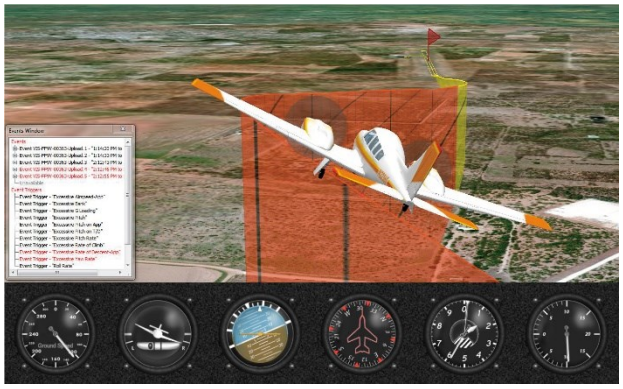
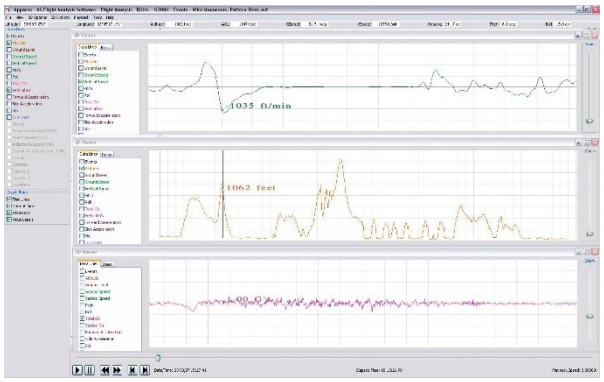
operations using analytical tools as well as to efficiently bring out the safety management function by incorporating it to safety management system (SMS) of aviation operators.

In daily risk management, it is important to improve flight safety by addressing each individual flight risk in a non-punished environment without accusing the responsibility of a pilot. FDM is very useful in this sense, since it can obtain and analyze objective information.



Application of analytical tool (display of flight route)



Analytical function of various data

(3) Monitoring of aircraft failure

It is feasible to identify the status of aircraft based on various recorded data and utilize it for the prevention of failure.

5. Importance of objective information in terms of accident investigations

When an aircraft accident occurs, accident investigators are sent to an accident site to collect information necessary to investigate its causes. In this process, the discovery of flight recorders (also called “black box”) draws the attention of the press in the case of a large aeroplane, but small aircraft are rarely equipped with this type of equipment. If small aircraft are equipped with FDM explained in Chapter 3, more than 10 parameters can be obtained from internal sensor, etc. and very useful information becomes available to investigate the causes, although the number of parameters is fewer than flight recorders. Moreover, if cockpit images which are usually not contained in flight recorders are recorded, it is very useful to investigate the accident, because the control of devices and external information can be obtained.

The next section presents the sources of data used in accident investigation reports by JTSB to consider how objective information obtained from FDM can be utilized to improve safety.

1. Status of on-board FDR and FDM in accidents involving small aircraft

The next graph shows the number of aircraft that had data from FDR or FDM in creating investigation reports on small aircraft published in the past 10 years (January 2013 ~ December 2022).

Among 95 accidents involving small aircraft (97 aircraft involved), 3 aircraft were equipped with FDR, while 1 aircraft equipped with FDM (See Figure 7).

When we pay attention to 20 aircraft involved in fatal accidents of pilots, no aircraft was equipped with any of this equipment.

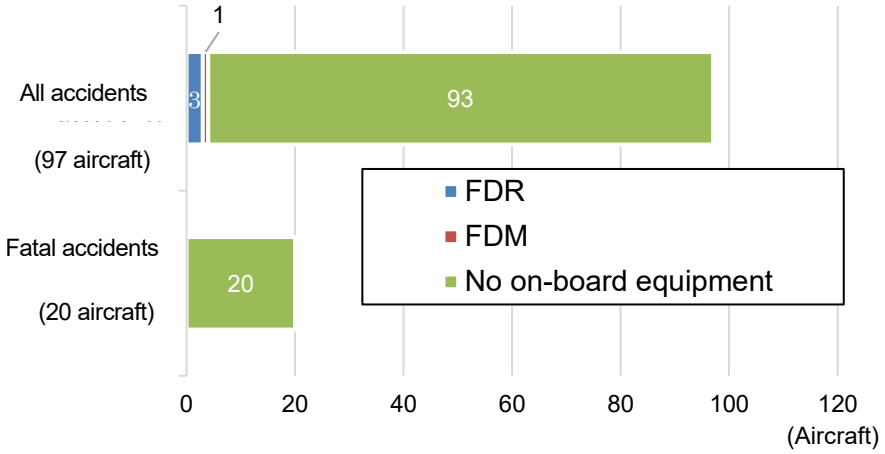
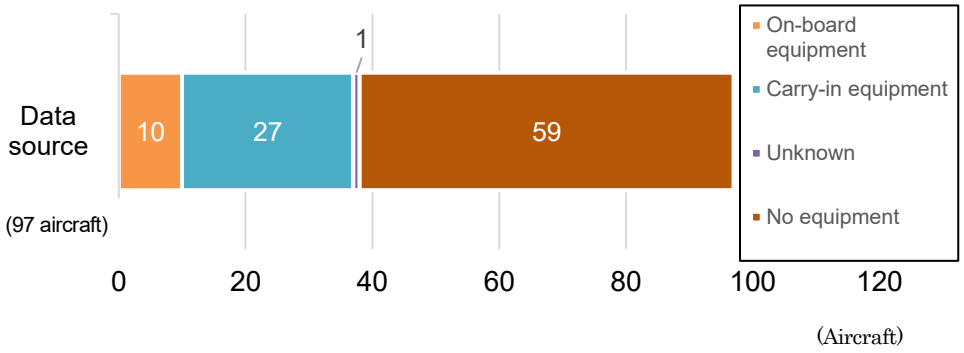


Figure 7: Status of on-board FDR/FDM in accidents involving small aircraft

2. Information on positions and altitudes of aircraft

The fact is that not many small aircraft are equipped with a flight recorder, because there is no obligation to do so, although it depends on when an airworthiness certificate or type certificate was granted or whether a small aircraft carries human beings or cargos for fee. Therefore, when an accident investigation is conducted, anything that contains data is used after checking if the positions of the aircraft are recorded in various navigation equipment for aircraft operations, equipment used for special services such as monitoring of transmission lines, etc. Moreover, we take the initiative to obtain and utilize data from portable GPS receivers brought in by pilots, etc. for secondary use, and video cameras or smartphones for business or personal use (if any), under the cooperation of their owners.

The next graph shows the number of aircraft from which on-board data could be collected to verify their positions, etc. in accident investigations. Out of 97 aircraft investigated, we could collect data from on-board equipment from only 10 aircraft (10%). Even if carry-in equipment such as portable GPS receivers are included, we could obtain data from only 37 aircraft (38%). The truth is that it is not feasible to obtain information on aircraft positions, etc. from approximately 60% of all accidents (See Figure 8).



※"No equipment" includes aircraft that had on-board equipment but no data was recorded

Figure 8: Status of positional information of small aircraft

It should be noted that, in an actual accident investigation, the aircraft position is identified by utilizing information recorded by ground facilities in addition to airborne data.

For example, ground facilities can provide information on positions and altitudes from aircraft control radars, videos from various security cameras installed inside and outside airports, videos recorded by drive recorders installed on airport service vehicles and public vehicles. Particularly, aircraft control radars can provide much information. Information from them is used in approximately 20% of investigation reports, but aircraft attitudes, etc. cannot be verified.

The following shows specific data utilized by JTSB other than FDR and FDM and use cases. Investigation reports are created by selecting necessary information from available information.

Integrated instruments

If any information is recorded in navigation instruments equipped for aircraft operations and various systems that control and display aircraft and engines, it is extracted.

Equipment for special duties

This equipment is installed for special duties. Data recorded there in is obtained and utilized. Some of examples are shown below.

- Dynamic management system (positional information obtained from GPS systems installed on helicopters, etc. is transmitted via satellites for search and rescue services so that the ground side can capture the positions on a real-time basis and share it with on-board equipment)
- Transmission line route mapping system (This system is used to patrol transmission lines, and information on positions and altitudes are recorded every second)
- Airborne image transmission system (Videos taken by visible cameras and the positional information from GPS systems are sent to the ground side for recording)

Portable GPS receiver

A portable GPS receiver is brought in by a pilot for duty or reference of aircraft operations. The precision of positions and a recording method vary.

Video camera

Videos and voice recordings taken by a video camera brought in by a pilot for his/her duty or personal use

Other on-board equipment

GPS information of smartphones brought in by pilots

Voice recordings of IC recorders brought in for training purposes

Aircraft control radars

These radars are under the jurisdiction of the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Defense for aircraft control and can obtain information on aircraft positions, altitudes, and routes. However, information cannot be obtained if an aircraft flies in the shade of a mountain or at a low altitude, because reflected waves (response waves) emitted from radars are used.

Airport security cameras, etc.

Surveillance camaras at runways and parking aprons of airports, various security cameras installed for various purposes, and videos provided by spectators.

Drive recorders

Videos of drive recorders installed on airport service vehicles and public vehicles

3. Information inside the aircraft's cockpit

The next graph shows the number of aircraft which provided on-board data for verifying the situations in cockpits (See Figure 9). If a cockpit voice recorder (CVR) is installed, communications with air traffic control authorities, equipment control noise, operating noise, warning alarms, and surrounding noise, etc. However, currently, cockpit images are not recorded except some aircraft, even in the case of large aeroplanes. On the other hand, FDM has the function of recording readings of instruments in cockpits and external sceneries. Even if this equipment is not installed, we take the initiative to obtain and analyze visual recordings of equipment capable of recording videos such as on-board professional cameras and personal video cameras for the purpose of investigating the causes of accidents.

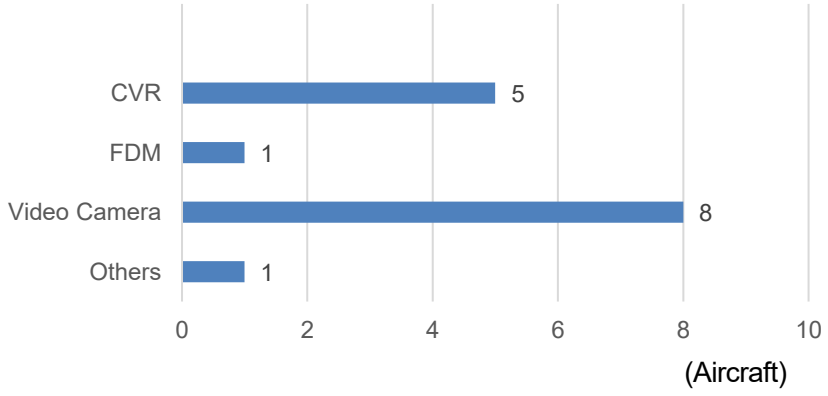


Figure 9: Information used to identify the situations in cockpits of small aircraft

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.