# Separation of Passenger Door on Instructional Flight East of Pori on August 19, 2022


L2022-03

## SYNOPSIS

Pursuant to section 2, subsection 2 of the Safety Investigation Act (525/2011), the Safety Investigation Authority Finland (SIAF) decided to investigate a serious incident that occurred near Pori on August 19, 2022, when the passenger door of a Diamond DA42 airplane separated on an instructional flight.

The purpose of a safety investigation is to promote general safety, the prevention of accidents and incidents, and the prevention of losses resulting from accidents. A safety investigation is not conducted in order to allocate legal liability.

Airline transport pilot Juha-Pekka Keidasto was appointed the investigation team leader. The appointed team members were licensed aircraft mechanic Jukka Jylö, special investigator Timo Naskali and air traffic control officer (retired) Toni Solatie. Psychologist Krista Oinonen was appointed as a subject matter expert. The investigator-in-charge was Chief Air Safety Investigator Janne Kotiranta.

The Austrian safety investigation authority (SUB) appointed appointed an accredited representative for the investigation, while the European Aviation Safety Agency (EASA) appointed a technical advisor.

The safety investigation examines the course of events, their causes and consequences, search and rescue actions, and actions taken by the authorities. The investigation specifically examines whether safety had adequately been taken into consideration in the activity leading up to the accident and in the planning, manufacture, construction and use of the equipment and structures that caused the accident or incident or at which the accident or incident was directed. The investigation also examines whether the management, supervision and inspection activity had been appropriately arranged and managed. Where necessary the investigation is also expected to examine possible shortcomings in the provisions and orders regarding safety and the authorities' activities.

The investigation report includes an account of the course of the incident, the factors leading to the incident, and the consequences of the incident as well as safety recommendations addressed to the appropriate authorities and other actors regarding measures that are necessary in order to promote general safety, prevent further accidents and incidents, prevent loss, and improve the effectiveness of actions conducted by search and rescue and other authorities.

An opportunity is given to those involved in the accident and to the authorities responsible for supervision in the field of the accident to comment on the draft investigation report. These comments have been taken into consideration during the preparation of the final report. A summary of the comments is at the end of the report. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

The investigation report was translated into English by TK Translations.

The investigation report and its summary were published on the SIAF's internet page at www.sia.fi. on 15 September 2023.

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Cover photo: Police

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# 1 FACTUAL INFORMATION

## 1.1 History of Flight

On Friday August 19, 2022, two student pilots of the Finnish Aviation Academy (FINAA) were preparing for an instructional flight on a Diamond DA42 airplane with the intention of proceeding under instrument flight rules to a training area located in the vicinity of Pori aerodrome. This was the flying student's second, and the observing student's third flight on the DA42.

After the students and their flight instructor had completed a preflight briefing and previewed the exercises to be conducted during the flight, the students stepped out and arrived at the airplane before the instructor.

They resumed preflight preparations and boarded the airplane. The observing student positioned in one of the two rear seats and closed the passenger door, while the flying student occupied the left front seat. The canopy was left open to allow the instructor to take position in the right front seat.

Upon arriving at the airplane, the instructor opened the passenger door and placed his kit on the left rear seat. Then he closed the door from the outside, assisted by the observing student, who moved the door handle to locked position. By this time the student had already strapped in. The instructor settled into the right front seat and strapped in, and the canopy was closed.

The instructor and the flying student initiated the before starting normal procedures checklist, in which one item is to ensure that the doors are closed.

After engine start, the flying student began taxi to a runway holding position, where the before takeoff checklist was completed. This also includes a check to verify that the passenger door is locked. The purpose of the checklist is to ensure that the airplane is ready to begin a flight. After the instructor and the student had checked that no warnings or cautions were displayed, the student began takeoff from runway 12 at 1010 h.

He followed the air traffic control clearance and set course to the training area. During climb, the observing student noted that the passenger door handle was not in locked position and notified the other crew members immediately, which caused some confusion. The instructor asked the observing student to try to push the handle to locked position, and the student complied, but without success.

The instructor saw that the door was ajar at its rear edge and asked the flying student to level the airplane. The instructor and the observing student made a combined effort to lock the door but were unsuccessful. The door opened fully and separated from the airplane. The instructor took control from the flying student. Only after door separation did the crew members note a “Door Open” warning on a cockpit display.

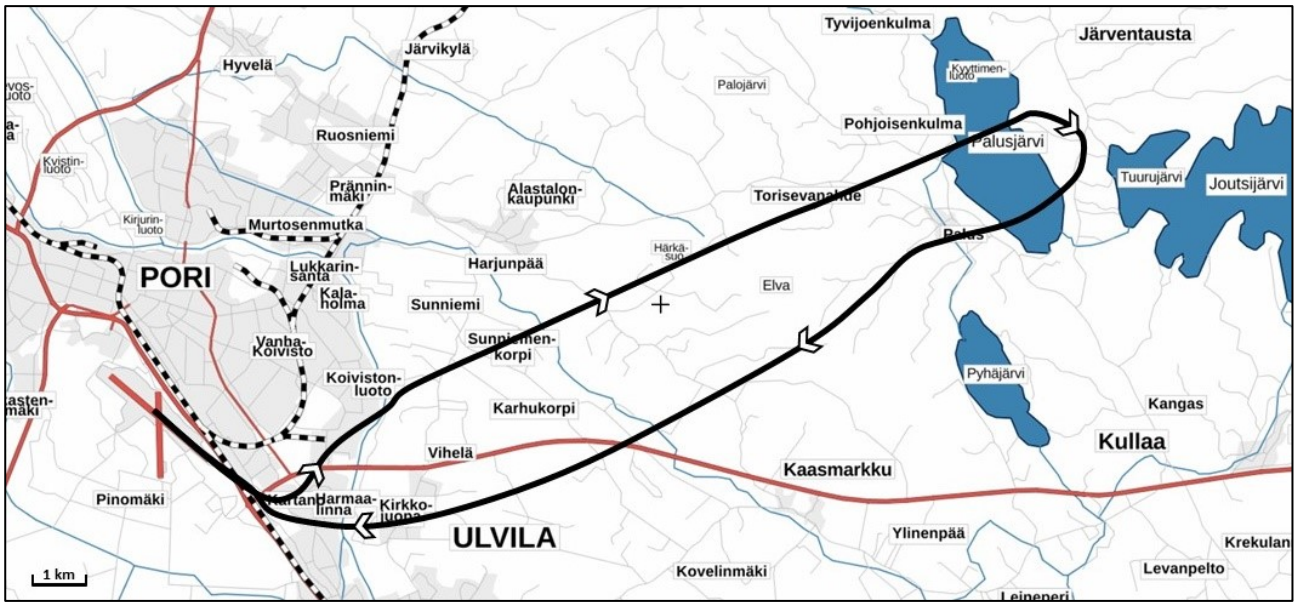


**Figure 1.** The airplane's track, derived from recorded radar data. (Base map: Clearmap ©National Land Survey of Finland 9/2022, annotated by SIAF)

## 1.2 Survival Aspects

At 1017 h, the instructor contacted air traffic control (ATC) and requested a clearance for return to Pori. The flight was cleared to proceed towards Pori for landing on runway 30. When the controller inquired if the flight was experiencing problems, the instructor replied that the airplane had lost the passenger door. The controller decided that an alert phase should be declared and asked the flight to provide specific information of the situation and to report the amount of fuel and the number of persons on board. ATC personnel made an emergency call to the emergency response center (ERC) at Pori at 1018 h, when the estimated time to landing was between 2 and 3 minutes and notified the aerodrome rescue service using the electric alerting system. Upon receiving the emergency call, the ERC dispatched four units of Satakunta Rescue Department to the airport to respond to a minor aircraft accident.

The airplane remained fully controllable despite the door loss. Although environmental noise in the cabin increased somewhat, the occupants could communicate through their headsets without problems. Some turbulent airflow was experienced by the rear seat occupant.

The airplane landed normally at 1023 h and taxied to the FINAA hangars, where the alerted rescue service unit also arrived. It became evident that there was no need for immediate rescue actions or medical assistance. The rescue department units, that had arrived on scene at 1023 h, were called off on the incident commander's decision by 1031 h. Rescue service personnel examined the airplane.

A police patrol from Pori Forensic and Crime Scene Investigation Center subsequently arrived and documented the airplane.

## 1.3 Injuries to Persons and Damage to Aircraft

The incident did not result in injuries.

The passenger door was torn off from its hinges and separated from the airplane, taking with it the gas spring strut that assists in door opening and supports the door in open position. The entire forward hinge arm had detached, but the emergency door release pin remained in place in the hinge bracket. The aft hinge arm had fractured, leaving the lower part attached to the

hinge bracket. The airplane sustained no additional damage, and the airframe showed no signs of door impact. The separated door was not recovered. The operation of the door warning system could not be tested during the on-site examination because the airplane could not be powered-up. However, the structure, operation and locking mechanism of the door could be examined using the internal and external controls on another DA42 that was parked in the FINAA's hangar.

**Figure 2.** Damaged door hinge assemblies. (Photos: SIAF)

# 2 BACKGROUND INFORMATION

## 2.1 Environment, Equipment and Systems

The incident airplane was a Diamond DA42 bearing the registration OH-DAN, S/N 42.N307. It was manufactured in 2018 and by the time of the incident it had accumulated a total of 1,969 h of flight time and 2,374 landings.

**The Diamond DA42** is a piston-engined twin that is widely used for flight training. Its maximum takeoff and landing mass is 1,999 kg. The type is certified for visual flight rules (VFR), instrument flight rules (IFR) and night visual flight rules (NVFR) operation. The cabin is entered via a hinged canopy and an upward-opening passenger door on the left side of the fuselage. The baggage compartment in the nose cone is accessible via two hinged doors.

**Garmin G1000** is a fully integrated flight, engine, communication, navigation and surveillance instrumentation system. It consists of two advanced multi-purpose displays known as the PFD[1] and the MFD[2]. The PFD provides airplane system alerts, including a door unlocked warning.


**Figure 3.** The PFD (left) and the MFD (right) (Photo: SIAF)

**The PFD** is installed on the left side of the instrument panel. It is the primary flight management display providing, among other parameters, airspeed, attitude information and heading information in a conventional horizontal situation indicator format. It is also used for selecting communications frequencies. The data fields and parameters are configured by operating keys and rotary knobs located to the right and left of the display screen.

**The MFD** is nearly identical to the PFD and is installed on the right side of the instrument panel. It incorporates the autopilot system controls and typically displays, among other information, engine data, navigation maps and flight planning information.

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1 Primary Flight Display.
2 Multi-Function Display.

**Crew alerting system** information is displayed in a notification window on the right-hand right edge of the PDF. The system generates messages to the pilot. These are accompanied by an aural warning that alerts the pilot to the appearance of a message.

The system uses three alert levels: warnings, cautions and advisories, of which warnings are the most critical. They will appear as red visual warnings in text form in the notification window, accompanied by a repeating chime and a flashing "Warning" message on red background in the bottom right corner of the display. The chime can be muted by the pilot.

| Level | Text Color | Importance | Audible Tone |
|---|---|---|---|
| Warning | Red | May require immediate corrective action | Warning chime tone which repeats without delay until acknowledged by the crew |
| Caution | Amber | May require future corrective action | Single warning chime tone |
| Annunciation Advisory | White | | None |
| Message Advisory | White | | None |
| Safe Operation Annunciation | Green | Lowest | None |

**Figure 4.** The characteristics of warnings, cautions and advisories. (Source: DA42 Airplane Flight Manual) (Source: Diamond Aircraft Industries)


**Figure 5.** A PFD view after a door warning. Warnings, cautions and advisories appear in the notification window on the right. When a warning is triggered, "Warning" flashes on red background in the bottom right corner and an aural warning sounds. (Photo: SIAF)

**The passenger door**, on the left side of the airplane, is attached to the upper fuselage by two hinge assemblies consisting of a hinge bracket and a hinge arm. The hinge brackets are fitted in recesses in the top edge of the door opening, and the composite hinge arms are mounted on the door. A gas pressure damper between the door rear edge and the fuselage prevents the door from dropping during closing, assists in door opening and keeps the door fully open on

the ground. It does not exert an opening force on the door in the fully down position, but after the door is slightly raised, it helps door opening. A damper failure will not open the door.

**Figure 6.** An undamaged passenger door in open position. (Photo: SIAF)

**A locking mechanism** is incorporated in the door structure. The door is closed from the cabin by pulling it down and locked by pushing a handle, located in the lower door frame, forward until it is parallel with the frame. A compression gas spring snaps the handle into the fully open position during door opening, and conversely, snaps the handle into the fully locked position during door locking and maintains it in this position. Two locking pins in the front and rear corners of the door keep the door closed and locked by engaging holes in two Teflon-coated guide plates mounted in the edges of the door opening. The tapered ends of the pins and the similarly tapered holes facilitate engagement. The door will not need to be pushed down for locking since the pins guide it into the correct alignment, and the external door handle will simultaneously move into locked position. The door can be opened and locked using either the internal or the external handle. A separate spring-loaded safety catch on the cabin side will keep the door in near closed position and thereby prevent the door from opening fully if it becomes unlocked. The catch can be operated from the inside or outside the cabin. The improved design of the safety catch retaining bracket has been in all aircraft built after 2012. In aircraft built after July 2014, the safety catch itself has also been improved. The OH-DAN (manufactured in 2018) was equipped with the latest design of the passenger door and the door looking mechanism from the factory. The passenger door had been maintained in accordance with the maintenance manual.


**Figure 7.** The internal door handle (right) in a partially open position and the safety catch (left). (Photo: SIAF)

**A door warning system** triggers a door open warning in case the canopy, the passenger door OR one of the two the baggage doors is not locked. The system is controlled by microswitches that sense the unlocked condition, and visual and aural warnings are generated in the PFD. The system is activated sequentially. When the canopy or least one door is open, a "Door Open" warning appears on the PFD if the avionics master switch is switched on and avionics are powered-up, but an aural warning will sound only if the canopy and all doors have been closed and locked together. It can be heard from the cabin loudspeaker and through headsets. While volume level for the loudspeaker sound cannot be adjusted, volume that sounds through the headsets depends on the setting of the headset volume control.

The passenger door warning system senses the position of the front locking pin. With the door fully locked, the pin rests against a microswitch in the guide plate hole. If pin engagement is insufficient, a warning is triggered. Rear locking pin operation is similar, but its position is not sensed by the system.

**A locked door is opened from the inside** by moving the internal handle, which withdraws the locking pins from the guide plate holes. The safety catch is then raised, and the door is pushed up. The door opens, assisted by the gas spring strut.

The door can be locked with a key from the outside, but the keylock must be unlocked during flight.

**Pori aerodrome** is located on the southern outskirts of the town. Because the aerodrome is the home base of the FINAA, traffic density is occasionally high.

The aerodrome has two runways. The main runway (12/30)[3] is 60 m wide and 2,351 m long. The cross runway (17/35)[4] is 30 m wide and 801 m long.

Fourteen local TRAs[5] located around the aerodrome can be reserved and allocated for training and other uses.

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3 Magnetic heading 117/297 degrees.
4 Magnetic heading 165/345 degrees.
5 Temporary reserved area.

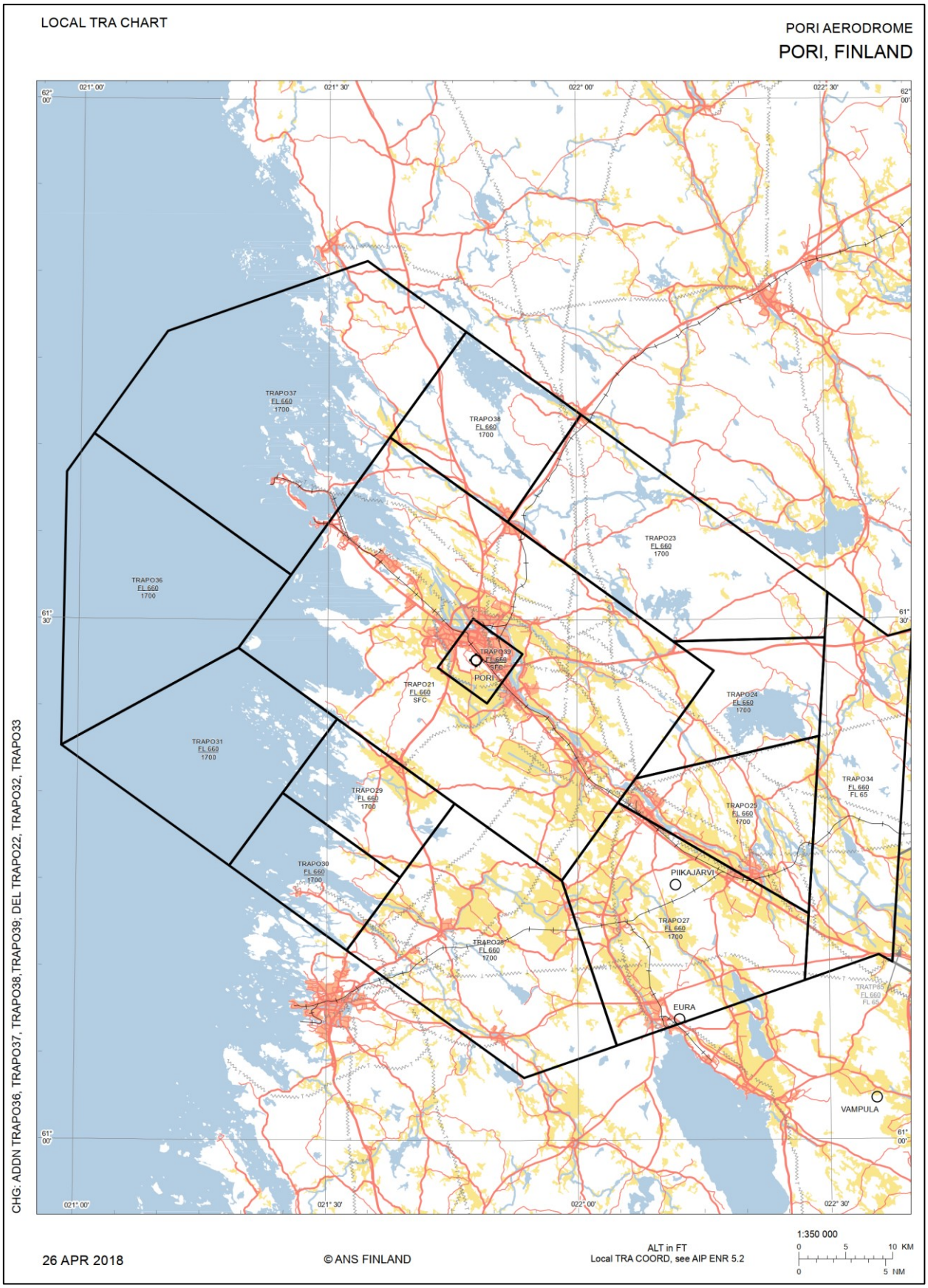


**Figure 8.** Temporary reserved areas around Pori aerodrome. (Source: AIS products and services, local TRA charts, Fintraffic ANS, based on National Land Survey of Finland resources: topographic database, 09/2012 and topographic map 1:250 000, 08/2012 and 10/2015)

## 2.2 Conditions

**Weather report**[6] Winds at the aerodrome at the time of the incident were light and from the east. Visibility was good, although rain showers were observed in the vicinity. Temperature was 20 °C and air pressure was 1,016 hPa.

**A terminal area forecast for Pori aerodrome**[7] had been in effect from 0537 h UTC[8]. It included moderate easterly winds for the valid period with no significant weather forecast, although temporary cumulonimbus or thunderstorm activity could be expected. Wind was forecast to veer to the southeast and increase in velocity after noon.

**A weather analysis from the Finnish Meteorological Institute** showed scattered rain bearing cumulonimbus clouds and good visibility in the area. Surface winds were light and from the east. Rain showers were observed in the vicinity of the aerodrome with the base of the rain bearing cumulonimbus clouds approximately 5,000 ft.

Because no observations were available from the incident location, a wind model and a wind aloft profile were created to cover the area of the community of Puhju, located between Pori and Lake Palusjärvi. The data indicated that the prevailing winds between the ground level and 5,000 ft were from the east. Wind direction and velocity between 2,000 ft and 5,000 ft were from 100° to 130° at 10 kt to 15 kt. At one thousand feet, wind was from 70° to 100° at 5 kt to 10 kt. A rain bearing cumulonimbus cloud in the vicinity had possibly caused an increase in wind velocity. Estimated wind direction and maximum velocity at 5,000 ft in the area were 140° to 160° at 25 kt.

## 2.3 Recordings

Radar data and radio communications recorded at Pori ATC facility were available for the investigation.

The airplane was not fitted with a position and flight data recording system.

### 2.3.1 Radar Data

Recorded radar data showed the track, speed and altitude of the airplane with time stamps. The data also helped to determine the area where the separated door had possibly landed and provided information of traffic in the aerodrome control zone. Two other aircraft had been airborne in the control zone at the time of the incident.

### 2.3.2 Radio Communications

Recorded radio communications between ATC and the airplane also contained time stamps. Correlation of this information and radar data enabled the investigators to determine the approximate position of the airplane at the moment of door separation.

## 2.4 Organizational and Management Information

**The instructor** held a valid pilot's license and an aeromedical certificate.

In December 2022, he had reported approximately 2,230 flight hours in total, of which approximately 1,230 h as instructor. He had approximately 970 h on the DA42.

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6 METAR EFPO 190620Z AUTO 11003KT 090V150 9999 VCSH //////CB 20/19 Q1016=

7 TAF EFPO 190537Z 1906/1915 09005KT CAVOK TEMPO 1906/1908 FEW050CB BECMG 1909/1911 15010KT PROB40 TEMPO 1910/1912 TS FEW050CB=

8 Coordinated Universal Time.

**The flying student** did not hold a valid license, nor was it required in the FINAA Training Manual approved by the competent authority. He held a valid aeromedical certificate and had accrued 126 h 36 min by the time of the incident flight. According to records provided by the FINAA, this total included 45 h 30 min on the FTD2/FNPT II flight training device and 1 h 20 min on the DA42 airplane.

**The observing student** did not hold a valid license, nor was it required in the FINAA Training Manual approved by the competent authority. He held a valid aeromedical certificate and had accrued 97 h 12 min by the time of the incident flight. According to records provided by the FINAA, this total included 42 h 20 min on the FTD2/FNPT II flight training device and 2 h 32 min on the DA42 airplane.

The students were undergoing an ATP(A) training program.

**The air traffic controller** held a valid air traffic controller's license with appropriate ratings and a valid aeromedical certificate.

**Fintraffic ANS** is responsible for airspace management in Finland and for the delivery of air route and air navigation services at 22 aerodromes. It also undertakes specific aeronautical search and rescue (SAR) and territorial surveillance tasks.

Air traffic services (ATS) at Pori aerodrome are provided by the local ATC facility. Alerting service is an integral part of ATS. It is activated to initiate an aeronautical SAR operation and alert the aerodrome rescue service. Its other task is to notify air traffic controllers, flight information service officers and other personnel as necessary about the situation and provide appropriate instructions.

**The Finnish Aviation Academy (FINAA)** is based at Pori aerodrome. It offers 16 commercial pilot training programs approved by the competent authority using aircraft listed in Table 1 and a range of flight training devices.

**Table 1.** Aircraft and flight training devices of the Finnish Aviation Academy

| Model | Number |
|---|---|
| C152 | 9 |
| C172 | 2 |
| DA42 | 5 |
| Extra 300 | 1 |
| EMB-500 | 2 |
| Flight training devices[9] | 8 |

**The safety management** policy of the FINAA is defined in the organization's manuals where key safety personnel, procedures and accountabilities are also described.

The FINAA's senior management convenes regular safety review board (SRB) meetings for the purpose of developing and planning the organization's operations. Other objectives of these meetings are to ensure the effectiveness of safety performance, regulatory compliance and the quality system and to monitor that corrective actions are taken in a timely manner. The

[9] Two of the fligth training devices are DA-42 FDT-2/FNPT II/MCC

recognition and mitigation of adverse trends is an additional objective. The SRB's decisions are forwarded to a staff member who is responsible for corrective actions.

If necessary, the SRB may establish a temporary safety action group (SAG) to assist the SRB, conduct safety risk analyses, and decide on corrective actions and oversee their implementation. The SAG will also review the effects of corrective actions on safety and implement any safety actions under the direction of the SRB.

**An internal safety investigation and reporting** system promotes information that could be used to improve safety and focuses on the identification of root causes, not on attributing blame. The accountable manager decides when an investigation is initiated; this usually happens after the identification of any trend that would seriously jeopardize safety. The recurrence of a similar significant occurrence or a major non-compliance may also trigger an investigation.

Only challengeable persons may be involved in an investigation, and individuals tasked with conducting risk analyses must have received risk analysis training before appointment.

After the occurrence under investigation, the FINAA conducted an internal safety investigation and decided to issue the following safety recommendations:

- *DA42 ground school should include actions after in-flight passenger door opening. No attempts should be made to close the door in flight.*
- *Instructors' standardization training should include the door closing procedure and emphasize that no attempts should be made to close the door in flight.*
- *Instructors should be reminded that the flight training device does not have a passenger door; for this reason, students will not develop a door closing routine, and particular attention should be paid on ensuring that the door is locked before flight.*

**Safety and risk management** policies are given particular attention in FINAA manuals. These policies include a change of management process, which is in turn divided into the preparation, assessment and implementation of a change. Other essential safety and risk management tools are risk identification, audits, reporting and continuous safety promotion. Urgent temporary changes, such as actions prescribed in aircraft manufacturers' safety bulletins, are implemented without delay.

**Diamond Aircraft Industries (DAI)** has received dozens of reports of passenger door losses on DA40 and DA42 airplanes since 2004. More than 30 occurrences were reported between 2004 and 2010. As a result, DAI has looked at possible problem areas, conducted tests, made structural changes and revised airplane manuals. By July 2021, the number of reported door losses increased to approximately 80.

DAI has made the following actions:

- In 2010, the emergency checklists were revised. The revised version states that if the passenger door is found unlocked, airspeed should be reduced to below 140 kt, and includes a note that the airplane can be flown to the next suitable airfield. An associated warning emphasizes that no attempts should be made to lock the door in flight because this may lead to safety catch disengagement and door separation.
- In 2010, an improved safety catch retaining bracket that enables better safety catch engagement to hold the door in near closed position was introduced. The improved design of the bracket has been in all aircraft built after 2012. In aircrafts built after July 2014, the safety catch itself has also been improved.

- In 2014, the inspection procedure of the door hinges for cracks or other damage was updated, and criteria for hinge replacement were given.[10]
- In 2017, a reinforced steel pin that attaches the compression gas spring to the locking mechanism was introduced. The purpose of the spring is to hold the door handle in open or closed, or unlocked or locked, position.
- Furthermore, DAI has required that the door locking mechanism and compression gas spring should be checked for every scheduled 200 flight hours maintenance action or during every annual inspection.

## 2.5 Preventive Actions of Authorities

A large number of similar occurrences have been reported worldwide and investigated by national safety authorities. These incidents and related findings are listed in paragraph 2.8.4.

On 24 November 2010, the European Safety Agency issued an airworthiness directive covering DA40 and DA42 airplanes[11]. The directive is discussed in detail in paragraph 2.7.

## 2.6 Rescue Services and their Preparedness

**Finavia** operates Pori aerodrome and maintains a regulatory rescue service at the aerodrome to respond to aircraft accidents and incidents within the aerodrome area. The level of service provided is determined by the size of aircraft operating to and from the aerodrome.

**Satakunta Rescue Department** exercised[12] overall command and control of rescue operations in the region of Satakunta in accordance with the Rescue Act[13]. The department was one of Finland's twenty-two regional rescue departments. Rescue department units were dispatched to the aerodrome in accordance with a predetermined incident response procedure. They remained holding in the vicinity of the aerodrome security gate, waiting for further instructions until called off by the incident commander.

The rescue department and aerodrome management have agreed that department personnel can open the gate giving access to the aerodrome maintenance facility without assistance, provided that the gate control system is activated from the facility. To gain access from the maintenance facility to the apron, a second, inner gate must be unlocked.

A rescue operation was not needed in the incident.

## 2.7 Regulatory Framework

**Airworthiness directives (AD)** are documents issued by the European Aviation Safety Agency (EASA) that must be complied with to ensure the continuing airworthiness of aircraft. Responsibility for AD implementation lies with continued airworthiness management organizations.

On 24 November 2010, EASA issued an AD and a new revision on 23 May 2011 covering DA40 and DA42 airplanes. The effective date of AD was 6 June 2011. The reason behind the AD was explained as follows.

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10 This was another action and was not directly related to the door separations.
11 2010-0235R1, 23.5.2011, DA40&DA42; https://ad.easa.europa.eu/blob/easa_ad_2010_0235_R1.pdf/AD_2010-0235R1_1
12 Until December 31, 2022, when the responsibilities were transfered to counties.
13 379/2011.

Since 2004, more than 30 reports had been received of in-flight losses of a passenger door on Diamond airplanes, the majority of which were DA40s. In addition, at least 18 doors had been replaced because of damaged hinges.

DAI had conducted analyses and structural tests to determine the root cause of in-flight door opening. The conclusions were that the primary locking mechanism provided adequate strength to keep the door closed in flight. It was determined that the root cause was the crew not properly securing the door prior to flight.

Damage to the hinges had been caused primarily by external loads, such as wind gusts, while the airplane had been parked.

All DA40 and DA42 airplanes have a system that provides a warning if the door is not locked. A secondary safety catch is also installed. The initial intended design function of this catch was solely to hold the door closed on the ground, protecting it from wind gusts.

However, the original retaining bracket could not necessarily prevent the door from opening in flight. Therefore, DAI designed an improved bracket and satisfactorily tested it to hold the door closed in flight. The AD states that if this modification is not carried out, the door could open and separate in flight.

In addition, DAI have revised the Airplane Flight Manual (AFM) emergency door unlocked/ open procedure.

The AD includes a detailed list of required actions, replacement parts and compliance times.

The Federal Aviation Administration of the United States issued corresponding ADs on 17 June 2011 (for DA42[14]) and 11 January 2011 (for DA40[15]).

**The DA42 airplane flight manual (AFM)**[16] explains that the canopy, passenger door and baggage doors share a common warning system, and the crew cannot therefore identify the unlocked door from the warning alone.

AFM Chapter 3 *Emergency Procedures* describes actions to be followed in various emergencies. The AFM also points out that maintaining safe flight will be the prime consideration even though this would delay the initiation of an emergency procedure.

Paragraph 3.12.2 states that no attempts should be made to lock the passenger door in flight since this would usually result in the separation of the door from the airframe. However, if a door has been lost the airplane can be safely flown to the next suitable airfield.

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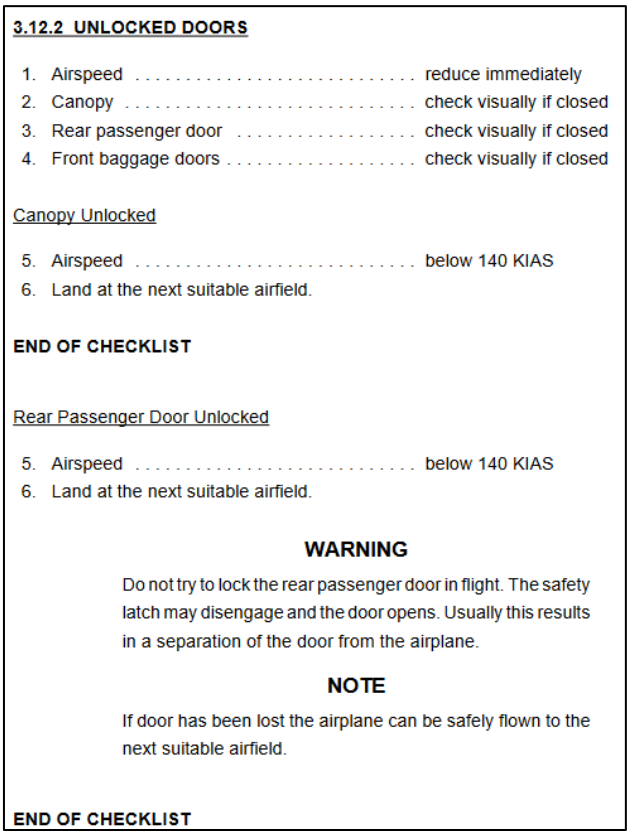
14 https://drs.faa.gov/browse/excelExternalWindow/8835cb7d-f856-4d76-901f-75fc2a71b581?modalOpened=true
15 https://drs.faa.gov/browse/excelExternalWindow/5f115470-3f5c-4373-bfc7-4d2e6c146d26?modalOpened=true
16 AFM para. 2.6.1 *Operating Limitations, Warning, Caution and Advisory Alerts on the G1000*.



**3.12.2 UNLOCKED DOORS**

1. Airspeed . . . . . reduce immediately
2. Canopy . . . . . check visually if closed
3. Rear passenger door . . . . . check visually if closed
4. Front baggage doors . . . . . check visually if closed

Canopy Unlocked

5. Airspeed . . . . . below 140 KIAS
6. Land at the next suitable airfield.

**END OF CHECKLIST**

Rear Passenger Door Unlocked

5. Airspeed . . . . . below 140 KIAS
6. Land at the next suitable airfield.

**WARNING**

Do not try to lock the rear passenger door in flight. The safety latch may disengage and the door opens. Usually this results in a separation of the door from the airplane.

**NOTE**

If door has been lost the airplane can be safely flown to the next suitable airfield.

**END OF CHECKLIST**

**Figure 9.** AFM paragraph 3.12.2 *Unlocked doors* (Source: Diamond Aircraft Industries)

**The Finnish Aviation Academy Operations Manual** (OM-B**,** *Standard Operating Procedures*[17]) contains guidelines for checklist use and states that the abnormal and emergency checklist procedures explained below are to be observed.

The manual contains some abnormal situations that include "memory items." These must be accomplished from memory before referring to the related checklist to ensure that all listed actions have been carried out.

Most abnormal procedures are in a "read and do" format. In this method, the crew members read each item in sequence and perform the required action before proceeding further.

Paragraph 1.1.2 of the manual notes that most accidents and incidents that can be attributable to crew actions result from non-adherence to published procedures and instructions.

## 2.8 Tests and Research

### 2.8.1 Search for Lost Door

Search for the lost door was planned on the basis of the airplane's assumed route and the location where the separation occurred. A preliminary search failed to locate the door.

The SIAF asked Patria to create an analysis of the door's trajectory based on wind aloft data and door characteristics, hoping this would enable a more accurate estimate of the final position of the door.

The analysis indicated that the door had traveled for a few seconds in the direction of the airplane's motion until drag had stopped this movement and the door had started drifting to

[17] Revision 8, addendum 6, para. 1.1.1.

the northwest or west-northwest, carried by prevailing winds. In addition to wind characteristics in different atmospheric layers, the door's drag coefficient had affected sink rate and thereby the distance the door had traveled. The door separated at an altitude of approximately 4,000 ft (approximately 1,200 m). Even though the exact location of the separation could not be determined, it was possible to identify a section of the flight route where it had occurred. This section was approximately 2 km long. Allowing for estimated variables used in the calculations, it was concluded that the door traveled 229 m to 880 m to the west and 99 m to 930 m to the north after separation. However, these calculations contain uncertainties, in particular with regard to estimated wind conditions, and the fact that the time of separation was unknown expanded the search area to a maximum of approximately 2.2 km$^2$. The area is predominantly wooded, interspersed by farm fields and dotted by small bodies of water.

The Police conducted a drone search focusing on the area that was determined to be the most likely site of door impact during modeling. The door was not located.

### 2.8.2 Decision Making in Mentally Demanding Situations

The DA42 flight manual emergency procedures include actions after in-flight passenger door opening. The crew members' decision to attempt door closing was not in accordance with the flight manual and was examined against research and theories related to human decision-making. An immediate attempt to lock a door that had abruptly opened in flight was characteristic of natural intuitive decision-making.

**In an abnormal or emergency situation**, decision-making ability is affected by situation-specific factors such as the suddenness or unexpectedness of the event, lack of past experience or a solution model, a perceived threat, or time pressure. These conditions impose loads on human information processing[18] and were apparent in the investigated incident.

In a mentally demanding situation, a human being's ability to analyze the situation, alternative courses of action and their consequences is limited. From this follows that when he or she encounters an abnormal or emergency situation, intuitive decision making naturally replaces analytic reasoning. Intuitive decision making is fast, automatic, and largely unconscious[19].

**Intuitive decision making** often leads to solutions that are appropriate to the desired end result, but it is prone to errors. So-called biases are inherent features of decision making[20]. Examples of biases include a tendency to resort to solutions of which past experience is available, or the solution can for some other reason be easily retrieved from memory. The latter feature also directs decision making in situations of which no past experience is available. The selected solution may be of a routine nature or familiar from another context. Furthermore, a human being tends to choose a solution that leads to a positive outcome quickly, rather than delays the attainment of the desired end result, which may be an underlying factor in an intuitive attempt to remove the perceived threat without undue delay.

**Control of decision-making tendencies** may be necessary when it is desired to ensure that a specific decision is made and a resulting action is executed, especially in situations where the action is non-routine. Control of decision-making is particularly justified in abnormal and emergency situations because these situations are mentally demanding and therefore hamper analytic reasoning. One way to control intuitive decision making is to rehearse a desired

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18 Wickens, C., Hollands, J., Banbury, S. & Parasuraman, R. (2016). *Engineering Psychology and Human Performance* (neljäs painos). Decision Making, s. 245-283. London/New York: Taylor & Francis.

19 Klein, G. (1998). *Sources of Power. How People Make Decisions*. Cambridge: The MIT Press.

20 Kahneman, D. (2011). *Thinking, Fast and Slow*. US: FSG.

action over and over again because learning and experience build-up embed the correct course of action in the memory and reduce the likelihood of intuitive errors[19]. Without repetition or personal experience, it would be unlikely that the procedure required in an extremely rare situation would be retained in memory. In the investigated incident, actions after the appearance of a "Door open" warning had been discussed with the students only once in conjunction with other training. The students had little experience of the locking mechanism and the door closing procedure, and none of the three crew members had been previously involved in a door open situation.

**The purpose of emergency procedures** is to serve as memory aids and assist decision making in stressful situations. Learning and repetition are needed to embed the contents of a procedure or of a checklist in human memory to such an extent that it can be automatically retrieved. Yet the mere existence of a written procedure and actions included therein does not guarantee that a person is continuously aware of their availability. During flight training, crew members are taught the "read and do" method, in which the required action is read in an emergency checklist before execution. This sequence is usually initiated when the alerting system displays a warning – usually a visual or an aural cue, such as a "Door open" warning, that functions as a previously learned trigger – that leads to the execution of a specific action. The crew members on the incident flight did not notice the "Door open" warning; instead, they saw that the door had opened and reacted intuitively.

**An ability to assess operation related risks** is similarly prone to intuition bias. This appears, for example, as the tendency to underestimate the probability of events of which an individual has no personal experience or knowledge[18]. This tendency may undermine an individual or organization's preparedness to occurrences that are considered rare and unlikely. Although several incidents of in-flight door separation on DA40 and DA42 airplanes had been reported to the airplane manufacturer (paragraph 2.8.4). the incident crew and FINAA were unaware of the frequency of these events and of associated major hazards.

### 2.8.3 Door Locking Mechanism and Door Warning System Tests

A new passenger door was fitted in the airplane after the incident, and updated Garmin G1000 software (1916.03) was installed. However, another FINAA DA42 had the same G1000 software (1916.01) as the incident airplane at the time of the occurrence. Tests and measurements were conducted on both airplanes, which also gave an opportunity to assess the effects of the software version on door warning system operation. Similarly, door locking mechanism operation was examined both in the newly installed incident airplane door and in the door of the hangared airplane.

**Examination of the internal door handle** disclosed that in both airplanes the microswitch indicated a locked condition although the handle was not pressed fully locked. Measurements showed that the handle could be pulled out to approximately 30° angle until an unlocked condition was indicated. Therefore, it is very easy to close the door and leave the door handle not fully locked, without this being sensed by the warning system. Neither does the mechanism snap the handle into the fully locked position, and therefore the handle needs to be pushed into the end position. The locking pins disengaged from the guide plate holes when the handle was pulled out to approximately 50° angle, which allows the door to open to a position where it is held only by the safety catch. When the handle is moved toward open position and the locking pins disengage from the guide plates, the compression gas spring snaps it into the end position, and the door becomes fully unlocked.

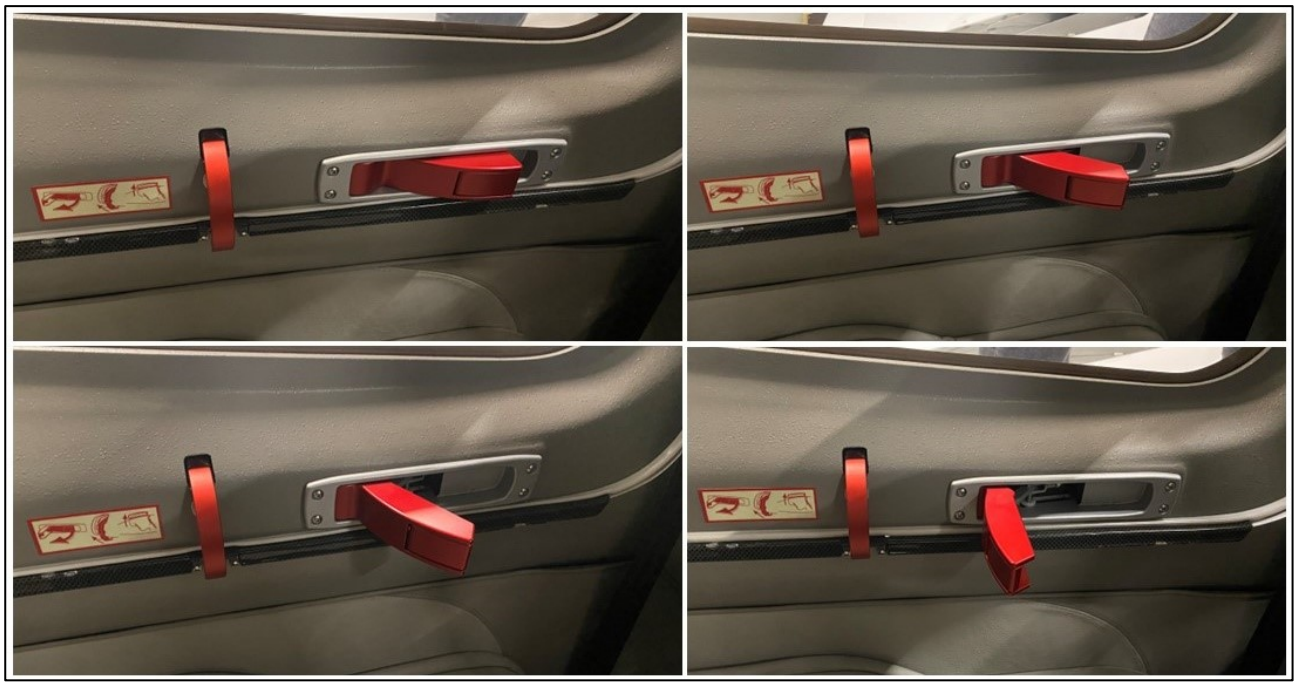

**Figure 10.** The internal door handle in four different positions. Top left: the handle is in the fully locked position. Top right: the handle is at approximately 30° angle; an unlocked condition is indicated. Bottom left: the handle is at approximately 50° angle, locking pins have disengaged from the guide plate holes, and the safety catch holds the door in near closed position. Bottom right: the handle is in the fully unlocked position. (Photos: SIAF)

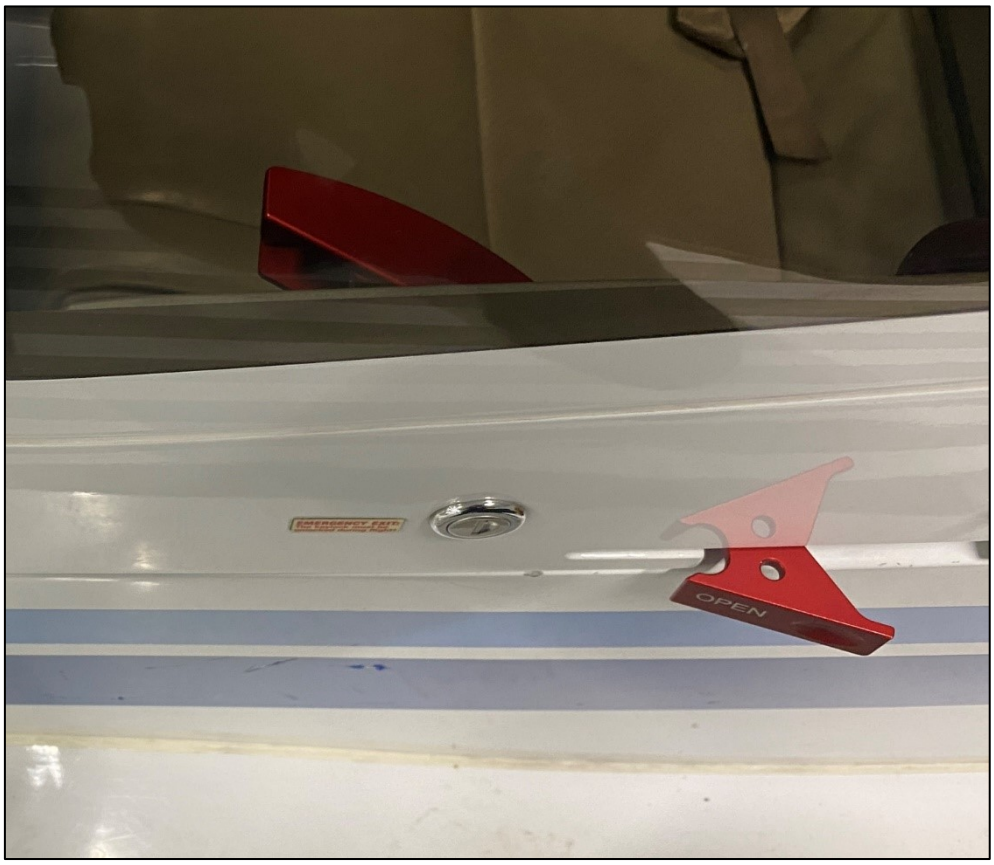


**Figure 11.** The external and internal door handle in the position that triggers the door warning. (Photo: SIAF)

When the door is held by the safety catch and is in near closed position, the locking pins are not aligned with the guide plate holes and the door cannot be locked solely by pushing the handle but should be simultaneously pulled towards closed position for locking.

**The external door handle** is mechanically connected to the internal handle and follows its movements. Examination of the two airplanes disclosed differences between handle positions with the handle in the fully locked position. In one airplane, the handle was visibly recessed in the door frame, while in the other, it was slightly proud of the frame surface. Depending on the airplane, to achieve full locking from the outside, it may be required to apply pressure on the handle until it becomes recessed in the door frame. On the other hand, in some airplanes the handle will not necessarily be in the fully locked position although it is flush with the frame.


**Figure 12.** The fully locked position of the external handle appeared different in the two airplanes. Left (OH-DAN with a new door): the handle is recessed by approximately 8 mm. Right (OH-DAM): the handle is slightly proud of the door frame. (Photos: SIAF)

The door handles on both airplanes operated as described in the maintenance manual. DAI has required that the door locking mechanism and compression gas spring should be checked for correct operation during every scheduled 200 flight hours maintenance action or during every annual inspection. When the handle of an open passenger door is moved toward locked position, the compression gas spring should snap it into the fully locked position at least 10 mm before the end position. Measurements indicated that this happened 26 mm before the end position. The point where the spring begins to pull the handle toward locked position is closer to the fully locked position than the point where the door warning activates; in other words, when the warning is triggered, no pull towards the locked position is exerted on the handle.

**14. Test the Passenger Door Handle Compression Gas Spring (if MÄM 42-097 is installed)**

| | Detail Steps/Work Items | Key Items/References |
|---|---|---|
| (1) | Open the passenger door. | |
| (2) | Move the door handle into open position.<br>Slowly move the door handle to closed position and check, if the door handle snaps into closed position by itself at least 10 mm (measured at the outermost point of the lever) before reaching the end position. | |
| (3) | If the distance is less then 10 mm, replace the compression gas spring. | Refer to Paragraph 13. |

**Figure 13.** Passenger door gas spring test procedure (Source: Diamond Aircraft Industries)

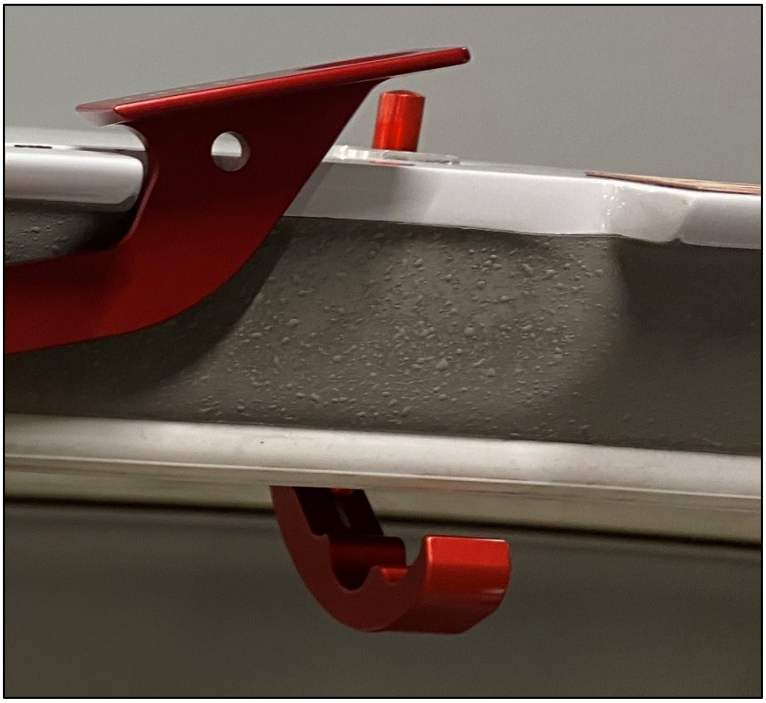

**Figure 14.** The external door handle in the position where the compression gas spring snaps the handle into the fully locked position. (Photo: SIAF)

**The door warning system** was tested with two Garmin G1000 software versions installed. The passenger door was opened and closed and locked in different phases of G1000 run-up. It was also opened in a simulated in-flight condition with the airplane systems ready for flight.

The tests revealed that with the software (1916.01) installed in the incident airplane at the time of the occurrence, a condition where door opening did not trigger the aural warning could be replicated. In this condition, the electric master switch was set to ON and G1000 run-up was in progress. The baggage doors, the canopy and the passenger door had been closed and locked. The passenger door was opened and locked after the PFD notification window

appeared but before G1000 run-up was complete. When the systems were ready for flight, the door was opened, which caused a red “Door open” warning in the notification window, but the aural warning did not sound and the blinking “Warning” text did not appear in the bottom right corner of the PFD. When the door was then locked and opened a second time, all alerts operated normally. The test sequence was repeated in the other airplane, that was fitted with updated software (1916.03). In this case, the warning system operated normally regardless the phase of G1000 run-up, and both aural and visual warnings were received.

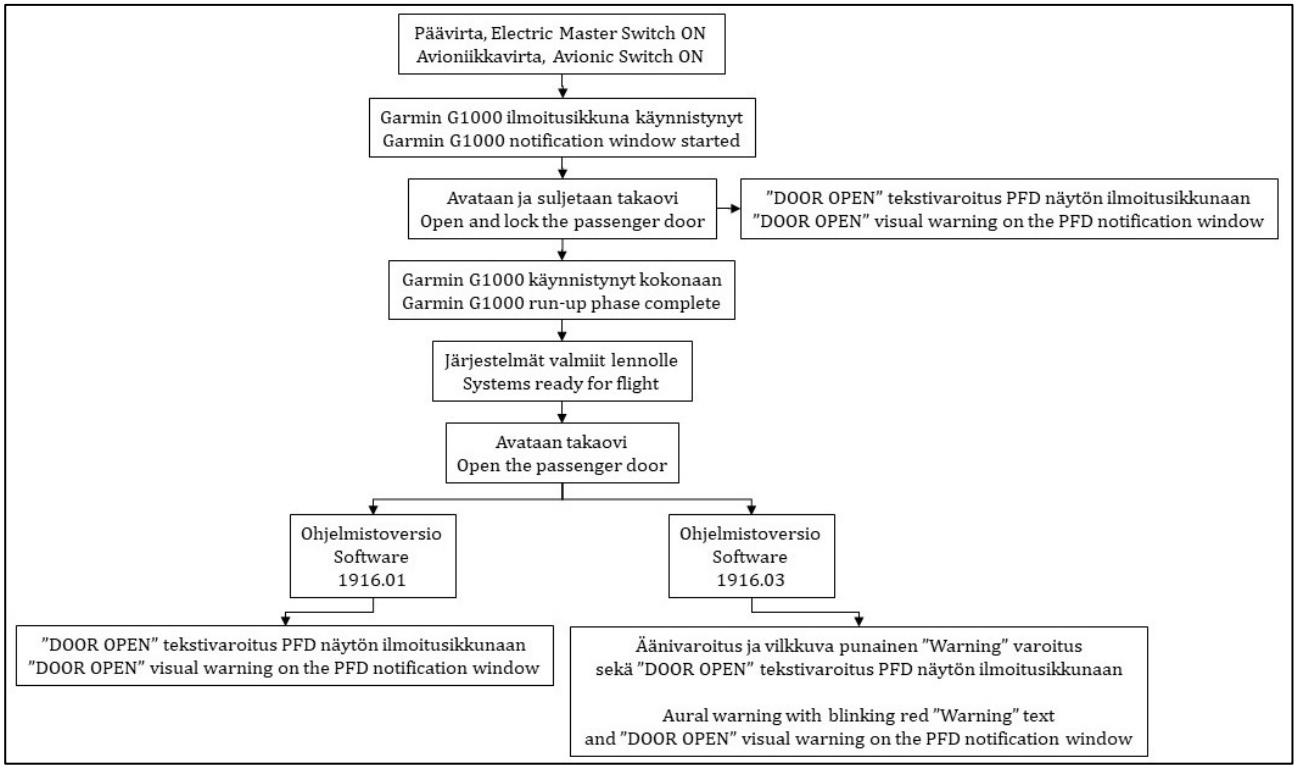


**Figure 15.** The door warning system test sequence and findings. The older software (1916.01) did not trigger the aural warning on door opening. (Diagram: SIAF)

### 2.8.4 Similar Occurrences

A significant number of in-flight passenger door unlocked or separation incidents on the DA42 and the single-engine DA40 have been reported over the past ten years. In 2010, DAI issued a service bulletin introducing an improved retaining bracket that would keep an unlocked door closed also in flight. Between 2004 and 2010, DAI received over 30 reports of in-flight door losses, most of which on DA40s. DAI revised the door unlocked procedure in the flight manual, emphasizing that no attempts must be made to lock the door in flight. Since then, there has been a relatively constant number of door separation events per year. With a total of approximately 80 reports received by DAI until July 2021. Between 2001–2023 there has been total of 94 cases of passenger door separations.

Table 2 shows DA42 passenger door occurrences entered in the ECCAIRS database of the European Commission.

**Table 2.** DA42 passenger door opening incidents reported to the European aviation safety authorities. The table lists occurrences that have involved inadvertent door opening.

| Date | Location | Airplane | Findings | Nature of incident |
|---|---|---|---|---|
| June 24, 2008 | Switzerland | DA42 | • Door warning on ground without aural warning, doors closed check.<br>• Door opened and separated after takeoff. | Opening and separation of door in flight. |
| April 30, 2010 | Switzerland | DA42 | • Door warning in flight, unlocked passenger door noted.<br>• Closure attempt using door handle caused door separation. | Opening and separation of door in flight. |
| May 18, 2011 | Austria | DA42 | • Door warning in early phase of flight.<br>• Closure attempt. | Opening and separation of door on instructional flight. |
| October 12, 2012 | United Arab Emirates | DA42 | • Door separation immediately after takeoff. | Opening and separation of door on instructional flight. |
| July 22, 2014 | Spain | DA42 | • Opening and separation of door during climb. | Opening and separation of door in flight. |
| August 5, 2014 | Turkey | DA42 | • Door warning with aural warning during climb.<br>• Sudden separation of door during visual baggage doors check. | Opening and separation of door in flight. |
| September 12, 2018 | France | DA42 | • Opening and separation of door during takeoff. | Opening and separation of door in flight. |
| August 20, 2020 | Finland | DA42 | • Instructor on another departing airplane noted open door and notified flight over radio. Door was closed. | Opening of door during taxi. |
| September 14, 2020 | Finland | DA42 | • Door warning during climb.<br>• Door was open at rear edge.<br>• Aft locking mechanism had failed. | Opening of door in flight. |
| June 20, 2021 | Spain | DA42 | • Door warning in early phase of flight.<br>• Opening and separation of door during doors check. | Opening and separation of door in flight. |
| October 3, 2021 | Canary Islands | DA42 | • Opening and separation of door during landing rollout.<br>• Passenger apparently unlocked door during landing rollout. | Opening and separation of door during landing rollout. |
| November 2, 2021 | Cape Verde | DA42 | • Unlocked door noted during climb.<br>• Immediate return; door separated during landing. | Opening of door in flight and separation during landing. |
| August 19, 2022 | Finland | DA42 | • Unlocked door noted in early phase of flight.<br>• Closure attempt caused door opening and separation. | Opening and separation of door on instructional flight. |

At least the following investigation reports are available on the internet:

- Netherlands 2011[21], DA40
- United Arab Emirates 2012[22], DA42
- Australia 2018[23], DA42
- Pakistan 2018[24], DA42
- Singapore 2019[25], DA42
- Tenerife 2021[26], DA42

Other similar occurrences reported on the media:

- India 2017[27], DA42

While most reports concluded that failure to ensure proper door locking[28] was a factor in the investigated incident, one investigation cited excessive free play on the forward hinge, possibly in combination with the inadequate operation of the safety catch. Incidents often happened after an airplane occupant had attempted to lock the door during flight, which is not permitted in the flight manual.

Safety recommendations suggested that the operator revise checklists, and attention was also called to checklist usage. Further to the foregoing, it was advised that personnel be reminded of the proper courses of action and that the matter be brought up during recurrent training. One recommendation proposed a change to the conditions under which an aural door warning is triggered.

Previous investigations and occurrence descriptions suggest that in several cases the door opened either immediately after takeoff or in an early phase of the flight. No mechanical defects were found, and tests showed that a properly locked door cannot open inadvertently.

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21 19.10.2022 https://www.onderzoeksraad.nl/en/media/attachment/2018/7/10/2011051_ph_tin_eng.pdf

22 19.10.2022 https://www.gcaa.gov.ae/en/departments/airaccidentinvestigation/Lists/Incidents%20Investigation%20Reports/Attachments/55/20123%20AIFN00182012%20FINAL%20REPORT%20PUBLISHED.pdf

23 19.10.2022 https://www.atsb.gov.au/publications/occurrence-briefs/2018/aviation/ab-2018-007/

24 19.10.2022 https://caapakistan.com.pk/Upload/SIBReports/SIB-414.pdf

25 19.10.2022 https://www.mot.gov.sg/docs/default-source/default-document-library/cas-186-da42-n181cw-door-detached-to-seletar-15-oct-19_2020-10-08-(final).pdf

26 19.10.2022 https://www.mitma.es/recursos_mfom/comodin/recursos/a-045-2021_informe_final_nm.pdf

27 19.10.2022 https://www.deccanchronicle.com/nation/current-affairs/311017/aircraft-door-falls-off-midair-plane-belonged-to-telangana-aviation-school.html

28 Visual verification of full locking from the cabin can be difficult because the internal handle will be proud of the door frame due to its curved shape, even in the end position.

# 3 ANALYSIS

A SIAF-developed format of the AcciMap approach[29] was used to support the analysis of the occurrence. The following text is arranged in accordance with an AcciMap diagram created during the investigation and shown below. The occurrence is depicted as a chain of events along the bottom of the diagram. Contributing factors at various levels can be examined by moving up and down the diagram.

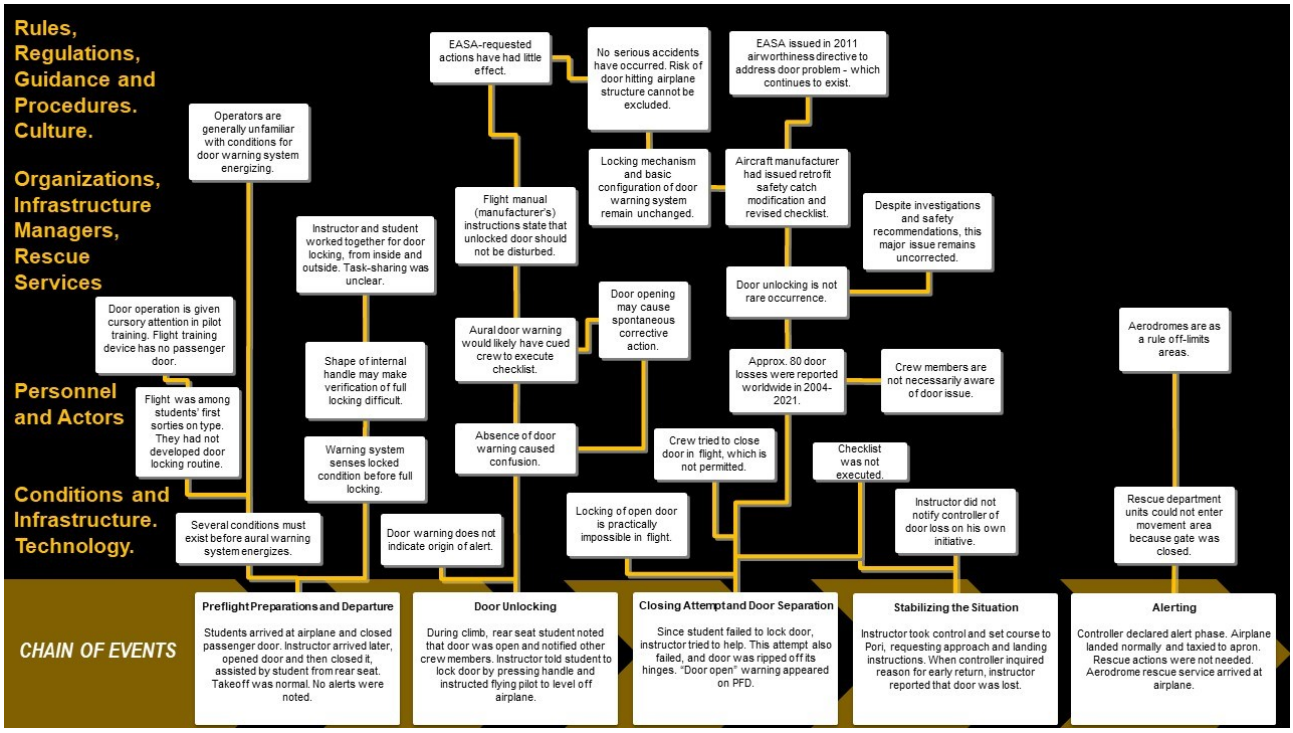


**Figure 16.** AcciMap diagram (Diagram: SIAF)

## 3.1 Investigation in General

### 3.1.1 Preflight Preparations and Departure

The students arrived at the airplane before the instructor. By the time of the instructor's arrival, they had taken their seats and closed the passenger door, which was subsequently opened to allow the instructor to place his kit on a rear seat. The instructor operated the external handle and the student in the rear seat assisted opening and locking with the internal handle. Although the handles move together and operate the same mechanism, in this kind of a scenario the individuals involved may experience a different sensation of door locking and of the handle reaching the fully locked position, and the door may be left in a partially locked condition unless they both ensure that the handle reaches the end position. The instructor and the student had not agreed on task-sharing during closing and locking.

Visual verification of full locking from the cabin is not easy to detect, because the internal handle will be proud of the door frame due to its curved shape, even in the end position. The fully locked position of the external handle was not identical in the two examined airplanes. To achieve the fully locked position, it may be necessary to apply pressure on the external

[29] Rasmussen, J. & Svedung, I. (2000) *Proactive Risk Management in a Dynamic Society*. Karlstad, Sweden. Swedish Rescue Services Agency.

handle until it is recessed in the door frame; from this follows that the flush position will not necessarily indicate a fully locked condition. Both handles should always be pushed into the end position because the compression gas spring alone cannot snap the handle into the fully locked position. The stiffness of the locking mechanism varies between airplanes and depending on the history of door operation.

Because the students had logged only a few flights on the DA42 they had not developed a routine in door closing. Door operation is discussed during training, but since it is considered a routine operation, it is not given much attention. Moreover, the DA42 flight training devices do not have a passenger door, so door operation and the verification of a locked condition are mainly left to be done on instructional flights.

Departure was normal, and no alerts were received. A door open alert consists of three indications: a red "Door open" warning in the PFD notification window, an aural warning and a blinking "Warning" text on red background in the bottom right corner of the display. Several conditions must be met before the door warning system is energized. The avionics must be powered-up and the G1000 run-up must be complete. The visual warning will appear any time the door is open after G1000 run-up has reached the phase where the notification window appears on the PFD.

Inconsistencies were noted in the operation of the aural warning. The system description states that the canopy, the baggage doors and the passenger door must have been locked together after the completion of G1000 run-up, otherwise the warning system will not be energized. The tests conducted on the airplane fitted with the older software disclosed that the system does not necessarily energize.

Two cases where the warning did not sound were observed during tests with the software installed in the incident airplane. One of these matched the system description in that the passenger door remained unlocked and the "Door open" warning appeared on the PFD. In the other case, the door was opened and then locked after the notification window had appeared but before G1000 run-up was complete. In this case, the aural warning did not sound on the next opening of the door. When test was repeated with the new software installed, the warning sounded. It is possible that a similar situation occurred on the incident flight. The crew members noted the "Door open" warning only after door separation, but the aural warning did not sound. Operators are generally unfamiliar with the conditions required for door warning system energizing.

The warning system senses a locked condition even before the door handle reaches the end position and the locking mechanism is fully engaged. In both examined airplanes the internal handle could be moved to approximately 30° angle before the system sensed an unlocked condition, and further movement to approximately 50° angle was needed to open the door fully. In the fully open position the handle is at 90° angle relative to the door surface. If the handle is pushed to a partially locked position the system may not activate.

### 3.1.2 Door Unlocking

During climb, the observing student occupying a rear seat noted that the door had unlocked and notified the other crew members. Because no door open warning was received, the situation caused confusion. Door unlocking should be accompanied by distinct, unambiguous visual and aural warnings.

The flight manual contains checklists that should be actioned whenever a warning or a caution is received. Should the crew members have heard an aural warning and noted a "Door open" warning on the PFD, they would likely have executed the applicable checklist and

carried out proper actions. The checklist states that an unlocked door should not be disturbed. A door open warning does not indicate the origin of the alert; i.e., whether it is triggered by a baggage door, the canopy or the passenger door.

Dozens of passenger door separations on the DA42 and DA40 airplanes have been reported over the years. EASA addressed the issue and requested action to rectify the problem, but the resulting corrective actions have had little effect, and notwithstanding EASA's effort, reports of door openings and separations continue to be received.

### 3.1.3 Closing Attempt and Door Separation

Because the student did not succeed in locking the door the instructor tried to lend him a hand. This attempt also failed, and the door opened and was ripped off its hinges. Only after this did the crew members note a "Door open" warning on the PFD.

It is practically impossible to lock an open passenger door in flight because the internal handle needs to be pushed in the direction that only tends to open the door further, and the locking pins cannot align with the guide plate holes. The safety catch is the only other handhold that could be used to pull the door toward closed position while operating the handle, but application of force will open the catch, and as a result the door swings open and separates from the airframe.

Trying to close the door in flight is not in accordance with emergency checklist procedures. The crew members had not been in a similar situation before, and because of the unexpectedness of the event the instructor made an intuitive decision and acted promptly in an attempt to deal with the hazardous situation immediately. The crew members forgot to refer to the checklist in a mentally demanding situation, and since there was no aural warning, they were not cued to do so. They had no previous experience of similar occurrences. Neither were they aware of reported door issues and therefore of the nature and seriousness of safety hazards caused by incomplete door locking.

A large number of door losses were reported worldwide between 2004 and 2021. The number of these reports may suggest that unlocking incidents have been even more common, so much so that passenger door unlocking cannot be considered a rare occurrence, and it appears that airplane operators are generally unaware of the risk of in-flight door opening.

Although investigation authorities have probed many of the door losses and issued safety recommendations, the issue remains unsolved. The airplane manufacturer has issued a retrofit modification to the retaining bracket to prevent door moving to the fully open position in flight, but the modification has not removed the unlocking problem. The manufacturer has also revised the emergency checklist. The foregoing corrective actions were primarily intended to address a situation where the door has already become unlocked, and no improvements to the reliability of the locking mechanism have been made.

Recurring door problems prompted EASA to issue in 2010 an airworthiness directive, but the issue continues to exist. Neither has their impact been adequately monitored, which has in turn precluded an assessment of the need for further actions.

However, no serious accidents have occurred, although in some incidents the door struck the airframe causing damage, which shows that a risk of a door hitting the empennage and essential flight control surfaces cannot be excluded. A separated airplane part can also cause injuries to persons and damage to property on the ground.

### 3.1.4 Stabilizing the Situation

The instructor took control and set course to the departure aerodrome, requesting approach and landing instructions. When the air traffic controller asked whether the early request to return was due to a problem, the instructor explained that the airplane had lost a door. He did not notify the controller of the door loss on his own initiative.

Information of any event that may affect a flight is important for controllers because, in addition to providing air traffic services, the tasks of a control facility include alerting the rescue services and initiating an aeronautical search and rescue operation if necessary. In this capacity, it has a central role in the expeditious raising of the preparedness of rescue services to an appropriate level, and to this end, controllers' actions and situational awareness have a major significance. In this particular case, knowledge of the nature of the incident, that is, a door loss, could have been helpful had the door caused damage on the ground.

The crew members did not refer to the checklist after door separation. In addition to speed reduction, the unlocked door procedure states that if the door has been lost the airplane can be safely flown to the next suitable airfield.

## 3.2 Analysis of Survival Aspects

### 3.2.1 Alerting

The air traffic controller declared an alert phase in accordance with the prescribed procedure. The airplane landed normally and taxied to the apron. Aerodrome rescue service arrived and examined the airplane. There was no need for rescue actions or medical assistance.

Units of Satakunta Rescue Department arrived at the gate of the aerodrome maintenance facility but could not proceed further because the gate was closed.

Contrary to their expectations, the department crews could not open the gate because its control system was not activated. Instructions for gate operation have since been amended.

# 4 CONCLUSIONS

Conclusions encompass the causes of an accident or a serious incident. Cause means the different factors leading to an occurrence as well as relevant direct and indirect circumstances.

1. The flight was among the students' first sorties on the DA42. The passenger door was opened, closed and locked reportedly simultaneously from the cabin and outside the airplane.

   ***Conclusion:*** *The students had not developed a routine in door closing and locking. Task-sharing during door operation was unclear.*

2. In-flight door opening was a rare and surprising event.

   ***Conclusion:*** *The crew members made an intuitive decision and acted promptly.*

3. The fact that the unlocking of the door was noted but no warning was registered contributed to the failure to skip the checklist and react intuitively.

   ***Conclusion:*** *System warnings cue crew members to checklist execution and thereby to a predetermined course of action.*

4. It is easy to leave the door partially locked. This is difficult to observe due to differences between individual airplanes, the shape of the internal door handle and warning system tolerances.

   ***Conclusion:*** *Full locking cannot be verified positively by visual inspection or by relying on the warning system.*

5. Although a large number of similar occurrences on the DA42 have been reported worldwide, aircraft operators and crew members were not aware of the door locking issues.

   ***Conclusion:*** *Operators and crew members do not receive timely information of common problems that are found in the aircraft types they operate.*

6. Door losses are a recurring issue.

   ***Conclusion:*** *Modifications and checklist revisions have not solved the issue.*

7. Prompted by recurring door losses, EASA issued in 2011 an airworthiness directive, but the resulting corrective actions have had little effect on the prevention of similar occurrences.

   ***Conclusion:*** *The monitoring of the effectiveness of approved corrective actions in safety-critical matters is inadequate.*

8. Rescue department units could not enter the movement area.

   ***Conclusion:*** *It is essential that responding rescue units can enter the area without delay.*

# 5 SAFETY RECOMMENDATIONS

## 5.1 Monitoring of Effectiveness of EASA Airworthiness Directives

After recognizing the passenger door loss problem on DA40 and DA42 airplanes, EASA issued in 2011 an airworthiness directive requiring corrective actions. As the type certificate holder, Diamond Aircraft Industries established corrective actions that were approved by EASA, and the airworthiness directive was officially published. Despite the mandated modifications, door losses continue to occur, but no further actions to rectify the problem have been proposed.

The Safety Investigation Authority Finland recommends that

*The European Union Aviation Safety Agency monitors and ensures that the actions prescribed in its airworthiness directives has the adequate and desired effect. [2023-S22]*

The monitoring of the effectiveness is an important element of a safety process.

## 5.2 Door Locking Mechanism and Door Warning System

A large number of door unlocking events and in-flight door losses have been experienced worldwide. The shape, structure, usability and feel of the internal door handle combined with warning system tolerances lead to situations where the operator cannot easily verify the full locking of the door. Furthermore, the fully locked position of the external handle varies between individual airplanes, which does not permit reliable visual checking.

The Safety Investigation Authority Finland recommends that

*Diamond Aircraft Industries modifies the door locking mechanism to allow operators to achieve and verify the fully locked condition without undue difficulty. The warning system should also alert the crew members if the door is not fully locked. [2023-S23]*

The 2011 airworthiness directive also states that the warning system should provide a warning if the door handle is not fully locked. Verification of correct locking should be a simple and easy procedure because the door is also operated by passengers.

## 5.3 Operator Awareness of Safety Matters

Operators are not necessarily aware of matters that affect the safety of aircraft even though they may be known to the type certificate holder or the competent authority.

Dissemination of information from type certification holders to operator level would cue the latter to recognize any potential risks.

The Safety Investigation Authority Finland recommends that

*The European Aviation Safety Agency ensures that type certificate holders regularly notify operators of any recurrent or serious safety findings related to applicable aircraft types. [2023-S24]*

## 5.4 Verification of Fully Locked Condition

Unlike in other same category airplanes, locking of the DA40 and DA42 passenger door should be verified with a particular care. The possibility of inadvertent door opening is mentioned in checklists, and the flight manual emergency checklist warns that an attempt to close an open door will usually result in the separation of the door from the airframe.

The Safety Investigation Authority Finland recommends that

> *as the type certificate holder, Diamond Aircraft Industries ensures that the warning labels, flight manual text and procedures of the DA40 and DA42 contain sufficient information that enables the operator to carry out proper actions and take particular care when opening and closing the passenger door. [2023-S25]*

Because written instructions seldom produce a result that is comprehensive enough and would stand the test of time, other actions will often be needed.

## 5.5 Safety Actions Taken

Immediately after the incident, Pori aerodrome amended the instructions for the operation of the maintenance facility gate so that Satakunta Rescue Department personnel can open the gate any time without assistance.

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## Investigation Material

1) Photographs, diagrams, and other material produced during on-site investigations
2) Interviews
3) Weather report EFPO19082022, Finnish Meteorological Institute
4) Radio communications recorded at time of incident between OH-DAN and Pori ATC
5) ATC radar data recorded at time of incident
6) ATC alert form on incident flight
7) ATS manual appendix 2 – Alerting manual, Fintraffic, January 26, 2022
8) Flight safety reports on incident, Traficom
9) Emergency response center alert log and related report
10) Southwestern Finland Police Department investigation notice and on-site investigation photographs
11) License, medical certificate and logbook data of crew members and air traffic controllers
12) Finnish Aviation Academy:
    i. OM-A, OM-B, OM-D and DA AFM
    ii. FINAA Management Manual (OMM)
    iii. Training Manual (TRM)
    iv. Quick Reference Handbook (QRH) Emergency & Abnormal Checklist
    v. Internal safety investigation report DA42 OH-DAN – August 19, 2022. In-flight door loss 1/2022
13) OH-DAN, Finnish Aviation Academy
    i. Door maintenance checklists
    ii. Failure history and corrective actions
    iii. Airworthiness review certificate
14) Passenger door dimensions, weight, construction and related drawings, Diamond Aircraft Industries
15) Estimated ground location of door lost from Diamond DA42 (OH-DAN), Patria Aviation, October 3, 2022
16) DA40 and DA42 passenger door occurrences entered in the ECCAIRS database of the European Commission
17) EASA AD No: 2010-0235R1, May 23, 2011
18) FAA AD No: 13/10/2011
19) FAA AD No: 2010-25-01
20) In-flight Passenger Door Separation – DA42 Series Airplanes, Diamond Aircraft Industries
21) AMM DA42 NG – 52-10-00 – maintenance practice – paragraph 14 – gas spring test procedure, Diamond Aircraft Industries
22) MSB 42NG-003_32 Software for Garmin G1000-G1000NXi, Diamond Aircraft Industries

## SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The draft final report was submitted for comments to the Finnish Transport and Communications Agency Traficom, the European Union Aviation Safety Agency, Fintraffic Air Navigation Services Ltd., Finavia, Satakunta Rescue Department, Finnish Aviation Academy, Diamond Aircraft Industries and the interested parties. Pursuant to the Safety Investigation Act, no comments given by private individuals are published.

**Traficom** had no comments on the draft report.

**Finavia** had no comments on the draft report.

**Finnish Aviation Academy** had no comments on the draft report.

**Diamond Aircraft Industries** wished to specify terms related to passenger door locking, locking mechanism and door warning system, and recommended textual changes to the report.

Diamond emphasized that pilots should ensure proper door locking and explained that unlocked door procedures can be rehearsed in a flight training device by activating the door warning even though the device is not fitted with a passenger door.

According to Diamond, there is no technical evidence to indicate that a partially locked door would not remain closed in flight. Neither are there confirmed reports of inadvertent in-flight door unlocking events.

The minor differences found between external handle positions have no significant effect on locking pin position, and the door is fully locked regardless. Furthermore, when the pins leave the fully engaged position, the pilots can clearly identify a “not closed” condition from the internal handle position.

Diamond maintains that since there is no difference in the logic of the aural door warning system between the two Garmin software versions the only explanation why there was no aural warning is that G1000 run-up was not fully completed.

Diamond also states that although JAR-23 requires only a visual door warning, an aural warning is offered as an additional function to make it easier for the crew to be aware of a changed alert status.

Diamond's view is that the door modifications and improvements have had an impact, and the rate of door separations has shown a sharp reduction since 2010–2011. Diamond also points out that considering the increasing fleet size, the relative number of door separation events has decreased over the past 12 years.

Diamond disagrees with safety recommendation 5.2 on the door locking mechanism and door warning system. Diamond explains that pilots are expected to close the door handle until a defined positive stop is felt. Due to the differential leverage of the locking mechanism, the handles in a nearly closed position do not move the locking pins from the fully engaged position. For this reason, handles at positions that are not yet sensed by the microswitch but where the pins start to be moved from the fully engaged position can be clearly identified by the crew as not fully closed. Beyond this handle position the crew receives a door open alert. Diamond concludes that there is no technical evidence of a confirmed report, nor has such an event been observed, that a not fully closed handle was the root cause of a passenger door separation.