4. Utilization of objective data from FDM and its effect

In order to investigate the causes of accidents, it is important to collect all objective information available in the first place. As described above, we conduct investigations based on information recorded not only in on-board equipment such as flight recorders but also in various devices such as drive recorders and smartphones. Collecting as much information as possible is the first step of accurate investigations of causes and adequate prevention of accidents.

It is not feasible to obtain statements about how an aircraft resulted in an accident especially in cases where passengers including a pilot seriously injured. Therefore, it is of extreme importance to investigate the causes based on diverse data contained in on-board equipment. It is not always feasible to obtain positional information from aircraft control radars or statements from witnesses. If an aircraft crashes in the mountainous area, it is difficult to identify a flight route without positional information, etc., causing headaches for accident investigators. In such a case, devices such as FDM capable of collecting and recording objective data are extremely useful, because they clarify the causes of accidents and more safety is ensured by sharing preventive measures among all operators of small aircraft.

The same principle applies to safety management activities of aviation operators such as collection and analysis of near-miss incidents. It is not practical to collect information from ground facilities, etc., especially in these activities. However, if devices such as FDM are installed, analysis and assessments can be made based on objective information recorded therein, contributing to the improved quality of safety management. Moreover, in the case of a private aircraft, it becomes feasible to objectively review the flight process of near-miss incident so that flight safety is ensured by improving pilot's own skills.

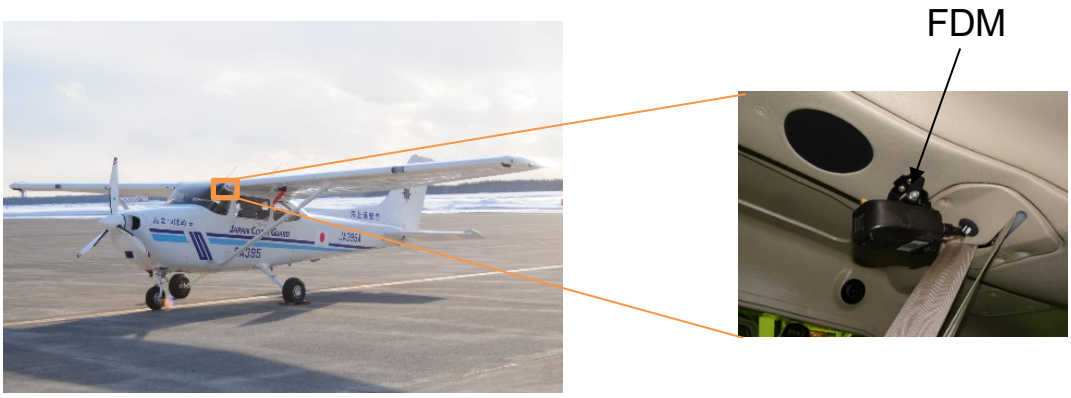
6. Usefulness of information in accident analysis

Based on the information explained so far, Chapter 6 will present what type of information is utilized to create investigation reports by taking aircraft equipped with FDM as an example as well as how objective information that was available for analysis is utilized to estimate the processes leading up incidents and accidents, the causes of accidents, and factors involved.

1. Example of an accident analyzed by on-board FDM

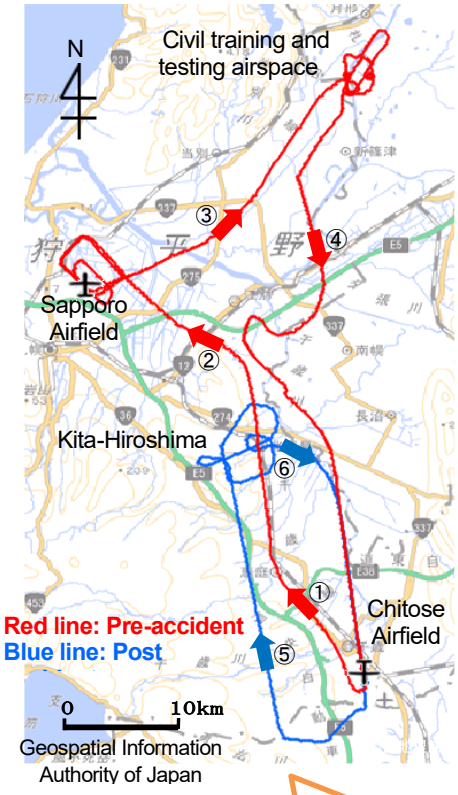
Time and date of the accident: August 21 (Tuesday), 2018, around 13:22 p.m.
Type: a Textron Aviation 172S
Outline of the accident:
The aircraft took off from Chitose airfield for the practical pilot competence examination flight associated with the rating change for pilot certificate, after completing examination in subjects associated with take-off and landing at Sapporo airfield, the aircraft conducted other examination subjects in civil training and testing airspace, and then headed for Chitose airfield. This aircraft suffered damage to the airframe by the touchdown accompanying a severe impact when landed at Chitose airfield.

The aircraft and FDM installed thereon



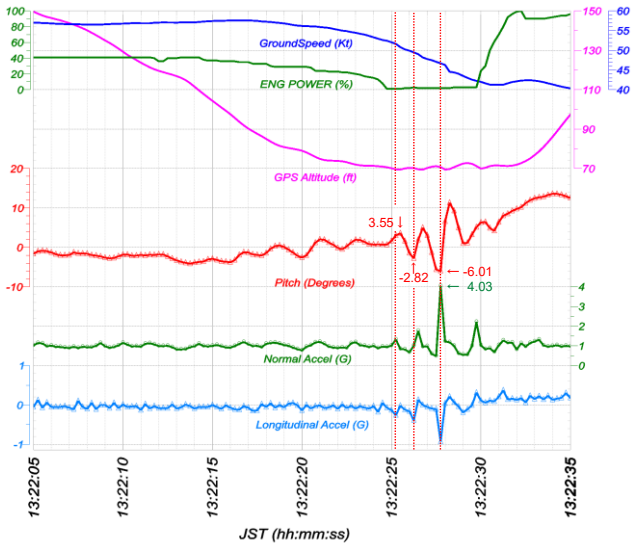
Records of FDM

Estimated flight route



The flight route of the aircraft was analyzed based on flight records in FDM

Various flight data such as altitudes and speeds



The altitude, speed, pitch angle, acceleration, and engine output were analyzed based on flight records in FDM

Records used to analyze the flight status in the investigation report

FDM data → Movements of the aircraft and the in-flight status such as pilot's control at the time of the accident, touchdown noise, engine output

Oral testimonies from the instructor and the pilot → Response to pilot's control including mental conditions of the pilot

Records from the drive recorder of commercial vehicle → Status of the aircraft's bouncing at the touchdown

Based on the above records, the situations described on the left-hand side were found out and led into the analysis on the right-hand side.

Process leading up to the accident	Analysis of probable causes
After completing the practical pilot competence examination flight associated with the rating change for pilot certificate in the training and testing airspace, etc., the examinee commenced the descent from a pressure altitude of 1,500 ft at an approach angle of 2.7 by Runway 18L at Chitose airfield, had the runway in sight at a pressure altitude of about 500 ft and passed over the runway threshold (THR) at an airspeed of about 72 kt with full flaps.	It is highly probable that the aircraft passed over the runway threshold at an airspeed of about 72 kt and was descending at an unstable pitch angle.
The first grounding The examinee kept the engine power to some extent, delayed the timing to close the throttle than usual and performed a flare maneuver. The aircraft touched down on the main landing gear at an air speed of about 62 kt and bounced after the touchdown.	The aircraft started increasing its pitch angle about 3 seconds before its first touchdown followed by decreasing its pitch angle about 2 seconds before its touchdown, then it touched down at around airspeed of 62 kt with increasing its pitch angle again about 0.5 seconds before its touchdown. From the above it is highly probable that the aircraft bounced because it touched down with abruptly raising its attitude to a landing attitude immediately before its touchdown with high airspeed.
The second grounding The examinee continued landing, landing presuming that the bounce of the nose at the second touchdown would subside, although the nose bounced.	It is highly probable that the examinee was unable to control the nose down properly, touched down on the nose gear and continued landing, that led the aircraft to enter porpoise condition where bounces were repeated because the pitch angle changed from 3.55 to –2.82.
The third grounding The examinee executed a go-around because the nose bounced more severely than the second touchdown. The examinee applied the engine maximum power to establish climb attitude and retracted the flaps.	The aircraft entered porpoise condition at the second touchdown, then –6.01 of the pitch angle, +4.03 of the vertical acceleration (G) and the loud sound of the landing gear were recorded at the third touchdown, therefore, it is highly probable that the airframe was damaged by severe touchdown of the nose gear in pitch down attitude (an attitude of the nose downward than the horizontal plane) at the third touchdown.
The examinee requested air traffic control for radar vector and landed at Chitose airfield at around 13:58 by Runway 18L approach after holding over Kita-hiroshima City as instructed by air traffic control.	

Probable causes of the accident

In this accident, it is highly probable that the aircraft suffered damages because it entered porpoise condition after the bounce at the first touchdown, and touched down hard on the nose gear in pitch down attitude at the third touchdown.

Since this aircraft was equipped with FDM and objective data such as the positions, altitudes, speeds, attitudes, etc. of the aircraft could be obtained, it was feasible to analyze how the accident happened in detail as described above. It is easier to comprehend a specific situation where the aircraft was damaged by comparing the situations when this accident happened and after the go-around (after the touchdown) based on data in FDM in analysis. Moreover, if an aircraft is equipped with FDM, the operator can obtain the same data as the one used to create the above investigation report. Therefore, this data contributes to the prevention of accidents in the future by making a comparative study with other flight cases and sharing its results with pilots.

The effectiveness of FDM is presented also in Chapter 3 (Analysis) of the investigation report.

The accident aircraft was equipped with FDM, its record was useful to analyze the flight situation of the accident aircraft in detail in this accident investigation. FDM stores various kinds of flight data and the cockpit audio and image, and it is probable that the extraction of unsafe factors in regular flights and the confirmation of the training results and others are able to be done by analyzing such data.

Furthermore, an accident investigation report of an aircraft which was not equipped with FDM (a helicopter crashed the mountain slope in Nagano prefecture in March 2017) mentions the importance of objective information including simple type flight recorders and the importance of equipment as shown below.

The helicopter was not required to be equipped with a flight recorder and was not equipped with one. In this accident, although all of the rescuers aboard the helicopter died, it was feasible to make use of video camera images taken by a rescuer as objective data to verify factual information and analyze the causes. However, it is probable that had the images not been available, scientific analysis of the accident would have been extremely limited in scope. For aircraft that are required to fly within small safety margins, such as in severe weather conditions or at low altitude for firefighting, disaster management, or other activities involving lifesaving and the like, the installation and utilization of a flight recorder, including the simple type can prove useful in better understanding of the characteristics and flight operations of an aircraft for special flight services by regularly analyzing and evaluating the flight conditions in ordinary flight operations, and if an incident or an accident occurs, it will contribute significantly to precisely identifying its causes and developing effective recurrence prevention measures.

Accordingly, equipping such aircraft with flight recorders is considered as high priority and it is desired to study for its realization and promotion with the cooperation of relevant parties.

2. Usefulness of FDM in accident investigations, etc.

In some cases, sufficient objective flight data may not be available in accident investigations even now. If those cases are eliminated as much as possible and the probable causes can be investigated more accurately based on scientific analysis, operational safety will improve. Since FDM is a very useful device in this sense, we expect FDM to be adopted more broadly.

7. Trends of overseas investigation authorities

Overseas accident investigation authorities are also interested in equipment such as FDM. In this Chapter, the trends of the National Transportation Safety Board (NTSB) and the Australian Transport Safety Bureau (ATSB) will be presented. Both accident investigation authorities state that equipping aircraft not mandated to be equipped with flight recorders with devices capable of recording flight data and image will help the prevention of future accidents. This point of view matches the purport of the Digests.

Websites of investigation authorities

NTSB https://www.ntsb.gov/advocacy/mwl/Pages/default.aspx

ATSB https://www.atsb.gov.au/safety-issues/AO-2017-118-SI-03

NTSB (United States) 2021-2022 MOST WANTED LIST

In the MOST WANTED LIST, NTSB publishes that it is requesting to the Federal Aviation Administration (FAA) that small aircraft used to transport passengers should be equipped with devices capable of recording flight statuses. Moreover, the effectiveness of FDM is mentioned in an individual investigation report cited as an example.(the partial excerpt is as follows)

Request of NTSB	The NTSB believes other types of passenger-carrying commercial aircraft such as charter planes and air tours, should be equipped with data, audio, and video recording devices. These operators should also have programs in place that analyze the data derived from these devices. Recorders and flight data management programs would not only help investigators solve accidents, but they would also help aircraft operators prevent crashes in the first place by allowing crew actions to be evaluated regularly.
Example of description in relevant report (AAR-21-01)	The value of crash-resistant flight recorder systems in preventing future accidents
	Certain circumstances of this accident could not be conclusively determined, including the visual cues associated with the adverse weather and the pilot's focus of attention in the cockpit following the flight's penetration of clouds and entry into IMC. A crash-resistant flight recorder system capable of capturing audio and