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REPUBLIC OF INDONESIA

FINAL

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Aircraft Accident Investigation Report

Genesa Flying School

Super Decathlon 8KCAB; PK-RTZ

Tunggul Wulung Airport, Cilacap Central Java

Republic of Indonesia

20 March 2018

2020

This Final Report is published by the Komite Nasional Keselamatan Transportasi (KNKT), Transportation Building, 3rd Floor, Jalan Medan Merdeka Timur No. 5 Jakarta 10110, Indonesia.

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Jakarta, 24 August 2020

KOMITE NASIONAL
KESELAMATAN TRANSPORTASI
CHAIRMAN

SOERJANTO TJAHJONO

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ABBREVIATIONS AND DEFINITIONS

ATS	:	Air Traffic Services
BKN	:	Broken (Cloud amount is assessed in total which is the estimated total apparent area of the sky covered with cloud). The Broken (BKN) is when the clouds cover more than half (5/8 up to 7/8) area of the sky.
BMKG	:	Badan Meteorologi klimatologi dan geofisika/Bureau of Meteorology, Climatology and Geophysics
CCTV	:	Close Circuit Television
CPL	:	Commercial Pilot License
DGCA	:	Directorate General
FIC	:	Flight Instructor Course
hPa	:	Hecto pascal
IAS	:	Indicated Air Speed
inHg	:	Inch of Hydrargyrum (Mercury)
ICAO	:	International Civil Aviation Organization
IR	:	Instrument Rating
KNKT	:	Komite Nasional Keselamatan Transportasi
LT	:	Local Time
mb	:	millibars
m	:	Meters
MPH	:	Mile per Hour
PPL	:	Private Pilot License
QFE	:	The Q code indicating air pressure at the current ground level.
QNH	:	The Q code indicating the atmospheric pressure adjusted to mean sea level.
RPM	:	Rotation per Minute
SCT	:	Scattered (Cloud amount is assessed in total which is the estimated total apparent area of the sky covered with cloud). Scattered (SCT) is when the clouds cover 3/8 to 4/8 area of the sky.
SE Land	:	Single Engine Land aircraft
TR	:	Type Rating Course
UTC	:	Universal Time Coordinate
VMC	:	Visual Meteorological Conditions
WIB	:	Local Time of Waktu Indonesia bagian Barat (Western Indonesia Time which is UTC + 7)

SYNOPSIS

On 20 March 2018, a Super Decathlon 8KCAB registered PK-RTZ was being operated by Genesa Flight Academy conducted an aerobatic solo flight exercise for preparing a flight demonstration in the graduation ceremony of the student pilots in Genesa Flying School.

The aircraft (PK-RTZ) departed Tunggul Wulung Airport, Cilacap at 0020 UTC (0720 WIB) together with three Cessna 172 aircraft (PK-RTA, PK-RTF and PK-RTW). After departure, these four aircraft conducted formation flight and fly pass exercise. After completion of the formation flight, three Cessna aircraft landed and waited on the end of runway 31 while PK-RTZ conducted aerobatic flight exercise. The planned was after the PK-RTZ conducted an aerobatic flight exercise and landed, the four aircraft would taxi in together to the apron. The aerobatic flight exercise was the first exercise conducted in Tunggul Wulung.

Refer to the amateur video footages of the aerobatic flight the aerobatic maneuver was conducted approximately of 2.5 minutes. The investigation reviewed the maneuver and found that the pilot conducted the aerobatic flight maneuvers of Loop, Cuban eight, Split-S, Loop, Split-S, Split-S and the last maneuver that was could not be determined.

At the last maneuver, the aircraft flew align with the runway 31, climbed then made left roll continued with nose up until the aircraft became inverted (upside down). The aircraft then flew down with the pitch down decreasing and crossed the runway 31. The aircraft bounced on the apron and flew toward the Perkasa Flying School hangar.

The pilot was fatally injured and six aircraft consist of four aircraft at the apron and two aircraft in the hangar were substantially damaged.

The investigation determined the contributing factor, the aircraft initiated the roll earlier and at lower altitude which not accordance to the guideline resulted in the aircraft altitude too low and the aircraft bounced to the apron during leveling off.

The KNKT issued the recommendation to the aircraft operator to address the safety issues.

1 FACTUAL INFORMATION

1.1 History of the Flight

On 20 March 2018, a Super Decathlon 8KCAB registered PK-RTZ was being operated by Genesa Flight Academy conducted an aerobatic solo flight exercise over Tunggul Wulung Airport, Cilacap[1]. The aerobatic flight[2] exercise was the first aerobatic flight conducted in Tunggul Wulung that was planned to be performed on the Genesa Flying School student pilot graduation day.

The aircraft departed Tunggul Wulung at 0020 UTC[3] (0720 WIB) together with three Cessna 172 aircraft (PK-RTA, PK-RTF and PK-RTW). After departure, these four aircraft conducted formation flight and fly pass exercise over Tunggul Wulung with call sign was Genesa Flight. The formation flight flew over the runway 31 and turned right continued with flew cross over the runway and turned left. The formation flight flew over the runway 31 and breaks the formation by joining left downwind one by one. After completion of the formation flight, three Cessna aircraft landed and waited on the taxiway near the end of runway 31 while PK-RTZ conducted acrobatic flight exercise. The planned was after the PK-RTZ completed the aerobatic flight exercises and landed, these four aircraft would taxi together to the apron.

The investigation collected several amateur video footages of the aerobatic flight exercises. The video showed that the pilot conducted the aerobatic maneuver for approximately 2.5 minutes. The reviewed of the maneuver found that the pilot conducted the series of maneuvers with the sequence was Loop, Cuban Eight, Split-S[4], Loop, Split-S, Split-S and the last maneuver that was un-identify maneuver.

At the last maneuver, the aircraft flew align with the runway 31, climbed then made left roll continued with nose up until the aircraft became inverted (upside down), The aircraft then flew down, thereafter the pitch down decreased to near level flight and crossed the runway 31.

1 Tunggul Wulung Airport Cilacap will be named as Tunggul Wulung for the purpose of this report.

2 Aerobatic flight means an intentional maneuver involving abrupt change in an aircraft's attitude, an abnormal attitude, or abnormal acceleration, not necessary for normal flight.

3 The 24-hour clock used in this report to describe the time of day as specific events occurred is in Universal Coordinated Time (UTC). Local time for Tunggul Wulung is Western Indonesia Standard Time /Waktu Indonesia Barat (WIB) or UTC + 7.

4 Split-S is an aerobatic maneuver in which the airplane is rolled into and inverted attitude followed by the second half of a loop downward.

	
The aircraft started to roll	The aircraft continued rolling to inverted position
	
The aircraft on to inverted position	The aircraft continued roll while on inverted position

Figure 1: The aircraft attitudes on the beginning of the last maneuver

The Tunggul Wulung tower CCTV facing toward to the Perkasa Flying School hangar recorded the last phase of the flight. The video footage showed that the aircraft pitch down decreased to near level flight while approaching the apron at low altitude and slightly roll to the right. The aircraft impacted four aircraft on the apron then bounced before entered into the Perkasa Flying School hangar and damaged two aircraft in the hangar.

The sequence of the aircraft attitudes before entered the Perkasa Flying School hangar as recorded on the Tunggul Wulung Tower CCTV are shown in the figure 2.

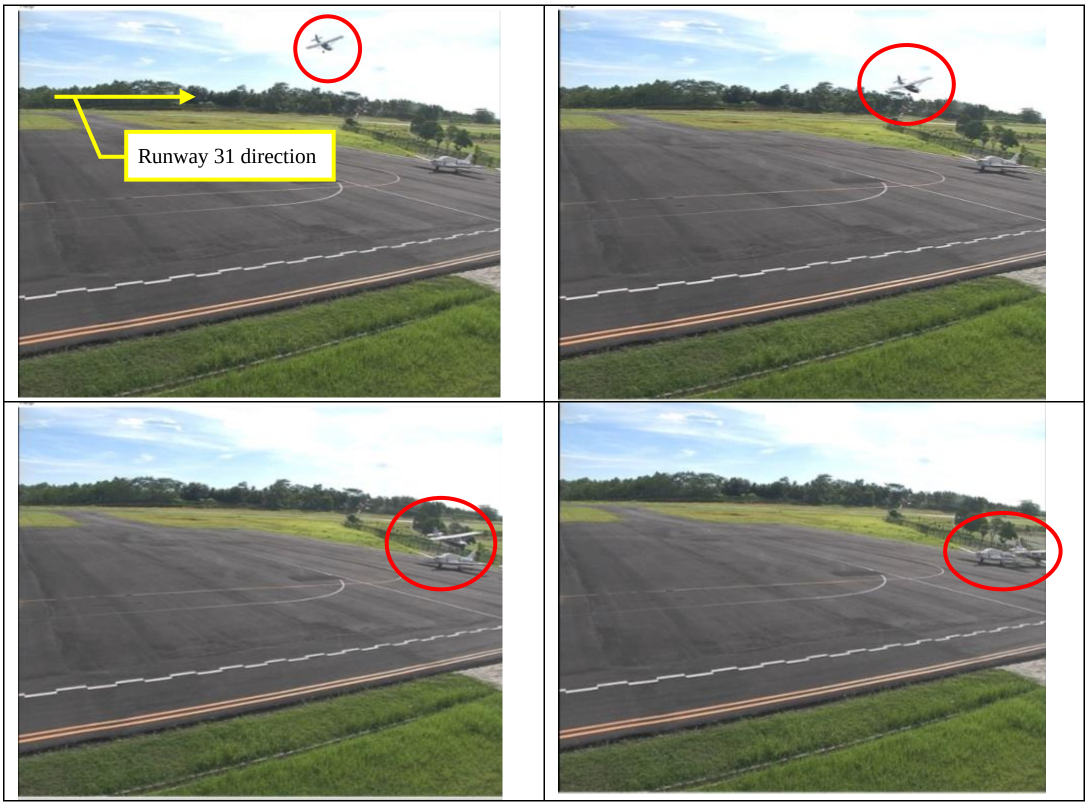


Figure 2: The aircraft on the last aerobatic maneuver

1.2 Injuries to Persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	1	-	1	-
Serious	-	-	-	-
Minor	-	-	-	-
None	-	-	-	-
TOTAL	1	-	1	-

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces.

Figure 3: The damage to the aircraft

1.4 Other Damage

The aircraft impacted to four aircraft that were parked on the apron and two aircraft in the Perkasa Flying School hangar. These six aircraft were substantially damage.

Figure 4: The damage to the three aircraft that were parked on the apron

Figure 5: The one aircraft that was parked on the corner of the apron damage

The two aircraft damage inside the hangar is shown in the figure below.

	
One of the damage aircraft at the left-inner corner of the hangar	The other damage aircraft at the right-outer corner of the hangar

Figure 6: The damage aircraft in the hangar.

1.5 Personnel Information

1.5.1 Pilot in Command

Gender	:	Male
Age	:	48 years
Nationality	:	Indonesian
Marital status	:	Married
Date of joining company	:	July 2017
License	:	CPL
Date of issue	:	17 October 2017
Certificate of Flight Instructor	:	30 January 2018
Aircraft type rating	:	Single Engine (SE) Land
Instrument rating validity	:	31 August 2017
Medical certificate	:	First Class

Last of medical	:	11 December 2017
Validity	:	11 June 2018
Medical limitation	:	None
Last line check	:	January 2018
Last proficiency check	:	5 August 2017
Flying experience		
Total hours	:	3,455.23 hours
Total on type	:	13:05 hours
Last 90 days	:	28:45 hours
Last 30 days	:	16:05 hours
Last 24 hours	:	30 minutes
This flight	:	48 minutes

The pilot had experienced of aerobatic flying during his service on Indonesia Air Force.

The pilot had been trained on Decathlon since 23 December 2017 and total hours on type was 13 hours and 05 minutes consisted of 7 hours and 5 minutes of type rating training, the aerobatic training for 2 hour 45 minutes, the flight instructor training for 35 minutes and the normal flight for 2 hours 40 minutes.

The aerobatic training consisted of introduction of basic aerobatic maneuver for low speed aircraft, including loop, cuban eight, immelman, hammer head.

1.6 Aircraft Information

1.6.1 General

Registration Mark	:	PK-RTZ
Manufacturer	:	American Champion Aircraft Corporation
Country of Manufacturer	:	Rochester, Wisconsin, United States of America
Type/Model	:	Super Decathlon 8KCAB
Serial Number	:	1010-2005
Year of Manufacture	:	2005
Certificate of Airworthiness		
Issued	:	2 March 2018
Validity	:	26 February 2019
Category	:	Normal and Acrobatic
Limitations	:	None
Certificate of Registration		
Number	:	3436
Issued	:	3 February 2018
Validity	:	2 February 2021
Time Since New (TSN)	:	442.02 hours
Last Major Check	:	100-hour inspection at 434.15 hours aircraft TSN

There was no aircraft abnormality reported during the last inspection in the maintenance log and after the last flight.

1.6.2 Engines

Manufacturer	:	Lycoming, Williamsport, Pennsylvania, United States of America
Type/Model	:	L-32458-51A
Serial Number-1 engine	:	AEIO-360-H1B
▪ Time Since New	:	442.02 hours

1.7 Meteorological Information

The weather information issued by Meteorological, Climatological, and Geophysical Agency (*Badan Meteorologi Klimatologi dan Geofisika* – BMKG) for Tunggul Wulung, issued 20 March 2018, at 0700 LT was as follows:

Wind	:	300/04 knots
Weather	:	SCT[5] 1,500 feet and BKN 10,000 feet with visibility of 5,000 meters.
Temperature	:	25°C
Dewpoint	:	25°C
QNH[6]	:	1010 hPa (29.84 inHg)
QFE[7]	:	1008 hPa (29.77 inHg)
Weather	:	no significant change expected

Based on observation to the video footage of the formation and aerobatic flight found that the weather during the flight met the requirement for Visual Meteorological Condition (VMC).

5 Cloud amount is assessed in total which is the estimated total apparent area of the sky covered with cloud. The international unit for reporting cloud amount for Few (FEW) is when the clouds cover 1/8 area of the sky, scattered (SCT) is when the clouds cover 3/8 to 4/8 area of the sky and Broken (BKN) is when the clouds cover more than half (5/8 up to 7/8) area of the sky.

6 QNH is an aeronautical code indicating the atmospheric pressure adjusted to mean sea level. It is a pressure setting used by pilots, air traffic control (ATC), and low frequency weather beacons to refer to the barometric setting which, when set on an aircraft's altimeter, will cause the altimeter to read altitude above mean sea level within a certain defined region.

7 QFE is an aeronautical code indicating the atmospheric pressure adjusted to airport elevation. It is a pressure setting refer to the barometric setting which, when set on an aircraft's altimeter, will cause the altimeter to read altitude certain airport elevation and will indicate zero when the aircraft is on the ground.

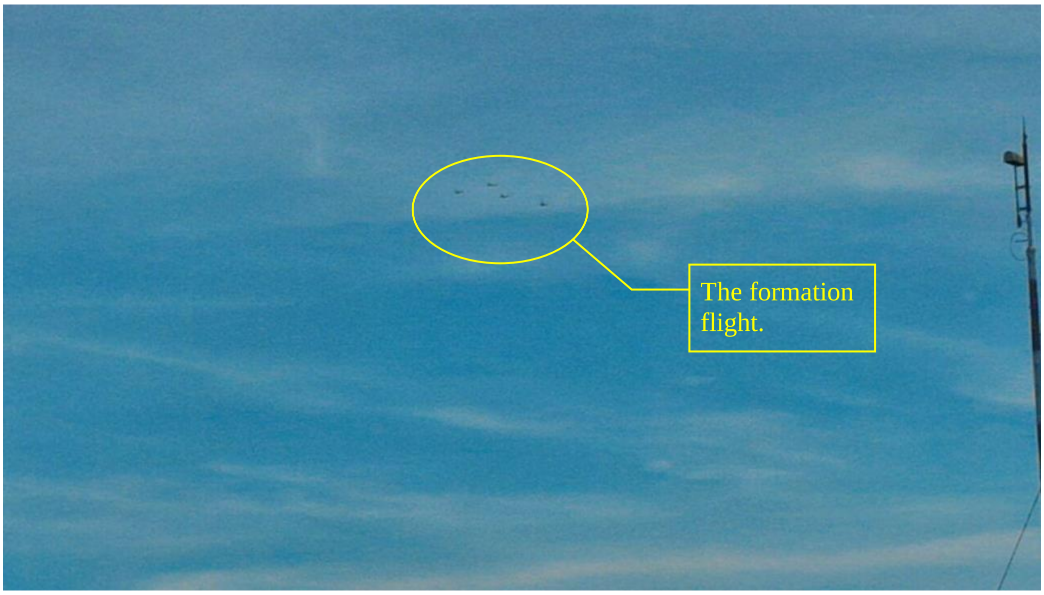


Figure 7: The formation flight and the weather at the time of occurrence

1.8 Aids to Navigation

Ground-based navigation aids, the aerodrome visual ground aids and their serviceability were not a factor in this occurrence.

1.9 Communications

All communications between ATS and the crew were recorded by ground based automatic voice recording equipment for the duration of the flight. The quality of the recorded transmissions was good.

The ATC flight plan and pilot communication with the Tunggul Wulung Tower controller did not mention the aerobatic flight exercise.

The excerpt of the communication is shown below.

Note:
Genesa 1 is the pilot of Cessna 172P PK-RTF
Genesa 2 is the pilot of Cessna 172M PK-RTA
Genesa 3 is the pilot of Cessna 172P PK-RTW
Genesa 4 is the pilot of Super Decathlon PK-RTZ
All the Genesa aircraft in this flight used call sign as Genesa flight.
Wulung is Tunggul Wulung tower controller

Time (LT)	From	Communication
07:20:53	Genesa 1	Genesa 1 was checking the communication with all Genesa flight members.
07:21:18	Genesa 1	The Genesa flight which consisted of four aircraft requested for engine start. The Wulung approved the request and advised the Genesa flight to call when ready to taxi.

Time (LT)	From	Communication
07:23:01	Genesa 1	Requested for taxi clearance and was approved by the Wulung controller and advised to call when ready to line-up runway 31.
07:28:58	Genesa 1	Reported for ready for departure and the Wulung controller issued the take-off clearance.
07:31:22	Wulung	The Wulung provided the airborne time.
07:34:25	Genesa 1	Reported that the Genesa flight reached holding point for flight exercise and was acknowledged by the Wulung controller. The Wulung advised the Genesa flight to report when ready to leave the flight exercise.
08:03:20	Genesa 1	The Genesa flight ready for leaving flight exercise and requested for joining left downwind runway 31.
08:05:47	Genesa 1	The Genesa 1 reported on the left downwind of runway 31 to the Wulung. The Wulung advised the pilot to report on final.
08:06:00	Genesa 2	The Genesa 2 reported on the left downwind of runway 31 to the Wulung. The Wulung advised the pilot to report on final.
08:06:09	Genesa 3	The Genesa 3 reported on the left downwind of runway 31 to the Wulung. The Wulung advised the pilot to report on final.
08:06:44	Wulung	The Wulung provided the landing clearance for Genesa 1.
08:07:36	Wulung	The Wulung provided the landing clearance for Genesa 2.
08:08:03	Wulung	The Wulung provided the landing clearance for Genesa 3.
08:13:52	Genesa 1	The Genesa 1 reported the Genesa flight parked at the end of runway 31 except for Genesa 4.
08:16:00	Wulung	The Wulung communicated with someone which confirming that they had already been informed.
08:16:12		End of recording

1.10 Aerodrome Information

Airport Name	:	Tunggul Wulung
Airport Identification	:	WAHL
Airport Operator	:	DGCA
Airport Certificate	:	077/SBU-DBU/XI/2013 issued on 18 November 2013
Validity	:	18 November 2018
Coordinate	:	07°38’40” S; 109°02’05” E
Elevation	:	69 feet (21 meters)
Runway Direction	:	13/31
Runway Length	:	1,400 meters

Runway Width	:	30 meters
Surface	:	Asphalt

1.11 Flight Recorders

The aircraft was not fitted with a flight data recorder or cockpit voice recorder. Neither recorder was required by current Indonesian aviation regulations for this type of aircraft.

1.12 Wreckage and Impact Information

Refer to the CCTV that facing to the Perkasa hangar showed the last moments when the aircraft about to impacted into the apron and impacted to four aircraft before entered into the Perkasa hangar.

The landing gears and the propeller scratch marks were found on the apron behind the first impacted aircraft. The ground scar at the apron indicated the flight direction approximately 080°.

The distance between marks of both main wheels spread wide suggesting the main landing gear widen out indicated compression of the main wheels to the apron. Thereafter, the marks of mainwheels and propeller vanished.

Figure 8: The landing gear and propeller marks toward the hangar

After the main wheel and propeller marks, three aircraft along the flight path were found damage. Further damage found on the hangar structure. The lower and upper windows inside the hangar showed damage as shown on the following figures. The aircraft stopped in the hangar.

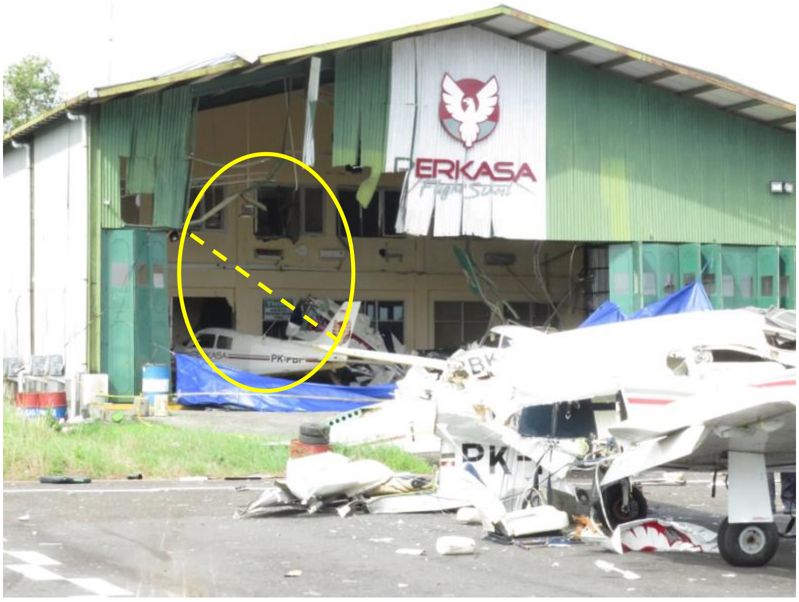


Figure 9: The Damage of the hangar

The damage to the upper forward hangar wall, the lower and upper windows inside the hangar, indicated that the aircraft was on right roll during the impact into the hangar wall. The investigation utilized the GeoCam application to define the roll angle of the aircraft before impacted into the hangar wall. The relative line showed that the aircraft was rolling to the right approximately 30°.

Inside the hangar, behind the hangar space was two storeys building which used for offices and class rooms.

The tail wheel was still intact to the aircraft lain in the hangar space. Both landing gears were detached from the aircraft. The left main landing gear was found on the office of the first floor approximately 6.5 meters from the entry door. The right main landing gear was found at the upper floor as shown in the figure below.

	
Left main landing gear near the entrance door of hangar room	Right main landing gear at upper floor of hangar room

Figure 10: The landing gears

The left main landing gear and the propeller was found broken on the first floor approximately 9 meters from the office entrance door, and the engine was found further away as shown in the figure below.

The engine detached, break through the windows and entered into the office room, created a hole on the office wall as shown in the figure below.

Figure 11: The trajectory of the thrown engine

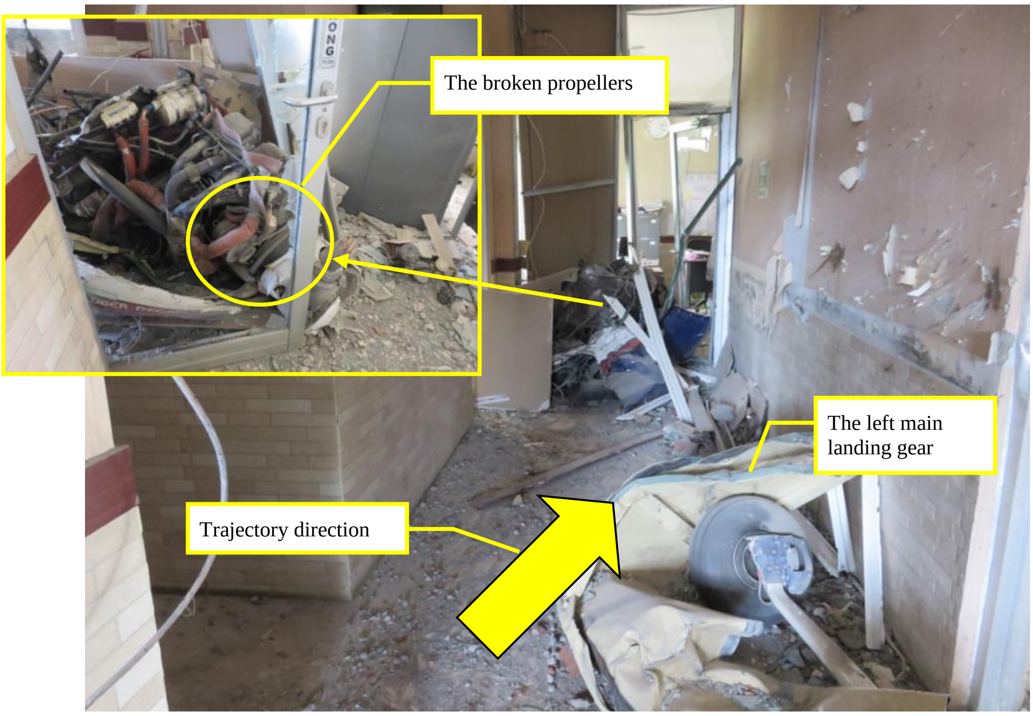


Figure 12: The engine and the left main landing gear found on first floor

Visual engine examination to fuel line and leakage indication to any fluid concluded that there was no abnormality to the engine.

The cockpit was severely damage and could not be examined.

The flight control surface cables of aileron, elevator and rudder could be moved and did not indicate of jamming. There was no any indication of damage to the flight control cables.

The both wings were detached, the left wing was found on top of the fuselage and the right wing was collapse underneath of the fuselage as shown in the figure below.

Figure 13: The right wing condition

The damage on the leading edge of the left wing most likely due to impact to the hangar upper forward structure before impacted into the office wall.

The vertical stabilizer and the rudder were severely damage as shown in the figure below.

Figure 14: The left wing, horizontal stabilizer, vertical stabilizer and rudder condition

1.13 Medical and Pathological Information

No medical or pathological investigations were conducted as a result of this occurrence, nor were they required.

1.14 Fire

There was no evidence of fire in-flight or after the aircraft impacted.

1.15 Survival Aspects

The pilot was found on second floor of the hangar building. The accident was not survivable.

1.16 Tests and Research

No tests or research were required to be conducted as a result of this occurrence.

1.17 Organizational and Management Information

1.17.1 Organization Information

Aircraft Owner	:	PT. Genesa Dirgantara
Aircraft Operator	:	PT. Genesa Dirgantara
Address	:	Komplek Puri Sentra Niaga Blok C 54 Kalimalang – Jakarta, Indonesia
Operator Certificate	:	PSC 141D-016 valid until 4 March 2019

Genesa Flight Academy is flying school organization under PT. Genesa Dirgantara which was approved to conduct the training for Private Pilot License (PPL), Commercial Pilot License (CPL), Instrument Rating (IR) and Flight Instructor Course (FIC) for Single Engine Land and Type Rating (TR) for Multi Engine Land.

The aircraft operator operates 13 aircraft consisted of two Cessna 172M, four Cessna 172P, two Cessna 172S, one Piper Seneca PA 34-220T, one AS355 FI helicopter, two R44 helicopter and the accident aircraft Super Decathlon 8KCAB. The flying school also operates the flight training device Redbird MCX000030 (STD60-54).

The flight training for student pilot was conducted at Tunggul Wulung Airport.

The Super Decathlon 8KCAB registration PK-RTZ was registered to Genesa Flight Academy however, this aircraft did not use for student pilot training.

1.17.2 Flight Preparation Plan

Genesa planned to conduct graduation ceremony on 24 March 2018 for the student pilots who had completed the training. The graduation ceremony was planned to have aircraft displayed including formation flight and aerobatic flight maneuver. This plan was agreed on a meeting in Jakarta on January 2018. The preparation of the flight exercise would be conducted in Nusawiru Airport at Pangandaran West Java and Tunggul Wulung.

On February 2018, the preparation of the flight exercise plan was executed in Nusawiru. The preparation included the class room to introduce the basic knowledge of formation flight. There were 14 flight exercises executed during the February 2018 and the aerobatic maneuver flight was not conducted during these flight exercises.

The flight exercises in Tunggul Wulung was planned to be conducted on 20 – 22

March 2018 followed by one day off prior to the graduation ceremony on 24 March 2018. The Genesa informed the planned and requested permit for the plan to AirNav Indonesia Branch Tunggul Wulung.

On 20 March 2018 which was the 15th flight exercises, was the first combination of the formation flight and aerobatic flight maneuver. The flight preparation briefing was conducted in the Genesa flight training office and the Super Decathlon pilot did not described the aerobatic maneuver that would be conducted. The briefing mentioned that after completed the formation flight exercise, the four aircraft would wait on the taxiway near the beginning runway 31 and after the aerobatic flight, all aircraft would taxi to the apron together.

1.17.3 Super Decathlon Flight Manual

The speed limitation refers to the Super Decathlon flight manual is shown in the figure below.

Speed Designation	Calibrated Air Speed		Airspeed Indicator Marking
	MPH	Knots	
Maneuvering (V_A)	107	93	None
Normal Operating Range	54-160	47-139	Green Arc
Maximum Structural Cruising (V_{NO})	160	139	
Caution Range	160-200	139-174	Yellow Arc
Never-Exceed (V_{NE})	200	174	Red Radial Line

Figure 15: Speed limit table of Super Decathlon aircraft

The performance of the aerobatic maneuver required by the aircraft refers to the Super Decathlon Aircraft Flight Manual is described below.

Basic Approved Acrobatic Maneuvers and Recommended Entry Speeds

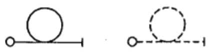
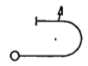
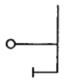
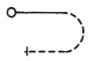
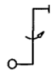
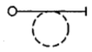
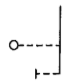
Maneuver	Aresti Symbol	Entry Speed IAS MPH	Remarks – Airspeeds I.A.S. MPH
Loop Normal – Inverted		140*	Enter 3.5 to 4 G's Speed at Top Approx. 40 MPH Exit 3.5 to 4 G's** Speed 140 – 150 MPH
Immelman		145*	Enter +4 G's Speed at Top Approx. 50 MPH Exit +1 G
Hammer Head Turn		140*	Enter +4.5 G's Speed at Top Before Turn: 40 MPH Exit +4.5 G's** 140 MPH
Snap Roll Normal & Inverted		90	Enter with Power Exit with Power No Full or Abrupt use of Flight Controls above V_A
English Bunt		70	Enter with or without Power –3.5 to –4.0 G's** when Pushing Thru from Vertical to Inverted Exit Inverted 140-150 MPH*
Vertical Slow Roll Up		180*	Enter 180 MPH Level Flight +4.5 Pull Up. Exit 40 MPH Up Push Over to Level Flight. Caution: Flight Above V_C (160 MPH-CAS) in Smooth Air Only
Vertical Slow Roll Down		60	Enter 60 MPH Push Over to Vertical Down Exit 150 MPH* Pull Out 4.5 G's** to Level Flight
Slow or Barrel Roll		130	Use Smooth Application of Controls No Full or Abrupt Use of Controls Above V_A
Outside Loop (Enter from the top)		70	Enter 70 MPH or Slower With or Without Power. Push 3.5 to 4 G's** to Inverted Speed at the Bottom 140-150 MPH* Add Full Power, Push Up 3.5 to 4 G's**. Exit Straight & Level 40-50 MPH
Horizontal Eight Inside – Outside		140*	Enter +4 G's Pull Up, Hold 45° Down Inverted, Enter Outside Loop 140 MPH* -3.5 to –4 G's. Exit From 45° Down Normal Flight – 140 MPH
Hammer Head Turn (Inverted Entry & Exit)		140*	Enter –3.5 to –4 G's Speed at Top Before Turn 40 MPH Exit From Vertical Down –3.5 to –4 G's** to Level Flight Inverted

Figure 16: The basic approved aerobatic maneuver and the entry speed

1.17.4 Civil Aviation Safety Regulation (CASR)

91.303 Aerobatic Flight

No person may operate an aircraft in aerobatic flight

(a) Over any congested area of a city, town, or settlement;

(b) Over an open air assembly of persons;

(c) Within the lateral boundaries of the surface areas of Class B, Class C, Class F, or Class G airspace designated for an airport;

(d) Within 4 nautical miles of the center line of any airway;

(e) Below an altitude of 1,500 feet above the surface; or

(f) When flight visibility is less than 3 statute miles (4.8 km).

For the purposes of this section, aerobatic flight means an intentional maneuver involving an abrupt change in an aircraft's attitude, an abnormal attitude, or abnormal acceleration, not necessary for normal flight.

1.18 Additional Information

1.18.1 The calculation of aircraft speed based on the propeller scratch mark

The investigation estimated the speed of the aircraft based on the ground scratchesar found on the apron as shown on the figure below.

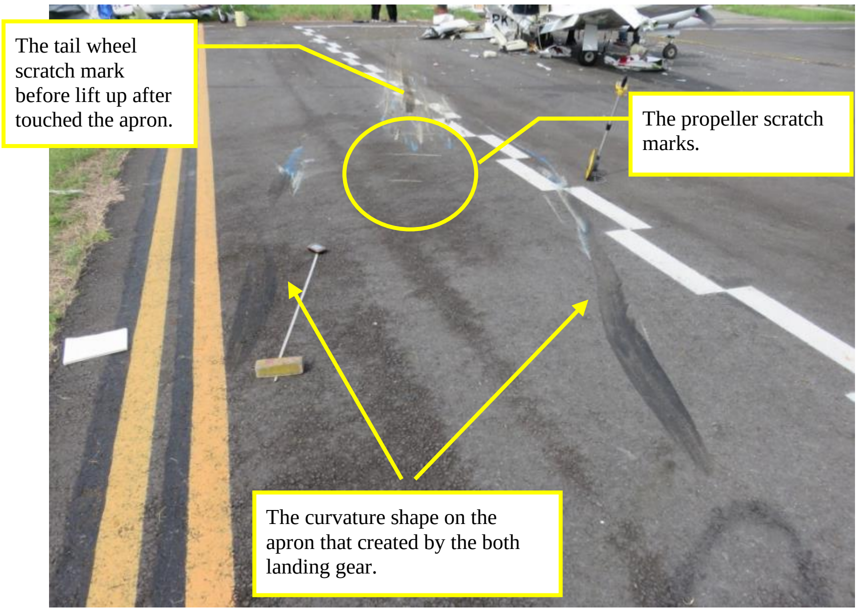


Figure 17: The ground marks found on the apron

The propeller scratch mark identification is as follow:

Scratch mark position	Distance from previous scratch (centimeters)	Length of the scratch (centimeters)	Remark
1		32	
2	88	58	
3	90	68	
4	97	45	The line created an angle approximately of 10°
5	250	91	The line created an angle approximately of 19°

The maximum propeller rotation speed is 2,700 RPM and the maneuvering speed for the propeller was limited at 2,600 RPM. The engine has two propeller blades.

Assuming the propeller speed was 2,600 RPM. The distance between first propeller scratch and the second propeller scratch was 88 cm (2.89 feet). Therefore, utilizing the Sweginnis and Wood Aircraft Accident Investigation[8], the aircraft speed calculation is as follow:

8 Aircraft Accident Investigation chapter 11 Propellers sub chapter 6 Propeller slash marks page 89-90 by Robert W. Sweginnis and Richard H. Woods

$$\text{RPM} = \frac{\text{V (in Knots)} \times 101.3\,\text{(a constant)}}{\text{N (distance between propeller blade marks)} \times \text{P (number of propeller blades)}}$$

$$2{,}600 = \frac{V \times 101.3}{2.89 \times 2}$$

V = 148.35 Knots

Based on the calculation, the estimated speed when the aircraft touched the apron was approximately between 140 and 150 Knots.

1.18.2 The Aerobatic Maneuvers

An aerobatic flight intended for a show or competition, normally performed within an area of one nautical mile long, wide, and height from the audience, to ensure that all maneuvers can be seen by the audience. Therefore, an aerobatic maneuver that requires a distance or altitude more than one nautical mile will not be performed. Another method is by combining or shortening a maneuver to ensure the maneuver can be performed within the area.

Based on the amateur video footages the pilot conducted aerobatic flight maneuvers of Loop, Cuban eight, Split-S, Loop, Split-S, Split-S and un-identify maneuver, which could be either Barrel Roll or incomplete Cloverleaf. The CCTV at the Wulung tower faced to the Perkasa Flying School hangar, showed the aircraft flew low and impacted the aircraft that parked on the apron and bounced before entered into the Perkasa hangar.

The investigation reviewed the maneuver technique based on the Aerobatic Guide Manual version 2.0 issued on January 2013 by Skyline Soaring Aerobatic Club Front Royal Virginia United States of America.

The Skyline Soaring Aerobatic Guide Manual basically describe the aerobatic maneuver for sailplanes which required the altitude between 1,200 and 1,500 feet, however the aerobatic maneuver technique relatively similar to the other aerobatic certified aircraft while the performance should refer to its aircraft flight manual or pilot operating handbook.

Loop

This maneuver uses a constant heading and variable pull through (variable G) while describing a circle in the vertical plane. The picture of the loop maneuver is as follow:

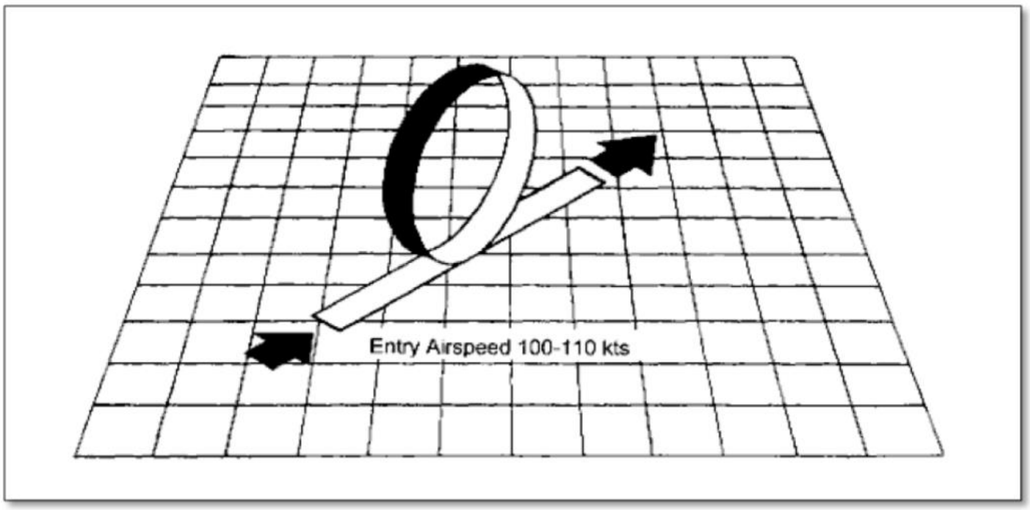


Figure 18: The Loop Maneuver

Cuban Eight

The Cuban Eight is a maneuver consisting of a 5/8 Loop followed by a half roll performed twice.

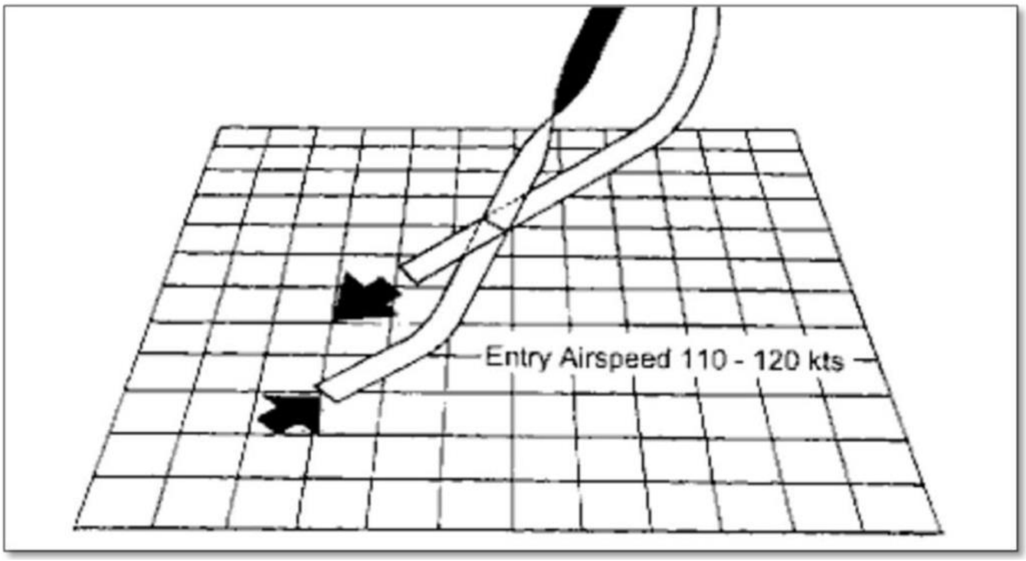


Figure 19: The Cuban Eight Maneuver

Split-S

The Split-S is a maneuver that combines a half roll to wings level inverted followed by the second half of a loop.

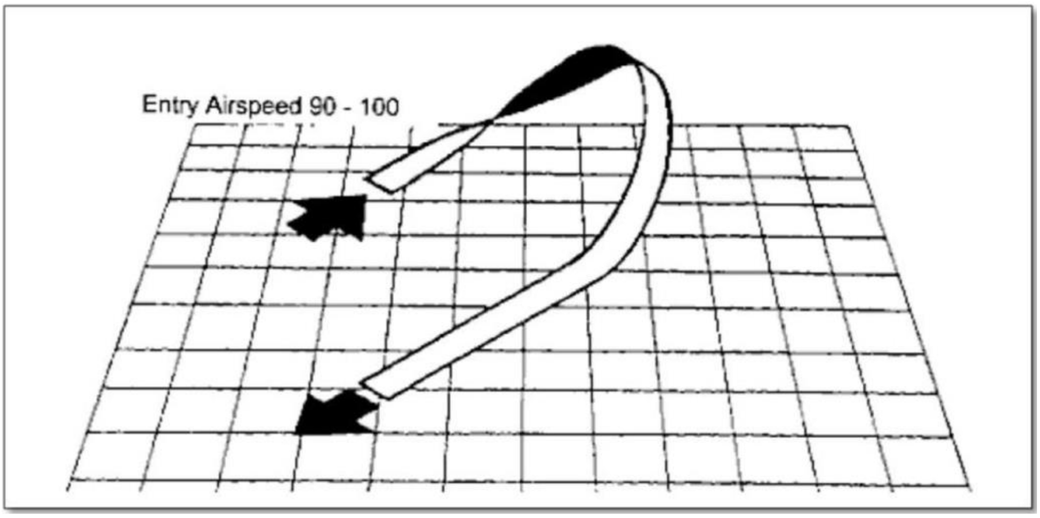


Figure 20: The Split-S Maneuver

Cloverleaf

This maneuver is a modification of a loop. When the nose reaches approximately 45° high, a quarter roll to the left is executed in the desired direction of turn, followed by a Split-S type maneuver once the wings are level inverted. This is done four times, rolling in the same direction each time.

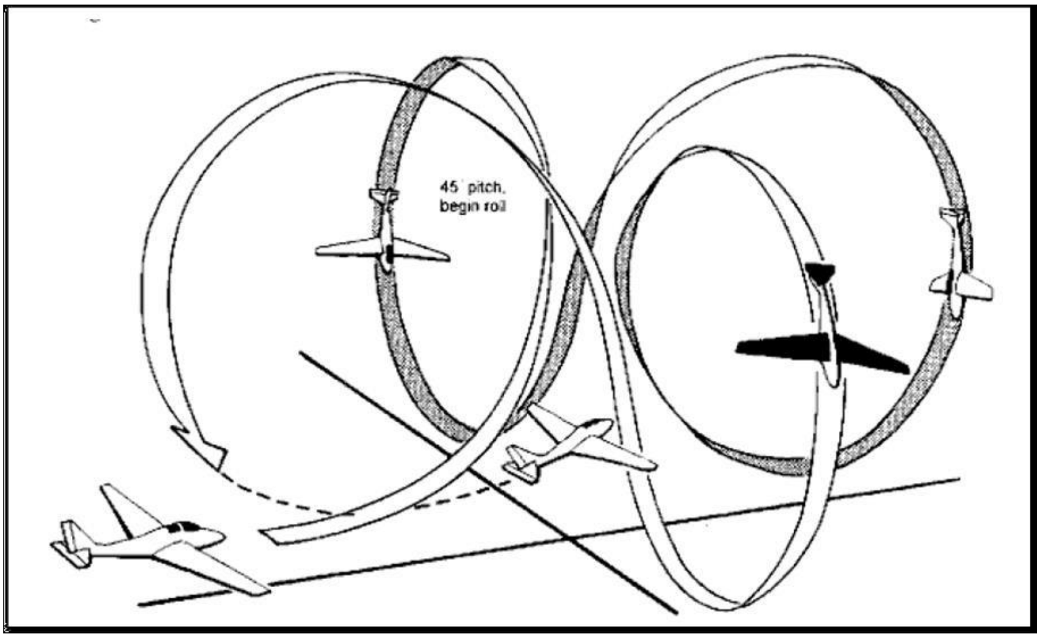


Figure 21: The Cloverleaf Maneuver

Barrel Roll

This maneuver is a coordinated roll in which the nose of the sailplane describes a circle around a point on the horizon. The manual did not include the picture of the barrel roll therefore the picture of the barrel roll was not presented.

1.19 Useful or Effective Investigation Techniques

The investigation was conducted in accordance with the KNKT approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

2 ANALYSIS

The investigation determined that the weather condition did not contribute to the accident. No deficiencies were found related to the evidence of pilot health and aerobatic skill issues. The examination of aircraft wreckage and maintenance history concluded that aircraft serviceability did not contribute to the accident. The analysis will discuss issue to the failure of the aerobatic maneuver execution.

The video footage shown that the pilot was conducting several aerobatic maneuvers consisted of Loop, Cuban Eight, Split-S, Loop, Split-S, Split-S and the last maneuver which end up to accident. All maneuvers were well performed indicated the pilot had the skill and good physical condition to perform aerobatic flight.

The last maneuver shown on the video was initiated with flying in direction align with the runway 31 heading. Afterward, the aircraft climbed and left roll until the aircraft on inverted position. The aircraft then flying down with the pitch down gradually decreasing and crossed to the runway 31 almost at level position. The observation of the ground marks indicated flight direction was about 080°.

The initial stage of the maneuver was similar to Cuban Eight however, the result of the aircraft was on direction about 080° did not indicate Cuban Eight maneuver which should be in opposite direction of the entry. Another possible maneuver with similar initial entry was Cloverleaf when the aircraft would level in direction perpendicular to the direction of entry. However, the flight direction that was about 080° which deviated about 40° to the correct heading of Cloverleaf maneuver.

Another possibility was the pilot attempted to combine several maneuver to ensure the aircraft was within one nautical mile from the apron which intended to be seen by the audience. However the investigation could not determine the maneuver intended to be performed. These indicated that either Cuban Eight or Cloverleaf was unsuccessfully performed. The heading deviation might have been the result of the pilot recovery action while aware that condition was not as expected

Comparing the Cuban Eight maneuver that successfully performed previously and the last maneuver, the video showed that on the last maneuver, the aircraft initiated the roll earlier and at lower altitude. According to the Aerobatic Guide Manual, the requirement to start roll during the Cuban Eight or Cloverleaf maneuver is when the pitch up angle minimum at 45° up. The video showed that the aircraft started to roll after initiated climb and the pitch up had not reached 45°. The early roll resulted in the aircraft altitude too low while on inverted position, which was the initial altitude when the aircraft flying down and resulted in the aircraft bounced to the apron during leveling off.

Investigation could not determine the reason of the pilot made early roll. One of the possibilities was the pilot experienced spatial disorientation[9]. Some articles related to spatial disorientation are available on the appendices of this report. While the pilot realized that the altitude was too low, a corrective action might have been made and resulted in the aircraft was not in a correct heading, either for Cuban Eight or Cloverleaf.

9 Spatial disorientation, the inability of a person to determine his true body position, motion, and altitude relative to the earth or his surroundings. Both airplane pilots and underwater divers encounter the phenomenon

3 CONCLUSIONS

3.1 Findings

Findings are statements of all significant conditions, events or circumstances in the accident sequence. The findings are significant steps in the accident sequence, but they are not always causal, or indicate deficiencies. Some findings point out the conditions that pre-existed the accident sequence, but they are usually essential to the understanding of the occurrence, usually in chronological order.

1. The aircraft had a valid Certificate of Airworthiness prior to departure and the investigation did not find any evidence of flight control problem.
2. The pilot held current license and medical certificate. No deficiencies were found related to the evidence of pilot health and aerobatic skill issues.
3. The weather at the time of the occurrence was within the visual meteorological condition minima.
4. The flight was the 15th training of formation flight which consisted of three Cessna 172 and one Super Decathlon and the first of formation flight combined with aerobatic flight.
5. The pre-flight briefing before the flight training only mention the flight formation that after flight formation training exercise was completed, the three aircraft was landed and standby at the end of runway 31 waiting for the PK-RTZ aircraft completed the aerobatic flight. The aerobatic maneuver did not discuss during the briefing.
6. The ATC flight plan and the communication with the Tunggul Wulung Tower controller did not mention the aerobatic maneuver that was planned or being made.
7. The pilot in the three aircraft which was landed and waiting at the end of runway 31 did not aware regarding the aerobatic flight maneuver conducted by the aircraft.
8. Based on the video footage, it was known that the aircraft conducted the aerobatic maneuver of Loop, Cuban eight, Split-S, Loop, Split-S, Split-S and the last maneuver that was un-identified.
9. The CCTV video footage showed that the aircraft flew at the low altitude, while the aerobatic manual required the aircraft flew at least 1,200 feet for conducting the aerobatic maneuver.
10. Based on the video footage, during the last maneuver, the aircraft initiated the roll earlier and at lower altitude which not accordance to the guidance to start roll is when the pitch up minimum is 45° for the Cuban Eight or Cloverleaf maneuver. The early roll resulted in the aircraft altitude too low during inverted which was the initial altitude when the aircraft flying down and resulted in the aircraft bounced to the apron during leveling off.
11. Investigation could not determine the reason of the pilot made early roll. One of the possibilities was the pilot experienced spatial disorientation.

3.2 Contributing Factors

Contributing Factors is defined as actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident.

The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability. The presentation of the contributing factors is based on chronological order and not to show the degree of contribution.

The KNKT concluded the contributing factors as follows:

The aircraft initiated the roll earlier and at lower altitude which not accordance to the guideline resulted in the aircraft altitude too low and the aircraft bounced to the apron during leveling off.

4 SAFETY ACTION

At the time of issuing this Final Report, the KNKT had not been informed of any safety actions resulting from this occurrence.

5 SAFETY RECOMMENDATIONS

5.1 PT. Genesa Dirgantara

04.O-2018-08.01

Based on the video footage, during the last maneuver, the aircraft initiated the roll earlier and at lower altitude which not accordance to the requirement to start roll is when the pitch 45° for the Cuban Eight or Cloverleaf maneuver. The early roll resulted in the aircraft altitude too low during inverted which was the initial altitude when the aircraft flying down and resulted in the aircraft bounced to the apron during leveling off.

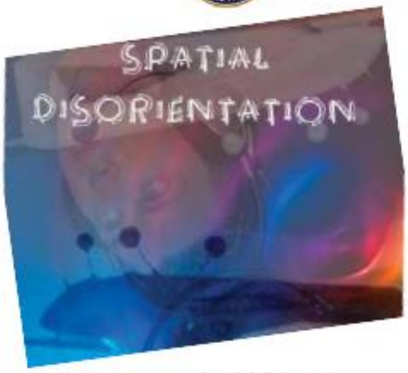
KNKT recommend the performance of aerobatic maneuver should follow the minimum requirement of the aerobatic flight technique and the aircraft performance.

6 APPENDICES

6.1 Spatial Disorientation

6.1.1 Spatial Disorientation Article Taken from Federal Aviation Administration

Federal Aviation Administration



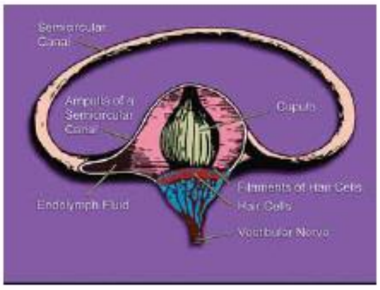
Spatial Orientation

Defines our natural ability to maintain our body orientation and/or posture in relation to the surrounding environment (physical space) at rest and during motion. Genetically speaking, humans are designed to maintain spatial orientation on the ground. The three-dimensional environment of flight is unfamiliar to the human body, creating sensory conflicts and illusions that make spatial orientation difficult, and sometimes impossible to achieve. Statistics show that between 5 to 10% of all general aviation accidents can be attributed to spatial disorientation, 90% of which are fatal.

Spatial Orientation in Flight

Spatial orientation in flight is difficult to achieve because numerous sensory stimuli (visual, vestibular, and proprioceptive) vary in magnitude, direction, and frequency. Any differences or discrepancies between visual, vestibular, and proprioceptive sensory inputs result in a sensory mismatch that can produce illusions and lead to spatial disorientation. Good spatial orientation relies on the effective perception, integration and interpretation of visual, vestibular (organs of equilibrium located in the inner ear) and proprioceptive (receptors located in the skin, muscles, tendons, and joints) sensory information.

❶

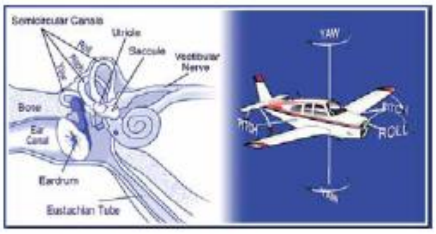


Vestibular Aspects of Spatial Orientation

The inner ear contains the vestibular system, which is also known as the organ of equilibrium. About the size of an pencil eraser, the vestibular system contains two distinct structures: the semicircular canals, which detect changes in angular acceleration, and the otolith organs (the utricule and the saccule), which detect changes in linear acceleration and gravity. Both the semicircular canals and the otolith organs provide information to the brain regarding our body's position and movement. A connection between the vestibular system and the eyes helps to maintain balance and keep the eyes focused on an object while the head is moving or while the body is rotating.

The Semicircular Canals

The semicircular canals are three half-circular, interconnected tubes located inside each ear that are the equivalent of three gyroscopes located in three planes perpendicular (at right angles) to each other. Each plane corresponds to the rolling, pitching, or yawing motions of an aircraft.



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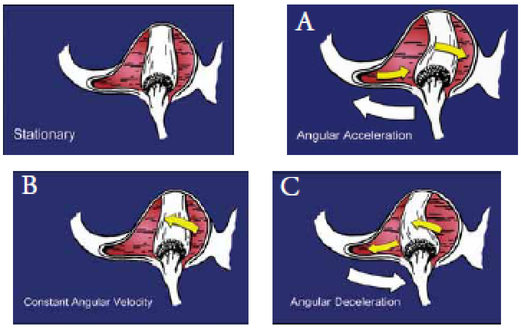
Each canal is filled with a fluid called endolymph and contains a motion sensor with little hairs whose ends are embedded in a gelatinous structure called the cupula. The cupula and the hairs move as the fluid moves inside the canal in response to an angular acceleration.

The movement of the hairs is similar to the movement of seaweed caused by ocean currents or that of wheat fields moved by wind gusts. When the head is still and the airplane is straight and level, the fluid in the canals does not move and the hairs stand straight up, indicating to the brain that there is no rotational acceleration (a turn).

If you turn either your aircraft or your head, the canal moves with your head, but the fluid inside does not move because of its inertia. As the canal moves, the hairs inside also move with it and are bent in the opposite direction of the acceleration by the stationary fluid (A). This hair movement sends a signal to the brain to indicate that the head has turned. The problem starts when you continue turning your aircraft at a constant rate (as in a coordinated turn) for more than 20 seconds.



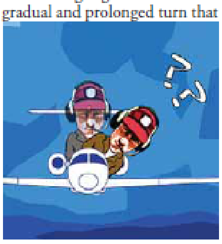
In this kind of turn, the fluid inside the canal starts moving initially, then friction causes it to catch up with the walls of the rotating canal (B). When this happens, the hairs inside the canal will return to their straight up position, sending an erroneous signal to the brain that the turn has stopped–when, in fact, the turn continues.

If you then start rolling out of the turn to go back to level flight, the fluid inside the canal will continue to move (because of its inertia), and the hairs will now move in the opposite direction (C), sending an erroneous signal to the brain indicating that you are turning in the opposite direction, when in fact, you are actually slowing down from the original turn.

Vestibular Illusions
(Somatogyral - Semicircular Canals)

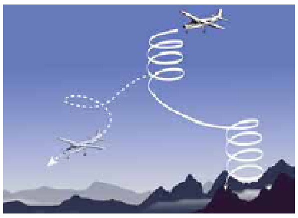
Illusions involving the semicircular canals of the vestibular system occur primarily under conditions of unreliable or unavailable external visual references and result in false sensations of rotation. These include the Leans, the Graveyard Spin and Spiral, and the Coriolis Illusion.

The Leans. This is the most common illusion during flight and is caused by a sudden return to level flight following a gradual and prolonged turn that went unnoticed by the pilot.



The reason a pilot can be unaware of such a gradual turn is that human exposure to a rotational acceleration of 2 degrees per second or lower is below the detection threshold of the semicircular canals. Leveling the wings after such a turn may cause an illusion that the aircraft is banking in the opposite direction. In response to such an illusion, a pilot may lean in the direction of the original turn in a corrective attempt to regain the perception of a correct vertical posture.

The Graveyard Spin is an illusion that can occur to a pilot who intentionally or unintentionally enters a spin. For example, a pilot who enters a spin to the left will initially have a sensation of spinning in the same direction. However, if the left spin continues the pilot will have the sensation that the spin is progressively decreasing. At this point, if the pilot applies right rudder to stop the left spin, the pilot will suddenly sense a spin in the opposite direction (to the right). If the pilot believes that the airplane is spinning to the right, the response will be to apply left rudder to counteract the sensation of a right spin. However, by applying left rudder the pilot will unknowingly re-enter the original left spin. If the pilot cross checks the turn indicator, he/she would see the turn needle indicating a left turn while he/she senses a right turn. This creates a sensory conflict between what the pilot sees on the instruments and what the pilot feels. If the pilot believes the body sensations instead of trusting the instruments, the left spin will continue. If enough



orientation clues. Common signs and symptoms of airsickness include: vertigo, loss of appetite, increased salivation and swallowing, burping, stomach awareness, nausea, retching, vomiting, increased need for bowel movements, cold sweating, skin pallor, sensation of fullness of the head, difficulty concentrating, mental confusion, apathy, drowsiness, difficulty focusing, visual flashbacks, eye strain, blurred vision, increased yawning, headache, dizziness, postural instability, and increased fatigue.

The symptoms are usually progressive. First, the desire for food is lost. Then, as saliva collects in the mouth, the person begins to perspire freely, the head aches, and the airsick person may eventually become nauseated and vomit. Severe airsickness may cause a pilot to become completely incapacitated.

Although airsickness is uncommon among experienced pilots, it does occur occasionally (especially among student pilots). Some people are more susceptible to airsickness than others. Fatigue, alcohol, drugs, medications, stress, illnesses, anxiety, fear, and insecurity are some factors that can increase individual susceptibility to motion sickness of any type. Women have been shown to be more susceptible to motion sickness than men of any age. In addition, reduced mental activity (low mental workload) during exposure to an unfamiliar motion has been implicated as a predisposing factor for airsickness.

A pilot who concentrates on the mental tasks required to fly an aircraft will be less likely to become airsick because his/ her attention is occupied. This explains why sometimes a student pilot who is at the controls of an aircraft does not get airsick, but the experienced instructor who is only monitoring the student unexpectedly becomes airsick.

A pilot who has been the victim of airsickness knows how uncomfortable and impairing it can be. Most importantly, it jeopardizes the pilot's flying proficiency and safety, particularly under conditions that require peak piloting skills and performance (equipment malfunctions, instrument flight conditions, bad weather, final approach, and landing).

Pilots who are susceptible to airsickness should not take anti-motion sickness medications (prescription or overthe- counter). These medications can make one drowsy or affect brain functions in other ways. Research has shown that most anti-motion sickness medications cause a temporary deterioration of navigational skills or other tasks demanding keen judgment.

An effective method to increase pilot resistance to airsickness consists of repetitive exposure to the flying conditions that initially resulted in airsickness. In other words, repeated exposure to the flight environment decreases an individual's susceptibility to subsequent airsickness.

If you become airsick while piloting an aircraft, open the air vents, loosen your clothing, use supplemental oxygen, keep your eyes on a point outside the aircraft, place your head against the seat's headrest, and avoid unnecessary head movements. Then, cancel the flight, and land as soon as possible.

FAA Aeromedical Training Programs for Civil Aviation Pilots

Physiological Training Course. The Civil Aerospace Medical Institute offers a 1-day training course to familiarize civil aviation pilots and flight crews with the physiological and psychological stressors of flight. Classroom training subjects include spatial disorientation, oxygen equipment, hypoxia, trapped gas, and decompression sickness.

Demonstrations. Spatial disorientation demonstrators provide pilots the experience of vestibular and visual illusions in a safe, ground-based environment–and they teach ways to avoid spatial disorientation while flying. Also, a ground-based altitude chamber flight offers a practical demonstration of rapid decompression and hypoxia. For information and scheduling, call (405) 954-4837, or check the FAA Web site:

www.faa.gov/pilots/training/airman_education/aerospace_physiology/index.cfm

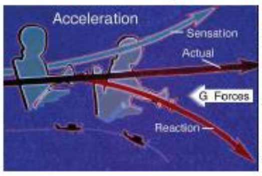
turn bends the haircell filaments that send a signal to the brain, indicating that the head and body have suddenly been moved forward. Exposure to a backward linear acceleration, or to a forward linear deceleration has the opposite effect.

Vestibular Illusions

(**Somatogravic - Utricle and Saccule**) Illusions involving the utricle and the saccule of the vestibular system are most likely under conditions with unreliable or unavailable external visual references. These illusions include: the Inversion Illusion, Head-Up Illusion, and Head-Down Illusion.

The Inversion Illusion involves a steep ascent (forward linear acceleration) in a high-performance aircraft, followed by a sudden return to level flight. When the pilot levels off, the aircraft's speed is relatively higher. This combination of accelerations produces an illusion that the aircraft is in inverted flight. The pilot's response to this illusion is to lower the nose of the aircraft.

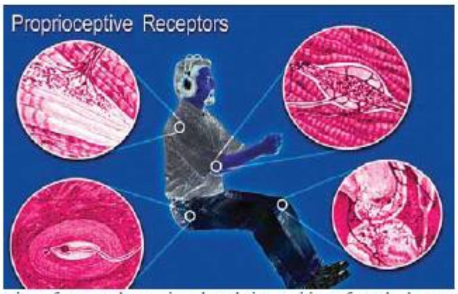
The Head-Up Illusion involves a sudden forward linear acceleration during level flight where the pilot perceives the illusion that the nose of the aircraft is pitching up. The pilot's response to this illusion would be to push the yolk or the stick forward to pitch the nose of the aircraft down. A night take-off from a well-lit airport into a totally dark sky (black hole) or a catapult take-off from an aircraft carrier can also lead to this illusion, and could result in a crash.



The Head-Down Illusion involves a sudden linear deceleration (air braking, lowering flaps, decreasing engine power) during level flight where the pilot perceives the illusion that the nose of the aircraft is pitching down. The pilot's response to this illusion would be to pitch the nose of the aircraft up. If this illusion occurs during a low-speed final approach, the pilot could stall the aircraft.

The Proprioceptive Receptors

The proprioceptive receptors (proprioceptors) are special sensors located in the skin, muscles, tendons, and joints that play a very small role in maintaining spatial orientation in normal individuals. Proprioceptors do give some



indication of posture by sensing the relative position of our body parts in relation to each other, and by sensing points of physical contact between body parts and the surrounding environment (floor, wall, seat, arm rest, etc.). For example, proprioceptors make it possible for you to know that you are seated while flying; however, they alone will not let you differentiate between flying straight and level and performing a coordinated turn.

How to Prevent Spatial Disorientation

The following are basic steps that should help prevent spatial disorientation:

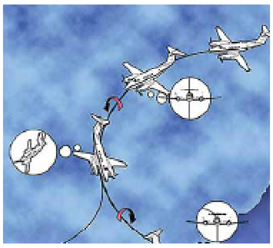
- Take the opportunity to experience spatial disorientation illusions in a Barany chair, a Vertigon, a GYRO, or a Virtual Reality Spatial Disorientation Demonstrator.
- Before flying with less than 3 miles visibility, obtain training and maintain proficiency in airplane control by reference to instruments.
- When flying at night or in reduced visibility, use the flight instruments.
- If intending to fly at night, maintain night-flight currency. Include cross-country and local operations at different airports.
- If only Visual Flight Rules-qualified, do not attempt visual flight when there is a possibility of getting trapped in deteriorating weather.
- If you experience a vestibular illusion during flight, trust your instruments and disregard your sensory perceptions.

Spatial Disorientation and Airsickness

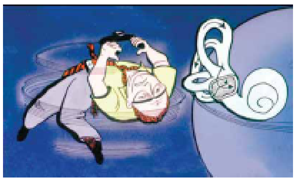
It is important to know the difference between spatial disorientation and airsickness. Airsickness is a normal response of healthy individuals when exposed to a flight environment characterized by unfamiliar motion and

altitude is lost before this illusion is recognized and corrective action is taken, impact with terrain is inevitable.

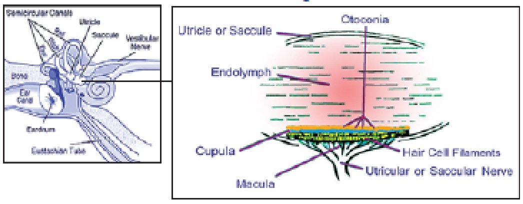
The Graveyard Spiral is more common than the Graveyard Spin, and it is associated with a return to level flight following an intentional or unintentional prolonged bank turn. For example, a pilot who enters a banking turn to the left will initially have a sensation of a turn in the same direction. If the left turn continues (~20 seconds or more), the pilot will experience the sensation that the airplane is no longer turning to the left. At this point, if the pilot attempts to level the wings this action will produce a sensation that the airplane is turning and banking in the opposite direction (to the right). If the pilot believes the illusion of a right turn (which can be very compelling), he/she will reenter the original left turn in an attempt to counteract the sensation of a right turn. Unfortunately, while this is happening, the airplane is still turning to the left and losing altitude. Pulling the control yoke/stick and applying power while turning would not be a good idea–because it would only make the left turn tighter. If the pilot fails to recognize the illusion and does not level the wings, the airplane will continue turning left and losing altitude until it impacts the ground.



The Coriolis Illusion involves the simultaneous stimulation of two semicircular canals and is associated with a sudden tilting (forward or backwards) of the pilot's head while the aircraft is turning. This can occur when you tilt you head down (to look at an approach chart or to write a note on your knee pad), or tilt it up (to look at an overhead instrument or switch) or tilt it sideways. This produces an almost unbearable sensation that the aircraft is rolling, pitching, and yawing all at the same time, which can be compared with the sensation of rolling down on a hillside. This illusion can make the pilot quickly become disoriented and lose control of the aircraft.



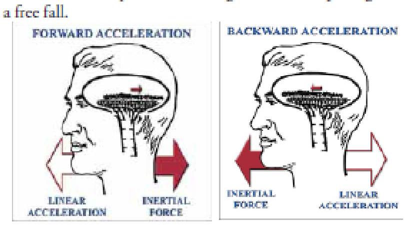
The Otolith Organs



Two otolith organs, the saccule and utricle, are located in each ear and are set at right angles to each other. The utricle detects changes in linear acceleration in the horizontal plane, while the saccule detects gravity changes in the vertical plane. However, the inertial forces resulting from linear accelerations cannot be distinguished from the force of gravity; therefore, gravity can also produce stimulation of the utricle and saccule. These organs are located at the base (vestibule) of the semicircular canals, and their structure consists of small sacs (maculas) covered by hair cell filaments that project into an overlying gelatinous membrane (cupula) tipped by tiny, chalk-like calcium stones called otoconia.

Change in Gravity

When the head is tilted, the weight of the otoconia of the saccule pulls the cupula, which in turn bends the hairs that send a signal to the brain indicating that the head has changed position. A similar response will occur during a vertical take-off in a helicopter or following the sudden opening of a parachute after a free fall.



Change in Linear Acceleration

The inertial forces resulting from a forward linear acceleration (take-off, increased acceleration during level flight, vertical climb) produce a backward displacement of the otoconia of the utricle that pulls the cupula, which in

6.1.2 Spatial disorientation taken from Encyclopaedia Britannica

(Written By: The Editors of Encyclopaedia Britannica)

Spatial disorientation, the inability of a person to determine his true body position, motion, and altitude relative to the earth or his surroundings. Both airplane pilots and underwater divers encounter the phenomenon.

Most clues with respect to orientation are derived from sensations received from the eyes, ears, muscles, and skin. The human sensory apparatus, however, is often not delicate enough to perceive slow and gradual changes in motion; also, when motion changes are abrupt, the sense organs tend to overestimate the degree of change. Spatial disorientation in aircraft can arise from flight situations or visual misinterpretation. Banks and turns often create false sensations. When turning gradually, a pilot may feel as though he were on a straight course but ascending; when a turn is corrected, the impression is that of descending. If the plane banks or ascends or descends slowly, the pilot may not perceive the change, and the plane will feel level to him. If the plane skids while turning, the sensation is one of being banked in the direction opposite from the skid. A reaction called “leans” is caused by level flight after a rapid roll; the inertia of the roll causes the body to lean in a direction opposite to the direction of turning even after the motion of the roll has been stopped. If the pilot rapidly looks downward while turning, the so-called Coriolis effect occurs, in which the plane feels as though it is descending. The usual reaction of the pilot is to pull back on the stick to raise the plane. In a spin, the illusion of non-motion is created if the spin is continued long enough; when the pilot corrects the spin, he has the feeling of spinning in the opposite direction, and his natural reaction is to counter his corrective measures and go back into the original spinning pattern. This phenomenon is known as the “graveyard spin”. The “graveyard spiral” results when the sensation of turning is lost in a banked turn. Because the pilot’s instruments show that he is losing altitude, he may pull back on the stick and add power, thus inducing a spiral motion. The oculogyral illusion is created by acceleration and turning: a turning target watched by a pilot while turning himself appears to move faster than it is actually going; it may appear to continue to turn even after the pilot has stopped his motion and the target has stopped. Another illusion is caused by forward acceleration: when a pilot takes off from land, the increased speed gives the impression of nosing the plane too high; to compensate the pilot may lower the nose and dive back to the ground. During a rapid deceleration the nose of the plane appears to drop; if the pilot corrects this feeling by trying to gain more altitude, the plane stalls and goes into a spin. The gravitational forces on a pilot cause the oculoagravic illusions: a target watched by a pilot appears to rise if weightlessness occurs and appears to fall when gravity is increased.

Visual misinterpretations do not usually depend on acceleration factors or on the sense of equilibrium but, rather simply, on visual illusions. The autokinetic phenomenon is the apparent wandering of an object or spot of light; when following another plane at night, the pilot may have trouble distinguishing between real and apparent movements of the lead plane. If two planes are flying parallel and level but at different speeds, they give the pilots the illusion of turning. Ground lights can be mistaken for the horizon or stars; fixed beacon lights can be mistaken for another plane flying in formation.

The only measures that can prevent spatial disorientation are thorough training and instrumentation.

6.1.3 The 6 Types of Spatial Disorientation, and How to Prevent Each One

(Written by Colin Cutler 08/26/2015)

Flying through the clouds on an IFR flight can be pretty exciting, but it's not without risk: between 5-10% of all general aviation accidents result from spatial disorientation, and of those accidents, 90% of them are fatal.

Here are the 6 types of illusions you can get flying in the clouds, and how you can prevent each one.

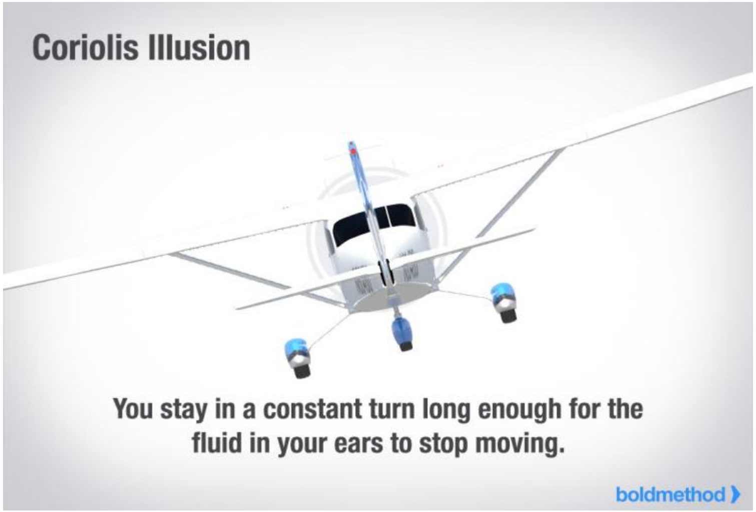
1) "The Leans"

The Leans happen when you enter a banked turn too slowly. For example, if you don't roll quickly enough into a left turn, the fluid in your ears won't start moving, and your brain thinks you're still straight-and-level. If you correct your wings back to level flight abruptly, your ears and brain think they're banking in the opposite direction (to the right). This makes you feel like you need to roll the airplane back to the left, or lean your body in that direction to be 'upright'. If you find yourself pressed against your flight instructor in the clouds, chances are you have the leans.

How to prevent it:

The best way to prevent the leans is to avoid super-slow turns in the clouds. You should never over-control your plane, but make sure your are authoritative with your control inputs.

2) Coriolis Illusion

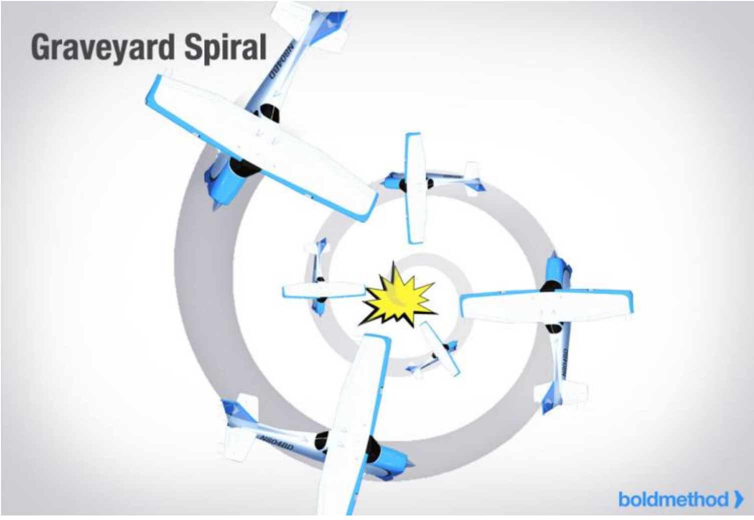


Coriolis illusion happens when you're in a constant turn long enough for the fluid in your ears to stop moving. As we mentioned before, when the fluid in your ears stops moving, your brain thinks it is 'straight-and-level'. At this point, if you move your head too quickly, such as looking at something in the cockpit, you can start the fluid in your ears moving in an entirely different axis. This makes you feel like the airplane is maneuvering in a way that it isn't, and if you aren't careful, you can put your plane in a dangerous attitude.

How to prevent it:

Never move your head quickly, and if you feel like you're getting disoriented, focus on your instrument scan pattern and bring the airplane to straight-and-level flight.

3) Graveyard Spiral

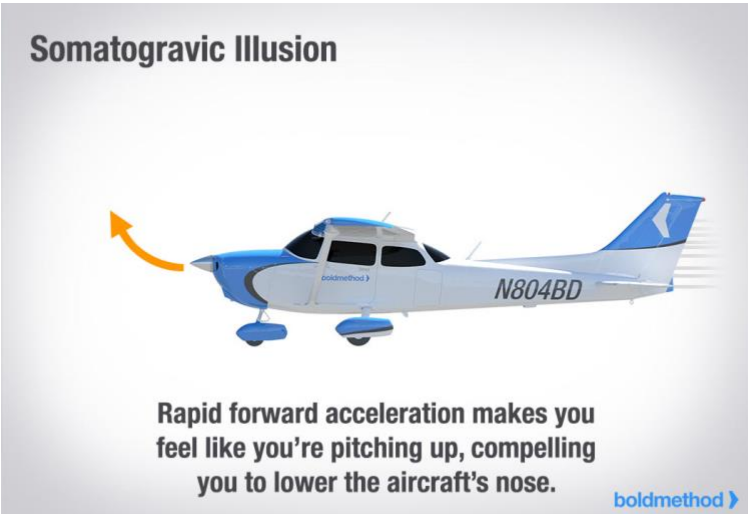


Like the name suggests, graveyard spirals aren't good. If you stay in a turn long enough, the fluid in your ears stops moving. As you return to level flight, you feel like you've turned in the opposite direction, and you return back to the original turn. Because airplanes lose altitude in a turn unless you add back pressure, the airplane starts descending. Because you think you're in a wings-level descent, you pull back on the yoke. But what really happens is you tighten the spiraling turn, and lose even more altitude.

How to prevent it:

Maintain a strong scan pattern, and don't fixate on any one instrument.

4) Somatogravic Illusion



When you accelerate quickly, the 'otolith' organs in your ears think you are pitching nose-up. This makes you want to push the nose of your plane forward, and you enter a nose-low dive attitude. The opposite is true of rapid deceleration. As you slow, you feel like you're pitching forward, and you tend to pitch up into a nose-high stall attitude.

How to prevent it:

Avoid rapid acceleration and deceleration in the clouds.

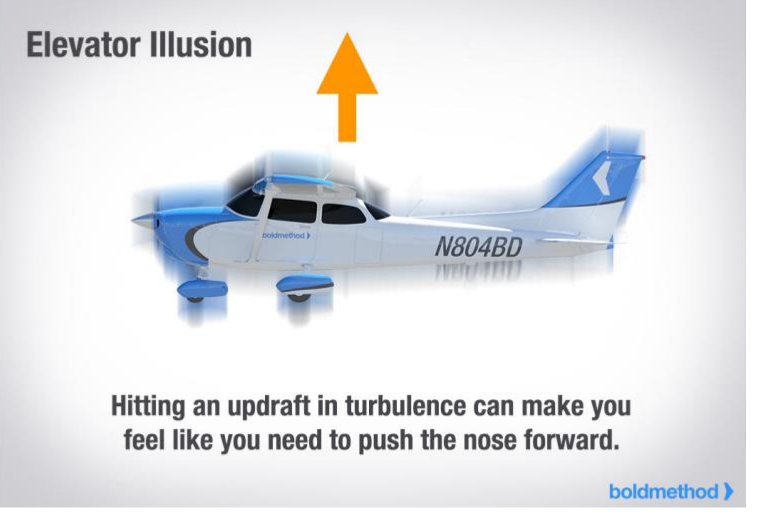
5) Inversion Illusion

If you pitch down too quickly from a climb to straight-and-level, you can get the illusion that you're tumbling backwards. The real dangers with this that it makes you want to push the aircraft even more nose-low, which puts you into a dive attitude. Even worse, the more you push forward, the more intense the illusion can become.

How to prevent it:

Slow, steady control inputs are the key when you're transitioning from a climb to straight-and-level flight.

6) Elevator Illusion



One of the most challenging things about flying in the clouds, especially in the summer, is that there's usually some turbulence as well. Elevator illusion happens when you catch an updraft, and your plane is abruptly accelerated vertically. Even though your plane is most likely in straight-and-level flight, you feel like you need to push the nose forward, entering a dive attitude.

How to prevent it:

Maintain a strong instrument scan pattern in turbulence, and if the updrafts and downdrafts become so strong that you are unable to maintain altitude, fly the attitude indicator, keeping your wings straight and level.

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