may be given to reduce the probability of safety risks as result of non conformities runway are as follows:

1. The probability of accident risk in wet conditions is generally larger than dry conditions. So that, to reduce the risk of accidents that occur required the provision of a standard cross-runway slope. In addition, it is necessary to provide good drainage system in the runway strip area.

2. Mitigation efforts need to be carried out simultaneously either with recovery by adding RESA or other preventive efforts such as the occurrence of water patch and standing water that exceed 2 mm.

3. Preventive and recovery efforts in the context of accident risk mitigation need to be part of SOP mandatory that is applied consistently at an airport.

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