

AA2018-4

**AIRCRAFT ACCIDENT
INVESTIGATION REPORT**

**INDEPENDENT ADMINISTRATIVE INSTITUTION
CIVIL AVIATION COLLEGE
JA5807**

June 28, 2018

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board and with Annex 13 to the Convention on International Civil Aviation is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi

Chairman

Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

AIRCRAFT ACCIDENT

INVESTIGATION REPORT

DAMAGE FROM BELLY LANDING
SENDAI AIRPORT, JAPAN
AT AROUND 13:40, AUGUST 25, 2016

INDEPENDENT ADMINISTRATIVE INSTITUTION
CIVIL AVIATION COLLEGE
HAWKER BEECHCRAFT G58, JA5807

May 25, 2018

Adopted by the Japan Transport Safety Board

Chairman	Kazuhiro Nakahashi
Member	Toru Miyashita
Member	Toshiyuki Ishikawa
Member	Yuichi Marui
Member	Keiji Tanaka
Member	Miwa Nakanishi

1. PROCESS AND PROGRESS OF INVESTIGATION

1.1 Summary of the Accident	<p>On Thursday, August 25, 2016, A Hawker Beechcraft G58, registered JA5807, operated by Independent Administrative Institution Civil Aviation College made a belly landing on the Runway 27 at Sendai Airport which caused damage to the aircraft during a training flight.</p>
1.2 Outline of the Accident Investigation	<p>On August 25, 2016, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and one other investigator to investigate this accident. In addition, on December 16, 2016, one more investigator was designated.</p> <p>Although this accident was notified to the United States of America, as the State of Design and Manufacture of the aircraft, the United States of America did not designate any accredited</p>

	<p>representative.</p> <p>Comments were invited from parties relevant to the cause of the accident and the relevant state.</p>
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2. FACTUAL INFORMATION

<p>2.1 History of the Flight</p>	<p>According to the statements of the instructor, the student A, the student B and the student C, the ATC communications recordings, the recordings saved in IC recorder on board to evaluate the educational effects, and the radar track recordings, the history of the flight up to the time of the accident is summarized as below:</p> <p>On August 25, 2016, at around 13:32 Japan Standard Time (JST: UTC + 9 hours, unless otherwise stated all time are indicted in JST using a 24-hour-clock), a Hawker Beechcraft G58 registered JA5807, operated by Independent Administrative Institution Civil Aviation College (hereinafter referred to as “the College”) took off from the Runway 27 of Sendai Airport for continuous touch-and-go trainings with an instructor sitting in the right pilot seat who was the captain (hereinafter referred to as “the Instructor”, who partially acted as PM¹), the student A receiving the training of PF as sitting in the left pilot seat, the student B receiving the training of PM as sitting the right seat in back row and the student C sitting in the left seat in back row as an observer of the training.</p> <p>After obtaining commercial pilot certificates for single engine plane for land, the student A, the student B and the student C were taking initial trainings and intending to obtain a type rating for multiple engine plane for land. The aircraft is the type of aircraft which could be maneuvered by only a captain, but for the College, in order to simulate roles of PF and PM as training, a student sitting in the left pilot seat plays PF and a student sitting in the right pilot seat as PM takes in charge of ATC communications and readout of checklist. Furthermore, the landing gear lever at the front of the left pilot seat could be operated by a student at the left pilot seat, the flaps</p>
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¹ “PF” and “PM” are terms used to identify pilots with their roles in aircraft operated by two persons. PF is an abbreviation of Pilot Flying and mainly responsible for maneuvering the aircraft. PM is an abbreviation of Pilot Monitoring and mainly monitors the flight status of the aircraft, cross checks operations of the F and undertake other no-operational works.

lever at front of the student at the right pilot seat was operated by an instructor at the right pilot seat with PF instruction, and “Standard Callouts²” are provided to carry out by a student at the left pilot seat and by an instructor at the right pilot seat.

Before the takeoff, the Instructor checked the forward cabin door (hereinafter referred to as “the Door”) as following a checklist, the position of the Door lever was slightly off from the position of being locked, so he felt some unease, however, a room light which indicates the Door was being closed or not was off, and as judging from the touch to close and the status of the Door lever, he had considered the Door was being closed.

At 13:33:02, when the aircraft entered the Down-wind Leg at the south-side traffic pattern toward the Runway 27, a local controller of Sendai Airport traffic control tower (hereinafter referred to as “the Tower”) issued the holding clearance before the Base Leg to the aircraft (a). (corresponding to (a) in the Figure 1; hereinafter the same for (b) to (k)) The student A said to the student B that he accepted the clearance; but because student B could not hear it which was shielded by the wind whistle from the Door, at 33:09, student B requested the Tower to make say the clearance again (b), and read it back. The student B thought that it was difficult to continue the training as it was and reported the wind whistle to the Instructor. The Instructor found out that the lever of the Door were slightly off from the lock position and was about to open, therefore he operated the lever but it did not improve. The Instructor told students that he would retighten the Door during the next landing roll and continue the touch-and-go training, students agreed to the intention of the Instructor. The student A decided to postpone to perform the pattern checklist - to confirm that the landing gears were retracted and the flaps were set at up or at approach position based on the training manual of the college until the Instructor would have completed to check the conditions of the Door.

At 13:34:43, the student A started making circling in order to hold before the Base Leg, and performed the checklist which had been

² “Standard Callout” means callouts excluding orders for specific operations like “FLAP UP” from the various callouts for normal operations.

postponed (c). The student A became aware of a warning horn sound and the activation of the annunciator of notifying the gear-up status on the PFD³ (described later in 2.7 (3)) due to the caution given by the student B sitting in the right-side rear seat, and reset the activation of the annunciator.

At 13:35:59, when the aircraft completed the first circling, the Instructor advised the student A not to be drifted by the strong wind from southeast (d).

At 13:37:31, the position where the aircraft completed the second circling was too closed to the runway, the Instructor advised the student A to that (e).

At 13:37:43, the aircraft received the order from the Tower “REPORT TURNING AT FINAL APPROACH” (f) and entered the Base Leg.

At 13:37:51, the aircraft received the order from the Tower to extend Down-wind Leg slightly.

From 13:37:51 to 13:38:18, after the Instructor advised student A as "THE SPEED IS TOO FAST AND THE ALTITUDE IS TOO HIGH", he called that “MAKE THREE-SIXTY ON BASE” in order to maintain a separation to a preceding aircraft and at the same time, increased the power to grasp the control wheel to assist the student A’s piloting (g).

At 13:38:45, because the student A as PF did not issue an order, the Instructor called that “FLAPS DOWN” as setting flap lever in the full-down position (See Photo 2.). After that, the student A only placed his hand on the control wheel and the assistance to the pilot by the Instructor became stronger (h).

At 13:38:54, when the student A acknowledged the warning display of the annunciator of notifying the gear-up status, he called that “GEAR UP WARNING, CHECK”; and at 13:38:57, he called for the landing checklist of the student B.

At 13:39:00, because the aircraft was too close to the runway, the student A was upset. Responding to the readout of “LANDING GEAR” of the landing checklist by the student B, the student A

³ “PFD” is the abbreviation of “Primary Flight Display” and means an integrated electrical instrument incorporating instrument to show Attitude Director Indicator, Flight Director, Air Speed Indicator, Altimeter, Vertical Speed Indicator, Messages Window and others.

answered “DOWN THREE GREEN” (i). Regarding above, when the student A answered to the readout of checklist, he did not have memory to confirm that the landing gears were extended down—The landing gear lever was pulled down and the Three Green Lights of the Landing Gears position Lights were turned on. The Instructor heard the callout “DOWN THREE GREEN” of the student A, he thought that the landing gears were extended, but he did not have memory that confirmed the status that the landing gears had extended.

At 13:39:03, the Tower cleared the aircraft for touch-and-go landing (j) and the aircraft entered the Final Approach with high approach angle where the Precision Approach Path Indicator (PAPI⁴) was showing white of all four units.

Because the student A as PF was entrusting the control of the aircraft to the Instructor, he wondered about the intentions of the Instructor whether to land as it was or not. The training manual provides that PF shall call whether to land or to go-around at 200 ft, but at 13:36, as the Instructor had called “LANDING” (k), the student A thought that they would land as it was.

Around 13:40, when the student A felt something strange about

not touch down for a while, even though he flared⁵, the propeller blades of the aircraft had made contacts with the runway, then the aircraft made a belly landing; rolled for a while



Photo 1 The aircraft

and stopped. At that time, the Instructor found out that the landing gears had been not extended because of the sound of metallic friction sound caused by the contacts between the propeller blades of the left engine and the runway, so he extended the landing gears but it could not be completed in time.

IC recorder had recorded discontinuous sound from the

⁴ “PAPI (Precision Approach Path Indicator)” is the lighting system to indicate an accurate descent slope. When an aircraft is “on glide path”, a pilot sees two white lamps outside and two red lamps inside. When slightly above the glide path (3°), sees the unit nearest to the runway as red and the rest units as white. When an aircraft is 3.58° or more higher, sees all units as white.

⁵ “Flare” is the operation to pull up a nose immediately before an aircraft makes a touchdown to a runway in order to absorb the impact of landing by reducing a speed and a descent rate.

warning horn from the middle of the Down-wind Leg until the time of the main power of the aircraft was shut off. (See Figure 1 “Estimated Flight Route Map.”)

The accident occurred at around 13:40 on August 25, 2016 on the Runway 27 (N38° 08' 29”, E140° 55' 29”) at Sendai Airport.

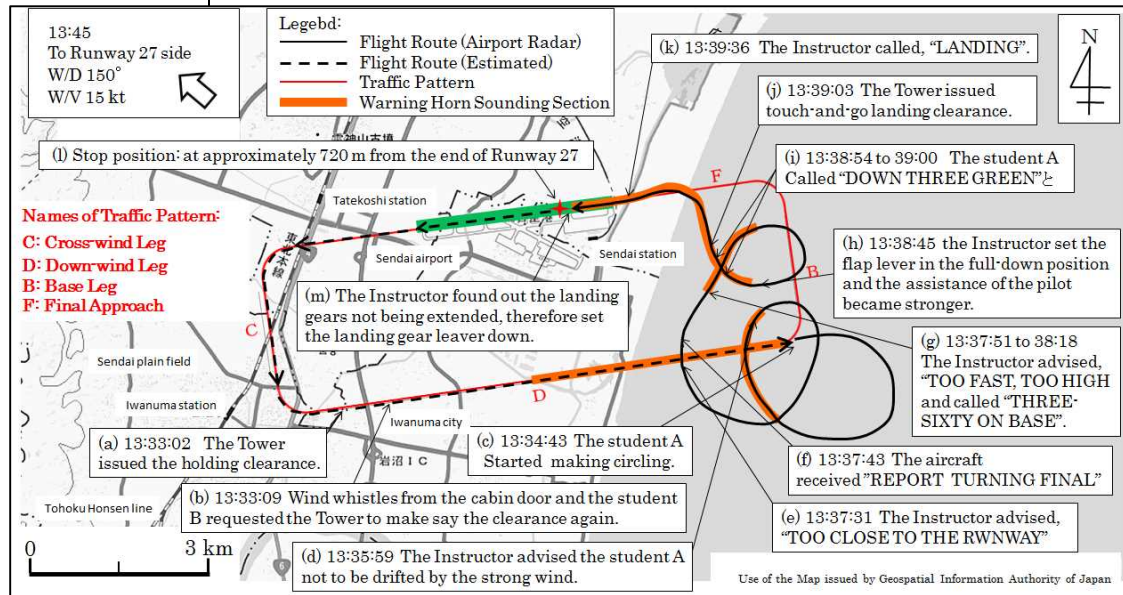


Figure 1 Estimated Flight Route Map

<p>2.2 Injuries to persons</p>	<p>None</p>
<p>2.3 Damage to the Aircraft</p>	<p>(1) Extent of Damage: Substantial (2) Damage to the Aircraft Fuselage: Scratch marks on underside surface and Deformation of keels Propellers: Bending of blades Flaps in right and left: Deformed damage of internal parts</p>
<p>2.4 Personnel information</p>	<p>(1) Captain Male, Age 62 Airline transport pilot certificate (Airplane) March 20, 2008 Specific pilot competence certificate Expiration date of piloting capable period July 1, 2018 Type rating for multiple engines (land) May 12, 1976 Flight instructor certificate (Airplane) December 16, 1994 Class 1 aviation medical certificate Validity: September 2, 2016 Total flight time 10,637 hours 20 minutes</p>

	<p>Total flight time on the type of aircraft 1,196 hours 20 minutes</p> <p>Flight time in the last 30 days 34 hours 20 minutes</p> <p>(2) Student A Male, Age 26</p> <p>Commercial pilot certificate (Airplane) July 7, 2016</p> <p>Specific pilot competence certificate</p> <p>Expiration date of piloting capable period July 7, 2018</p> <p>Type rating for single engines (land) July 7, 2016</p> <p>Class 1 aviation medical certificate Validity: July 7, 2017</p> <p>Total flight time 167 hours 00 minute</p> <p>Total flight time on the type of aircraft 5 hours 20 minutes</p> <p>Flight time in the last 30 days 5 hours 20 minutes</p> <p>Number of times to land 23 times</p> <p>(3) Student B Male. Age 24</p> <p>Commercial pilot certificate (Airplane) July 7, 2016</p> <p>Specific pilot competence certificate</p> <p>Expiration date of piloting capable period July 7, 2018</p> <p>Type rating for single engines (land) July 7, 2016</p> <p>Class 1 aviation medical certificate Validity; July 7, 2017</p> <p>Total flight time 158 hours 40 minutes</p> <p>Total flight time on the type of aircraft 6 hours 45 minutes</p> <p>Flight time in the last 30 days 6 hours 45 minutes</p> <p>Number of times to land 21 times</p>
2.5 Aircraft information	<p>(1) Type: Hawker Beechcraft G58</p> <p>Serial Number: TH-2165</p> <p>Date of Manufacture: November 3, 2006</p> <p>Certificate of airworthiness: No. Toh-27-300</p> <p>Validity: September 30, 2016</p> <p>Category of airworthiness: Airplane, Normal N</p> <p>Total flight time 4,582 hours 39 minutes</p> <p>Flight time since the last periodical check (Annual Inspection implemented on August 16, 2016): 23 hours 08 minutes</p> <p>(2) When the accident occurred, the weight and the position of the center of gravity of the aircraft were estimated to have been within the allowable range.</p>
2.6 Meteorological	<p>Aeronautical weather observations made at the Airport around the time of the Accident were as follows:</p>

information	<p>13:45 Wind Direction 150°, Wind Velocity 15 kt, Visibility 25 km</p> <p>Clouds: Amount 1/8 to 2/8, Type Stratus, Cloud Base 1,500 ft, Amount 3/8 to 4/8, Cloud Base unknown or unobservable</p> <p>Temperature 28°C, Dew points 23°C</p> <p>Altimeter setting (QNH) 29.73 inHg</p>
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2.7 Additional information	<p>(1) Situation at the Accident Site</p> <p>Marks hit by propellers blades and marks scratched by the undersurface of the fuselage were left on the Runway 27 from approximately 370 m inside of the Runway 27 threshold where the aircraft made a first touchdown until approximately 720 m where the aircraft stopped.</p> <p>(2) Confirmation of Landing Gears and others</p> <p>At the investigation after the accident, the landing gears, the flaps, the Door, the warning horn, the annunciator and the headset was confirmed that they did not have any functional malfunction.</p> <p>(3) Activate Condition of Warning Horn and Annunciator</p> <p>When any of the following conditions are satisfied, a warning horn and annunciator of notifying the gear-up status would be activated:</p> <ul style="list-style-type: none"> - Reduce one of the throttles to 13 inHg in the manifold air pressure or less without extending the landing gears. - Flaps are in the full-down position without extending the landing gears. (See Photo 2.)
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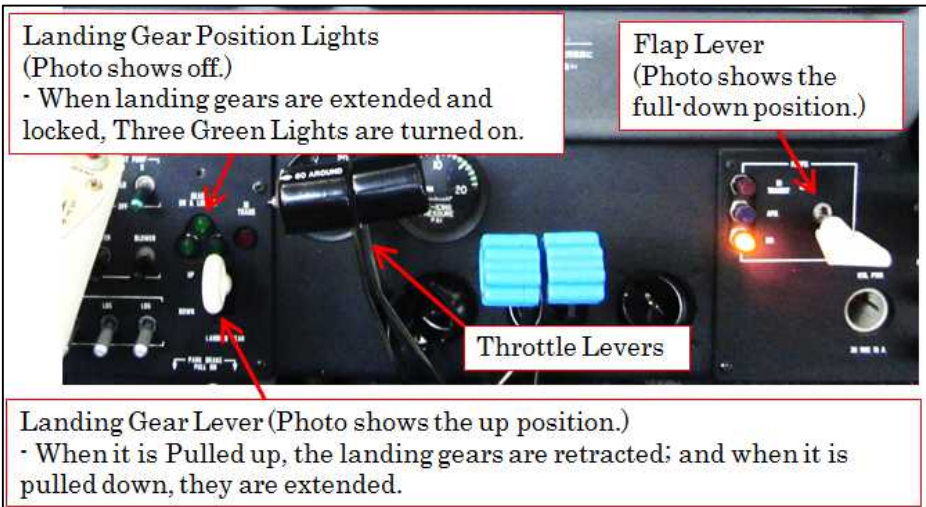


Photo 2 Landing Gear Lever and Flap Lever

(4) Annunciator of Notifying the Gear-up Status

When the conditions are satisfied, the warning horn and the annunciator of notifying the gear-up status would be activated; and the red alert “GEAR UP” would be displayed on the PFD; and the display of the Alert soft key at the right lower corner would be changed into the red blinking alert “WARNING”.

When pressing the soft alert key meaning reset operation, the red blinking alert “WARNING” would be changed into the white display. When re-pressing the soft alert key, the details of the alert “GEAR UP–Gear up with power below 13 inHg or flaps down” would be displayed. (See Photo 3.)

However, as long as they are consistent with the operating conditions, the warning horn will not stop even if reset.



Photo 3 Display of the Annunciator on PFD when reset

(5) Operation of Landing Gears

The training manual contains the following descriptions regarding how to operate landing gears at each leg of the traffic pattern for normal landing (abstract):

a Down-wind Leg

- PF shall perform the pattern checklist as considering the flight situation (speed and others) at the appropriate timing.
- PF shall extend landing gears at 27th second from the time of passing abeam of the end of runway. At the time, after PF called “GEAR DOWN”, if the call was appropriate, PM (Instructor) in the right pilot seat would read back, then PF would complete to extend the landing gears and confirm the

Three Green Lights.

b Base Leg

- PF calls for the landing checklist of PM in the right rear seat (including the confirmation that the landing gears are extended).
- PF performs the landing checklist.
- PF confirms the status that the landing gears are extended and lock, and calls "DOWN THREE GREEN".

c Final Approach

- When the conditions of "enabling a landing safely due to the stable approach", "completing the landing checklist" and "being cleared for landing" are satisfied at 200 ft or higher an altitude above ground, call "LANDING".
- PM in the right pilot seat shall confirm that the landing gear lever is in the down position and call "DOWN THREE GREEN".

For the case of the aircraft, it is difficult to see the landing gear lever and the Three Green Lights from the right rear seat, therefore the College designates PM in the right pilot seat to check the position of the landing gear.

(6) Abnormal Operation

During the flight, regarding the operation when the Door is opened, the flight manual provides as follows (The College provides "EMERGENCY & ABNORMAL CHECKLIST" in the chapter "Emergency Operation" in the training manual.):

Chapter 3A Abnormal Operation

4. Forward Cabin Door Open during Flight:

If the latch of forward cabin door is not engaged correctly, it may open during takeoff rolling or during flight. The door will remain open about three inches, but the flight characteristics of the aircraft will not be affected. The rate of climb declines.

- (1) Maintain the control of aircraft.*
- (2) Try not to close the door until after landing.*
- (3) All passengers should wear the seatbelts and sit in the seats.*
- (4) Land as soon as possible by following the normal*

	<p><i>procedure.</i></p> <p><i>When the passenger in the right-side seat could assist:</i></p> <p><i>(5) Hold the door in order to prevent it from opening due to shakes during and after landing.</i></p> <p>(7) Cases of Incomplete Operation of the Door Lever</p> <p>Since April, 2011, the College had seven cases of the incidents of incomplete locked the Door on the same type aircraft. On September 2014, along with adding slip marks as a mark at the locking position of the Door lever, publicize the securement of closing the lever after explaining the following contents:</p> <p><i>“As the characteristic of the G58 type door lever, due to the difference in the hardness of seals and others, the power adjustment to push the door forward differs individually per each of aircraft. Besides, after locking the door, due to the allowance at the lever itself, the slip mark at the locking position could be deviated and it is hard for the locking status after the door closed to check.”</i></p>
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3. ANALYSIS

3.1 Involvement of weather	None
3.2 Involvement of pilot	Yes
3.3 Involvement of equipment	None
3.4 Analysis of known items	<p>(1) Aircraft Situation at the Time of Belly Landing</p> <p>According to the investigation after the accident, the function of the landing gear system, the flaps, the Door, the warning horn, the annunciator and the headset have no abnormality. Based on these, it is certain that the aircraft made a belly landing both without operating to extend the landing gears and without finding that; which caused damage to the aircraft.</p> <p>(2) History of Forgotten of Both the Operation to Extend the Landing Gears and Confirmation</p> <p>When flying the traffic pattern, aircraft might be made the throttle reduce to 13 inHg or less to adjust the altitude or the speed</p>

(hereinafter referred to as “the Reducing throttle”), and if the conditions are met, on each occasion the warning horn and the annunciator of notifying the gear-up status (hereinafter referred to as “the Gear-up Warning”) activate. Besides, during the Reducing throttle, the warning horn could not be stopped, however, regarding the annunciator of notifying the gear-up status, PF shall perform the reset operation after making decisions whether the landing gears should be extended or not at each occasion.

The training manual provides that PF shall normally extend the landing gears at 27th second after passing abeam of the runway threshold and enter the Base Leg. Therefore, the training manual don’t provide in case of holding before the Base Leg, but it is considered appropriate for PF to extend the landing gears before entering the Base Leg after released from holding.

Based on the recordings of the IC recorder, it is probable that the aircraft performed the Reducing throttle during circling in between the half-point of the Down-wind Leg and the point before the Base Leg and the Gear-up Warning was activated twice. The student A confirmed the activation of the Gear-up Warning and reset the annunciator of notifying the gear-up status, however, it is probable that this case was not about the timing to extend the landing gears, and it was reset following the proper procedure.

When entering the Base Leg, the student A performed the Reducing throttle as following the Instructor’s instruction that “THE SPEED IS TOO FAST, THE ALTITUDE IS TOO HIGH”; but it is probable that the Gear-up Warning at the third times was activated because the landing gears were not extended. At that time, it was probable that the landing gears should be extended because the aircraft was already on the Base Leg. Furthermore, at around the time to complete the circling on the Base Leg, it is probable that the forth times Gear-up Warning was activated because the Instructor set flap lever in the full-down position with not extending the landing gears.

When the third times and the forth times Gear-up Warning were activated, it is somewhat likely that the student A reset the annunciator of notifying the gear-up status in a reflex manner

without thinking whether it was the time to extend the landing gears. When PF responded to the check items for the status of the landing gears in the landing checklist, it is necessary to confirm the status of the landing gear lever and the Three Green Lights, but it is somewhat likely that the student A called that “DOWN THREE GREEN” without confirming by visual observation.

Regarding that the student A reset the annunciator of notifying the gear-up status in a reflex manner without thinking whether it was the time to extend the landing gears; it is somewhat likely that the circling was getting too close to the runway because he was preoccupied with the operations to adjust speed and altitude and did not have the time to spare and was upset.

On the other hand, it is probable that he entrusted the student A to check the status of the landing gears, could not acknowledge the Gear-up Warning and was not aware of his forgotten of both the operation to extend the landing gears; because the Instructor was focusing on the next stage to close the Door again during the landing roll in order to continue the training.

(3) Top Priority to the Flight Safety

It is probable that the student B talked to the Instructor that it was not possible to continue the training, because he had hard time to hear the ATC communication which was shielded by the wind whistle caused by the incomplete locked the Door at the Down-wind Leg.

On the other hand, it is probable that the Instructor check the Door prior to the flight, but because the function of the Door did not have any abnormality, the aircraft took off with the incomplete locked the Door. It is probable that; the Instructor was worrying about the incomplete locked status because wind whistle was generated; however, he judged that the Door could be closed again during a landing roll without interrupting the touch-and-go training; therefore, his grasping the flight condition which was critical to secure the safety became insufficient because he was preoccupied with that.

At the incomplete locked status of the Door, in addition, the aircraft was deviated largely from the traffic pattern because of the

	<p>wind; nevertheless, the Instructor did not abort the training, and without giving the clear instruction to exchange the roles as keeping the student A on the control wheel, the Instructor assisted the flight control of the student A. If the proper training circumstance was not obtained like that, it is necessary for an instructor to abort the training immediately by placing the priority to the flight safety.</p> <p style="padding-left: 40px;">It is desirable for the College to make the all instructors notice of the actions taken to the troubles experienced during trainings from the perspective of top priority to the flight safety.</p>
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4. PROBABLE CAUSES

<p>In this accident, it is certain that the aircraft made a belly landing both without extending the landing gears and without the sufficient confirmation of the status during the touch-and-go training at Sendai Airport, and which caused damage to the aircraft.</p> <p>Regarding that the aircraft made a landing both without extending the landing gears and without the sufficient confirmation of the status; it is probable that the Instructor was not aware of his forgotten of both the operation to extend the landing gears and the confirmation because the grasp of flight situation by the Instructor became insufficient.</p>

5. SAFETY ACTIONS

<p>In order to prevent the re-occurrence of the similar cases, the College added the action (1) to the training manual, and then educated all instructors and students about the all actions including the existing action (2) to action (10):</p> <p>(1) When the PF called that “LANDING”, PM (in the right rear seat) should call that “NO WARNING” after confirming followings:</p> <ul style="list-style-type: none"> - there are no “WARNING” alert in red blinking on PFD - there are no “GEAR UP” in red on PFD. - the warning horn is not activated. <p>At last, PM (in the pilot seat) should call that “DOWN THREE GREEN”, after confirming that the landing gear lever is pulled down and the Three Green Lights are turned on.</p> <p>(2) It is critical for an instructor to reconfirm the roles of PM and PF and make the exchange of roles be clear. When exchanging the roles between PF and PM, the</p>

instructor shall call that “I HAVE” to the student of PF and the student shall reply that “YOU HAVE” to exchange the roles. However, the student should recognize that he continues to be PF unless the instructor calls that “I HAVE.”

(3) When performing a checklist, PM (instructor) should confirm that the response of PF should be matched with the Three Green Lights and the landing gear lever.

(4) When an abnormal situation occurred, check the existence of applicable “EMERGENCY & ABNORMAL CHECKLIST” after securing the safety.

(5) When the Door opened during the flight, follow that “CABIN DOOR OPEN IN FLIGHT” described as “EMERGENCY & ABNORMAL CHECKLIST” bellows:

- Land as soon as possible with placing the top priority to the safety.
- Try not to close the Door.

(6) Reconfirm the followings in the training manual:

- the operation of cabin door
- the Door of being locked for sure (the Door status, the position and the display of the Door lever, and the Door light turned off)

Acknowledge the individual difference in the firmness and the position of Door lever per aircraft.

PF shall re-confirm as necessary.

(7) Message which is in red or yellow of indicating abnormality should be shared with flight crew without leaving that as it is. As a characteristic of the aircraft, during the flight at traffic pattern, warning horn would be often activated. However, it should be understood that there should be no warning horn or no warning display of the annunciator when landing.

(8) Promote to make “assertion”.(including the crews in the rear seats)

(9) Reconfirm the following determination criteria of “go-around”

- Stable approach which enable a safe landing
- Completion of landing checklist
- Reception of landing clearance

(10) As described in the training manual, re-confirm the priority to avoid the worsening of the situation by implementing more appropriate procedure for sure depending on the situation during an emergency/abnormal operation.