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SAFETY BOARD

Fatal accident Dyn'Aéro MCR01

5 June 2022

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The Hague, 8 November 2023

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The Dutch Safety Board

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N.B: This report is published in the English language, with a separate summary in the Dutch language. If there is a difference in interpretation between the Dutch and English version, the English text will prevail.

INHOUD

SUMMARY

A Dyn'Aéro MCR01 BAMBI Micro Light Aircraft (MLA) with registration EC-ZAF, crashed in the Beer Canal/Caland Canal on 5 June 2022. Both the pilot and passenger were fatally injured. The aircraft was destroyed and only few aircraft parts were recovered.

According to the filed flight plan, the pilot planned to fly the aircraft from Norway to France. During the second leg, the aircraft crossed Dutch airspace. Before the aircraft left the Eelde Terminal Manoeuvring Area (TMA), the Eelde tower controller advised the pilot to contact Dutch MIL Info on frequency 132.350 MHz. The pilot read the frequency back as 135.350 MHz, which was not corrected by the tower controller. This was the last radio communication received from the pilot. The pilot did not establish contact with Dutch MIL Info, or any other Dutch air traffic service provider later on. For the remainder of the flight, the aircraft was visible to the different air traffic service providers on the radar, but with unknown identity and therefore no flight plan displayed, as the aircraft did not carry a Mode S transponder. The radar track of the aircraft was lost near Rotterdam at 17.58 hours. Approximately 35 minutes later, parts of aircraft wreckage were found floating on the water of the Beer Canal and Caland Canal.

The cause of the accident could not be determined. Based on available radar data, the accident occurred at approximately 17.58:30 hours. Radar data confirm that altitude variations occurred during the last part of the flight before the aircraft descended from 800 feet above mean sea level (AMSL) and impacted the water.

An extensive analysis of the available weather information was performed to determine the actual weather conditions at the time of the accident. Along the route in Dutch airspace, weather conditions were initially quite good. In general, there was a visibility of more than 10 km, a light eastern wind and a cloud base between 3,000 and 5,000 feet. When the aircraft flew along the Dutch coastline in southern direction, the weather conditions were deteriorating: the cloud base was descending to 2,000 to 3,000 feet with a visibility of 3,000 to 5,000 metres. It seems plausible that the descent of the aircraft along the route to Hoek van Holland was necessary in order to remain in Visual Meteorological Conditions (VMC). During the last trajectory flight visibility may have been further reduced with few/scattered clouds between 1,000 and 1,500 feet and a visibility of 1,500 to 2,000 metres in light, possibly moderate, rain. It cannot be established with certainty whether there was a discernible horizon, due to the possibility of reduced visibility as a result of light up to moderate rain in the vicinity of the accident site. With a cloud base between 1,000 and 1,500 feet, it is considered unlikely that the pilot lost visual contact with the surface during the last part of the flight.

Due to the limited wreckage parts recovered, a possible technical cause or contributing factor of a technical nature cannot be fully excluded. Examination of the available wreckage parts did not indicate pre-existing defects or anomalies.

In addition to the cause of the accident, the Dutch Safety Board decided to focus part of the safety investigation on the cooperation and communication between Air Traffic Control the Netherlands (LVNL) and the Dutch Coastguard Centre (as Joint Rescue Coordination Centre (JRCC)). The disappearance of a radar target of a VFR (Visual Flight Rules) flight is not a direct indication of an emergency or crash of the aircraft. Despite the unknown identity and unknown destination, LVNL did take action following the loss of radar track. The Last Known Position (LKP) tool[1], developed by LVNL after the Cessna accident at the Maasvlakte in 2012, was used to extract data for the accident aircraft. This data was shared with the JRCC. Analysis of the actions following the loss of radar track of EC-ZAF showed that there are still areas for improvement regarding the notification and provision of information between the two organisations.

First, at the time of the accident, there was no clear shared framework on when and for which situations to contact the JRCC. Early notification and contact between LVNL and JRCC about suspicious situations contributes to more efficient and effective search and rescue operations. This was already identified by the Dutch Safety Board during the investigation of a Cessna accident at the Maasvlakte in 2012.[2]

Second, direct contact and communication between LVNL and JRCC is essential in order to be able to provide relevant information for the search and rescue operations, even in cases where the situation is still unclear.

Third, timely retrieval and provision of Last Known Position (LKP) Tool output information by LVNL is important for the search and rescue operation. Also, the JRCC staff did not clearly understand the interpretation of the radar responses listed, although the radar data sent by e-mail was accompanied by a written explanation.

Following the accident, LVNL has updated its Quick Reference Handbooks for air traffic controllers, adding to inform JRCC of situations where due to circumstances or flight path the controller assumes that the general aviation aircraft is in serious difficulty, even though the pilot did not (yet) report an emergency.

Although the cause of the accident remains undetermined, the investigation highlighted lessons that the Dutch Safety Board considers useful to share with the General Aviation community.

1. In general, it is good practice to include a risk assessment for adverse weather along the route, in your pre-flight preparation. Plan your flight according to weather limits, taking into account the lowest cloud base, minimum visibility and maximum winds aloft. Besides regulatory limits, it is important to take your personal (stricter) limits into consideration as well. During the flight, the encountered weather conditions might be different than expected and adjusting your initial plan might be necessary. Examples of adjusting your plans such as flying a different route, diverting to an en

1 Tool used by LVNL to find and retrieve relevant information of an aircraft radar track (aircraft 3D position, ground speed and ground track).
2 Dutch Safety Board, *Aircraft missing, Cessna accident at Maasvlakte* 2, May 2013.

route aerodrome, or even cancelling or delaying the flight, are options that should be considered.

2. For the effective provision of alerting service to VFR flights, VFR pilots are responsible for making themselves known to the local air traffic service provider, either by means of a filed flight plan, transmission of aircraft identity and/or established radio contact.
3. If communication with air traffic services on the next frequency cannot be established, do not hesitate to do a frequency check at the previous air traffic service provider. Other options to verify the correct frequency are to check the frequencies depicted on navigation charts, information provided in navigation applications on tablet/mobile devices and to refer to notes made during flight preparation.

ABBREVIATIONS

ACC	Area Control Centre
AESA	Agencia Estatal de Seguridad Aérea (Spanish National Aviation Authority)
AIP	Aeronautical Information Publication
AMSL	Above mean sea level
ARO	Air Traffic Services Reporting Office
ATC	Air Traffic Control
DGAC	Direction générale de l'Aviation civile (French National Aviation Authority)
EASA	European Union Aviation Safety Agency
ELT	Emergency Locator Transmitter
FIC	Flight Information Centre
FIR	Flight Information Region
FISO	Flight Information Service Officer
FMPC	Flow Management Position Controller
IFR	Instrument Flight Rules
JRCC	Joint Rescue Coordination Centre
KNMI	Royal Netherlands Meteorological Institute
LVNL	Air Traffic Control the Netherlands
LT	Local time
METAR	Meteorological Aerodrome Report
MLA	Micro Light Aircraft
PFD	Primary Flight Display
PPL(A)	Private Pilot Licence – Aeroplane
RPA	Rotterdam Port Authority
SEP	Single Engine Piston

TAF	Terminal Area Forecast
TMA	Terminal Manoeuvring Area
TMZ	Transponder Mandatory Zone
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

GENERAL OVERVIEW

Identification number:	2022061
Classification:	Accident
Date, time of occurrence:	5 June 2022, 17.58 hours[3]
Location of occurrence:	Beer Canal/ Caland Canal, the Netherlands
Operator:	Private owner
Registration:	EC-ZAF
Aircraft type:	Dyn'Aéro MCR01 BAMBI
Aircraft category:	Micro Light Aircraft (homebuilt), single engine
Type of flight:	General Aviation – Pleasure
Phase of operation:	En route
Damage to aircraft:	Destroyed
Flight crew:	One
Passengers:	One
Injuries:	Fatal (two)
Light conditions:	Daylight

3 All times in this report are local times (UTC + 2 hours), unless otherwise specified.

1 INTRODUCTION

A Dyn'Aéro MCR01 BAMBI Micro Light Aircraft (MLA) with registration EC-ZAF, crashed in the Beer Canal (near Caland Canal) on 5 June 2022. Both the pilot and passenger were fatally injured. The aircraft was destroyed and only few aircraft parts were recovered.

According to the filed flight plan, the pilot planned to fly the aircraft from Norway to France with a stopover at Husum-Schwesing airport in Germany. During the second leg to Buno Bonnevaux airport in France, the aircraft crossed Dutch airspace. The radar track of the aircraft was lost near Rotterdam at 17.58 hours. Approximately 35 minutes later, parts of aircraft wreckage were found floating on the water of the Beer Canal and Caland Canal.

The Dutch Safety Board, on behalf of the State of Occurrence, conducted the safety investigation into this accident. The investigation focussed on two aspects:

1. The cause of the accident;
2. The process of alerting and the information exchange between Air Traffic Control the Netherlands (LVNL) and the Dutch Coastguard Centre (as Joint Rescue Coordination Centre (JRCC)[4]) after the radar track was lost.

In all likelihood, the swiftness/speed of the alerting and initial search phase did not affect the chances of survival for the pilot and passenger. However, it is of common interest that a missing aircraft is noticed and localised within a reasonable time. As a search operation into a missing aircraft does not occur very frequently, the Dutch Safety Board decided to focus part of the safety investigation on the cooperation and communication between LVNL and JRCC. Relevant in this case is an investigation by the Dutch Safety Board on an accident with an Cessna 172M in 2012.[5] This investigation found among others that the LVNL and JRCC did not collaborate effectively.[6]

The investigation aimed at answering the following questions:

1. What was the cause (were the causes) of the accident with EC-ZAF?

2. What lessons can be learned with respect to the provision of alerting service and the coordination between LVNL and JRCC?

3. What lessons can be learned for VFR pilots in general?

4 In the Netherlands, the Dutch Coastguard Centre combines both maritime and aeronautical search and rescue services as Joint RCC. The legal task of the JRCC for aviation is to search for missing aircraft both on water and on land in Amsterdam FIR. See also Section 2.9.

5 Dutch Safety Board, Aircraft missing, *Cessna accident at Maasvlakte* 2, May 2013.

6 Appendix B contains a short summary of relevant factors and the safety recommendations in relation to the investigation of the present accident.

The investigation did not focus on the search and rescue (SAR) operation itself. Only aspects related to the alert phase, the identification of a missing aircraft and the notification of and information provision to the JRCC were investigated.

The following safety investigation authorities and its technical advisors participated in and/or provided information for the investigation:

- *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* of *France* representing the State of Manufacture;
- *Comisión de Investigación de Accidentes e Incidentes de Aviación Civil* of Spain representing the State of Registry;
- *Statens havarikommisjon* of Norway, as both the pilot and passenger were Norwegian nationals;
- *Bundesstelle für Flugunfalluntersuchung* of Germany, as the last point of departure was an airport in Germany.

In addition, the Dutch Safety Board gathered information from LVNL, Dutch Coastguard Centre, Royal Netherlands Meteorological Institute (KNMI) and Rotterdam Port Authority (RPA).

Chapter 2 presents the relevant factual information. In Chapter 3, the analysis is presented. Findings and conclusions are summarized in Chapter 4.

2 FACTUAL INFORMATION

2.1 History of the flight

The pilot, a Norwegian national, owned a Dyn'Aéro MCR01 Micro Light Aircraft (MLA) with registration EC-ZAF. On Sunday 5 June 2022, he planned to fly his aircraft from Bergen airport (ENBR), Norway with a stopover at Husum-Schwesing airport (EDXJ), Germany to Buno Bonnevaux Airfield (LFFB), France. The pilot departed together with a passenger (the pilot's son) from Bergen airport at 10.15 hours and flew to Husum-Schwesing airport, where they arrived at 13.35 hours. The air traffic controller of this aerodrome stated that during the stopover the pilot used the computer in the crew office and his smartphone for flight preparation. According to the flight plan filed by the pilot, his intention was to fly under Visual Flight Rules (VFR) to Buno Bonnevaux Airfield, France (LFFB). The planned route filed for crossing Dutch airspace indicated waypoint Kubat (near Delfzijl), Drachten airport (EHDR) and waypoint Alina (near Alkmaar).

The aircraft took off from the German aerodrome at 15.48 hours. The aircraft entered Amsterdam Flight Information Region (FIR) near the town of Delfzijl around 16.50 hours, see Figures 1 and 2. The aircraft crossed the Eelde TMA[7] at an altitude between 4,700 to 5,000 feet (class E airspace[8]). The pilot contacted Eelde Tower and reported according flight plan, 5,000 feet and transponder code 7000. Following a question from the Eelde tower controller, the pilot confirmed to remain VFR. The controller replied to the pilot that Mode S was not showing[9] and the pilot reported to have a Mode C transponder.[10]

Before the aircraft left the Eelde TMA, the Eelde tower controller advised the pilot to contact Dutch MIL Info on frequency 132.350 MHz. The pilot read the frequency back as 135.350 MHz, which was not corrected by the tower controller. It must be noted that on the radio telephony recordings used for this investigation, strong background noise was audible during the transmissions of the pilot. This was the last radio communication received from the pilot. The pilot did not establish contact with Dutch MIL Info, or any other Dutch air traffic service provider later on. For the remainder of the flight, the aircraft was visible to the different air traffic service providers on the radar, but with unknown identity and therefore no flight plan displayed. This was due to the fact that the aircraft

7 Terminal Manoeuvring Area (TMA) or terminal control area: A control area normally established at the confluence of Air Traffic Service routes in the vicinity of one or more major aerodromes. (Source definition: ICAO Annex 11)

8 Eelde TMA is class E airspace, which is controlled airspace where Air Traffic Control provides only traffic information (as far as practical) to VFR flights. Continuous two-way air-ground voice communication is not required.

9 Eelde TMA is a Transponder Mandatory Zone (TMZ), wherein an operational Mode S transponder is mandatory for all aircraft. Airborne Mode S transponders with elementary surveillance functionality broadcast among others aircraft identity and altitude.

10 Airborne Mode A/C transponders transmit the configured transponder code and aircraft altitude, but do not transmit details of the aircraft identity.

did not carry a Mode S transponder and there was no communication established between the pilot and the involved air traffic service providers.

The flight continued and after leaving the Eelde TMA, entered Dutch MIL airspace, passed over the town of Drachten, crossed the IJsselmeer and then changed course to a more southerly direction. The aircraft entered the Schiphol TMA 1 (class A airspace[11]) at 17.28 hours at around 7,000 feet[12]. The supervisor of Schiphol Approach made several calls using the standard emergency frequency in an attempt to contact the pilot, but without any response. The supervisor of Schiphol Tower called the Dutch Aviation Police to ask if they had a helicopter available to intercept the unknown VFR flight crossing the Schiphol TMA 1. A police helicopter took off from Amsterdam Airport Schiphol (hereafter, Schiphol) with the intention to intercept the aircraft at approximately 17.45 hours.

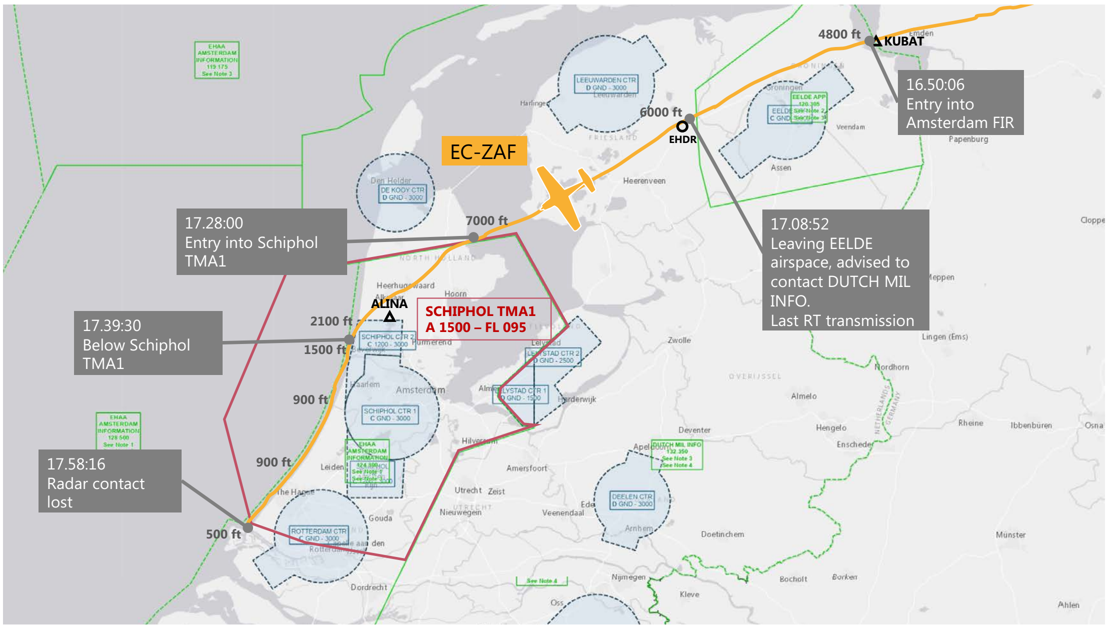


Figure 1: Trajectory of the aircraft. (Source radar data: LVNL)

11 Schiphol TMA 1 is class A airspace, which is controlled airspace. VFR flights shall not be operated in airspace class A (Aeronautical Information Publication (AIP) the Netherlands).

12 Around Flight Level 70. Below the transition altitude of 3,500 feet, altitude is expressed in feet Above Mean Sea Level (AMSL), based on the prevailing QNH of 1012 mbar.

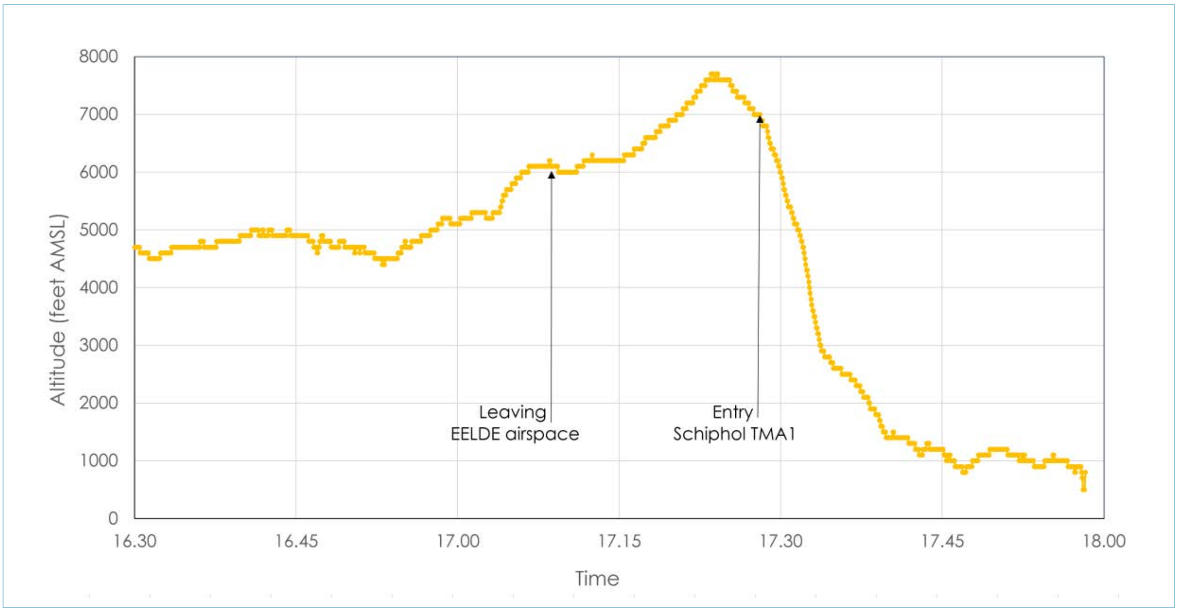


Figure 2: Altitude of the aircraft, expressed in feet AMSL, QNH 1012 mbar. (Source radar data: LVNL)

In the meantime, the aircraft had descended. North-west of Schiphol it started following the Dutch coastline southwards. At around 17.39 hours, the aircraft flew west of Schiphol and descended below the Schiphol TMA 1. The aircraft continued to follow the coastline in uncontrolled airspace[13], and started a shallow descent to an altitude of 800 feet where it levelled off. The police helicopter, flying over land, was unable to catch up with the aircraft. As the aircraft had left the controlled airspace around Schiphol and the helicopter encountered poor visibility conditions, north of Leiden the crew decided to return to Schiphol after consultation with Air Traffic Control the Netherlands (LVNL).

During flight, the passenger of the accident aircraft made a Snapchat video recording of approximately ten seconds with his mobile phone. The recording[14] shows the pilot flying the aircraft by holding the stick with his left hand, with his right hand resting on his left forearm. Both hands are relaxed. The flight conditions were clear of clouds and light rain. There was sight on ground on the left side of the cockpit and sight on water on the right side of the cockpit. The visibility at the right side of the cockpit was more than at the left side. The Primary Flight Display (PFD) indicated the aircraft was flying straight and level at an altitude between 700 and 800 feet with an indicated airspeed of 121 knots in the direction 225 degrees. The active frequency on the radio was set on 135.355 MHz and the standby frequency was set on 124.305 MHz. The Mode C transponder was set on code 7000 and switched to altitude mode. The display of an electronic device (IPad) is partially visible with the navigation application SkyDemon displayed. Based on the information derived from the recording combined with the radar data, it is estimated that the recording was taken two to four minutes prior to the accident.

13 Class G airspace, which is uncontrolled airspace where Air Traffic Control only provides flight information service, if requested, to VFR flights. Continuous two-way air-ground voice communication is not required.
14 The passenger sent the recording to a friend using his mobile phone. The recording was available for the investigation.

Last radar contact was at 17.58 hours, when the aircraft was flying in the port area of Rotterdam. At 18.34 hours, wreckage parts were found floating on the water by a vessel of the Rotterdam Port Authority (RPA).

A detailed analysis of the flight path based on data obtained from LVNL and RPA is provided in Chapter 3.1. A factual description of the sequence of events related to the provision of alerting service after the last radar contact of the aircraft is described in Section 2.9.

2.2 Injuries to persons

The pilot and the passenger were both fatally injured. The human remains of the pilot and passenger were found on respectively 18 and 19 June 2022 in the harbour area.

2.3 Wreckage and impact information

The aircraft was destroyed as a result of the impact with water. Only part of the aircraft was recovered. Several major parts of the aircraft, including the fuselage and the engine, were not found, despite an intensive search operation (sonar and scan operation) led by the police during the next days.

The recovered wreckage parts were examined by the Dutch Safety Board. The severely damaged left wing was recovered (see Figure 3). The flap was still attached to the wooden rear spar, the aileron was found separately. The flap and aileron sustained relatively minor damage. Of the right wing, only the front and rear spar of the wing were recovered; the wing skin was missing (see Figure 4). The aileron was attached to a piece of the rear spar and had minor damage. The flap had severe damage and both hinges were still attached to parts of the rear spar.

The tailplane (horizontal stabilizer) was recovered in a fractured condition, separated in a left and a right part (see Figure 5). The trim-tab was partly in place on the left side. The trim rod was connected to the trim-tab by a rod-end. During the examination, the rod-end was stuck and unable to move freely. The two rivets to hold the rod-end in place were intact. The other side of the trim rod was loose, one rivet was missing and one rivet was damaged. Both tailplane attachment fittings, attaching the tailplane to the vertical fin, were sheared. Only a part of the inner construction of the vertical fin was recovered. It was noticed on the wreckage that the attachment fittings on the tailplane were the originally installed type 1 fittings.[15]

Both seats, parts of the hull structure (i.e. parts of the wooden front and aft frames, see one part in Figure 6) and a number of smaller, fractured parts, including parts of the propeller were recovered. Apart from the flaps, no parts of the flaperon system were recovered.

15 See further information in Section 2.8 Manufacturer bulletins.

There were no indications of fire on the wreckage parts found. No data recording systems or other devices that contained data were retrieved. In addition, there were no signs of collision with an external object (scratches, colour marks). In the area where EC-ZAF crashed, the Maasvlakte, there are several wind turbines, chimneys and cranes. No damages to any obstacles were reported following the crash of the aircraft.

Figure 3: Left wing. (Source: Dutch Safety Board)

Figure 4: Right wing parts. (Source: Dutch Safety Board)

Figure 5: Tailplane. (Source: Dutch Safety Board)

Figure 6: Parts of hull structure frames. (Source: Dutch Safety Board)

2.4 Pilot information

The pilot, age 58, held a valid Private Pilot Licence – Aeroplane (PPL(A)) issued in Norway with the rating Single Engine Piston (SEP) land. Initial issue of this license was in July 2015. The SEP rating was valid until 31 March 2024. The medical class 2 certificate was valid until 7 March 2023.

The pilot's latest logbook showed 264 hours total flying hours, all on single engine aircraft. The last flight prior to the accident flight was on 18 April 2022. On 17 and 18 April, the pilot flew the accident aircraft in four legs from Spain via France and Germany to Norway.

The pilot bought EC-ZAF in January 2022 and recorded a total flying time of 22 hours and 50 minutes on the aircraft, which he performed in the period January to April 2022. In the logbook, the pilot recorded for 2022 a total of 26 hours and 55 minutes, no flight hours in 2021 and 2 hours and 30 minutes in 2020. Before that, the last flight recorded took place on 11 July 2017. The pilot recorded in total 5 hours and 55 minutes Instrument Flight Rules (IFR) training, of which 5 hours and 35 minutes in 2009 and 20 minutes in 2012.

2.5 Aircraft information

The aircraft, a Dyn'Aéro MCR01 BAMBI with registration EC-ZAF and serial number 0073/1462, was a two seat aircraft built from a kit in the year 2000. The MLA has a carbon fiber fuselage with wooden frames and a cantilever low-mounted wing with wooden mid and aft spars. The wing skin and control surfaces are made of light alloys. It has a Rotax 912 piston engine and a two-blade propeller (see Figure 7). The aircraft had a basic empty weight of 232 kg and a maximum take-off weight of 450 kg.

Figure 7: The aircraft parked at Bergen Airport Flesland (older picture, not taken on day of the accident), Norway. (Source: owner)

The pilot bought the aircraft in Spain in January 2022.[16] The aircraft had a valid restricted airworthiness certificate, issued by the Spanish National Aviation Authority (Agencia Estatal de Seguridad Aérea, AESA) on 13 August 2020, which was valid until cancelled by AESA.[17] The last inspection of the aircraft as part of the renewal of the airworthiness certificate was carried out by AESA in June 2018. The AESA inspector identified no discrepancies during this inspection. In 2020, the renewal was done based on a self-assessment by the (previous) aircraft owner.

The maintenance records for the aircraft were not found at any location and also not recovered at the accident site and were therefore not available for examination.

Weight and balance data for the accident flight are not known. Before the flight was commenced, the aircraft had a fuel uplift of 43,46 liter super plus gasoline at Husum-Schwesing airport. According to the submitted flight plan, the aircraft had a Mode C transponder and no Emergency Locator Transmitter (ELT) on board.

2.6 Meteorological information

2.6.1 Forecast

It is not known if the pilot had checked the weather conditions en route before departure from Husum-Schwesing airport and if he did, what sources he used.

The Dutch Safety Board obtained the low level forecast[18] issued on 5 June 2022 at 10.36 hours by the Royal Netherlands Meteorological Institute (KNMI). This forecast is indicative of the weather information available to the pilot during his stopover at Husum-Schwesing airport regarding the weather to be expected in the Netherlands. The graphic low level forecast valid between 09.00 and 18.00 hours UTC (11.00 and 20.00 hours local time) is depicted in Figure 8.

16 The Spanish aircraft register did not list the pilot as current owner of the aircraft.

17 A restricted airworthiness certificate is a certificate for aircraft that fall outside the framework of Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency. The regulation and supervision of these type of aircraft is the responsibility of the relevant national aviation authority.

18 The low level forecast is a forecast issued by KNMI three times a day for the area in between surface and flight level 100.

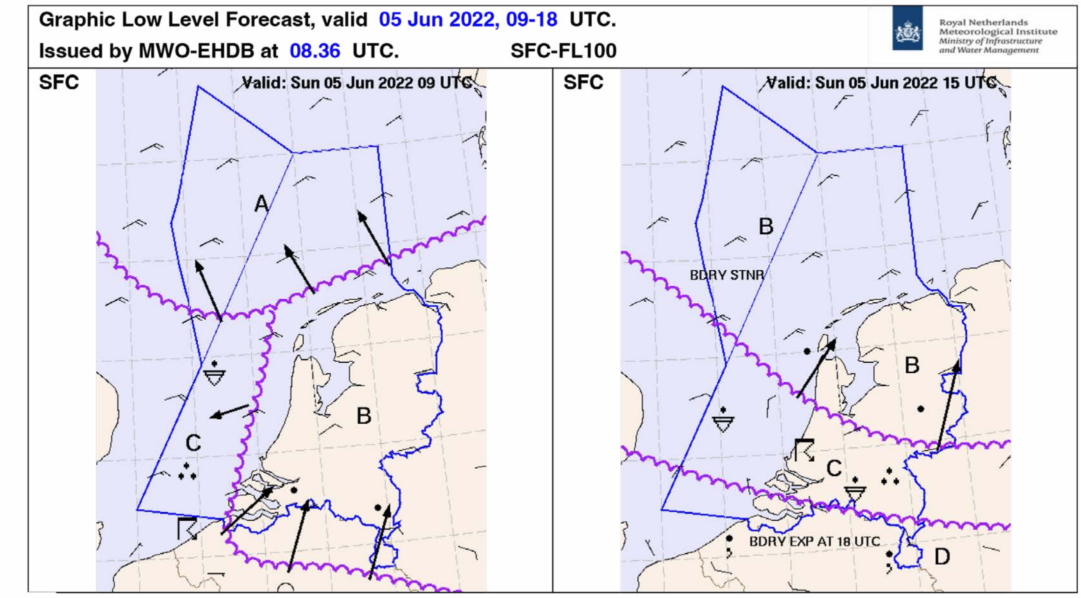


Figure 8: Graphic low level forecast for 09.00 UTC (left) and 15.00 UTC (right). (Source: KNMI)

The relevant meteorological areas for the accident flight are areas B and C. The forecast indicated for area B alto cumulus clouds at 7,000 feet or higher with a visibility of more than 10 km and some local light rain. The forecast for area C showed significant weather: temporary rain, occasional isolated showers of rain and thunderstorms, visibility more than 10 km, in precipitation 5,000 to 8,000 metres and local 3,000 to 5,000 metres. During thunderstorms with rain, a visibility of 3,000 to 1,500 metres was forecasted with a risk of visibility below 1,500 metres. Broken clouds (BKN)[19] stratus cumulus were forecasted between 3,000 and 5,000 feet. Mainly over land, east and south, the forecast indicated an increasing risk to encounter BKN stratus between 500 and 1,000 feet. In showers few (FEW) and/or scattered (SCT) cumulonimbus were possible with a cloud base between 4,000 and 6,000 feet and with cloud tops above flight level 100.

The full details of the low level forecast are presented in Appendix C.

Schiphol and Rotterdam The Hague airport (EHRD) were aerodromes close to the route of the aircraft. For both aerodromes, a Terminal Area Forecast (TAF) issued on 5 June 2022 at 12.56 hours was available; see Appendix C for details. These forecasts indicated for the time the accident aircraft crossed Dutch airspace a visibility of 6,000 metres decreasing to 2,500 metres (with a probability of 30%) during thunderstorm with rain and a cloud base at 3,000 feet (BKN).

19 Cloud coverage, the fraction of the sky covered by visible clouds, is measured in eights (oktas): OVC, overcast: 8/8 octas coverage. BKN, broken: 5/8-7/8 octas coverage. SCT, scattered: 3/8-4/8 octas coverage. FEW, few: 1/8-2/8 octas coverage.

2.6.2 Actual weather

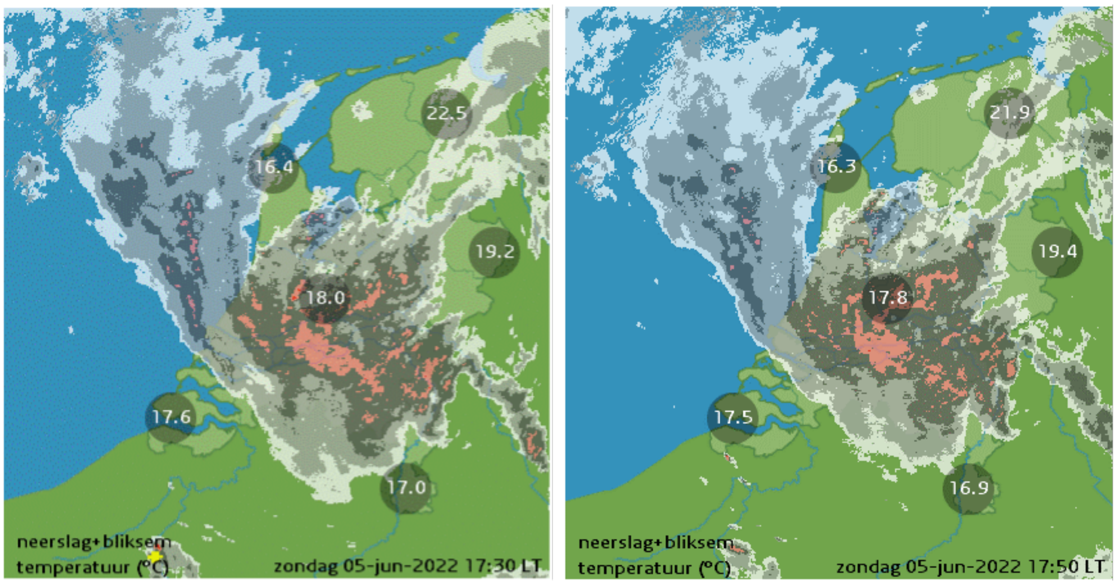
The KNMI provided the Dutch Safety Board with an assessment of the actual weather conditions from the moment the aircraft entered Dutch airspace until the time of the accident.

General weather conditions

An active low-pressure area over mid-Brabant at 14.00 hours was slowly moving northeast, at 17.00 hours situated above north-Limburg and at 20.00 hours over the east of Gelderland. There was an occluded front around the low-pressure area, expanding from east to west over the south, mid and west part of the Netherlands. The freezing level was at flight level 100.

Weather en route in Amsterdam FIR

Along the route, conditions were initially quite good. In general, there was a visibility of more than 10 km, a light eastern wind and a cloud base between 3,000 and 5,000 feet. When the aircraft flew along the coastline in southern direction, the weather conditions were deteriorating: the cloud base was descending to 2,000 to 3,000 feet with visibility of 3,000 to 5,000 metres. It cannot be ruled out that in the last part of the trajectory there were also FEW/SCT clouds between 1,000 and 1,500 feet and a visibility reduction to 1,500 to 2,000 metres occurred. Radar images show that on the route along the coastline (between 17.44 and 17.58 hours) light, possibly temporarily moderate rain fell (see Figure 9). The cloud cover consisted of various layers. The chance of hidden cumulonimbus (CBs) on the route was very small (unlike the inland, where various embedded CBs were present). The Meteorological Aerodrome Reports (METARs) of Schiphol and Rotterdam The Hague airport are presented in Appendix C.

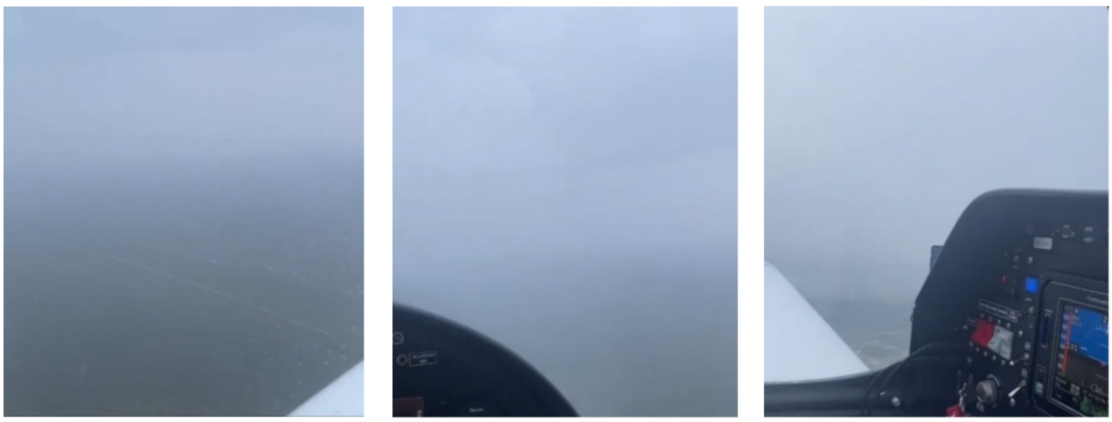


Legend: ■ cloudburst, ■ heavy showers, ■ heavy precipitation,
■ moderate precipitation, ■ light precipitation, □ very light precipitation, ■ thunderstorm

Figure 9: Radar images showing precipitation, lightning (yellow) and temperature. (Source: KNMI)

Weather in the vicinity of the accident site
The occluded front, a transition zone between colder and warmer air, was situated in the immediate vicinity of the Maasvlakte. The weather condition was mostly periods of light to moderate rain with a horizontal visibility between 3,000 and 5,000 metres. The predominant cloud base (more than 5 octas) was between 2,500 and 3,500 feet with FEW/SCT clouds between 1,000 and 2,000 feet. There were no (embedded) cumulonimbus (CBs) around the site. The prevailing wind between ground and 500 feet came from a direction of 290 degrees with 10 knots, at 1,500 feet variable with 5 knots.

From the passenger's video recording, taken approximately two to four minutes before the accident, an impression of the weather conditions could be obtained. The recording shows Visual Meteorological Conditions (VMC) with light rain. In all directions, either ground or water are in sight, see also the images taken from the recording in Figure 10. In south-westerly and westerly direction the horizon is visible, while in easterly direction the horizon is moderately visible.



Direction west *Direction southwest* *Direction east*

Figure 10: Images from video recording taken approximately two to four minutes prior to the accident.

Other observations
An additional weather observation was obtained from the police helicopter that attempted to intercept the aircraft, following the airspace infringement of Schiphol TMA 1. During this interception attempt, the police helicopter flew overland in a south-westerly direction approximately between 6 and 15 kilometres from the coastline and at a distance of 18 to 20 kilometres northeast from the aircraft. The police helicopter crew stated that the weather was poor and that they had to fly at an altitude of around 400 to 500 feet to continue visually navigating towards the aircraft. Sometimes the clouds were observed to be lower and sometimes higher, so that the helicopter flew towards the aircraft with circumferential movements.

2.7 Medical and pathological information

The Dutch Forensic Institute conducted a post-mortem examination on the body of the pilot. The pathological conclusion is that the death of the pilot can be explained by the consequences of a very violent force acting on the body in the context of the aircraft accident. The toxicological examination did not reveal any conclusive indications regarding the presence of ethanol and carbon monoxide. No evidence of ingestion and/or administration of drugs was obtained in the toxicological examination.

2.8 Manufacturer bulletins

The manufacturer of the aircraft kit[20] has issued a number of service bulletins for the aircraft type and model in question on its website. For some service bulletins, the French National Aviation Authority (Direction générale de l'aviation civile, DGAC) issued a mandatory airworthiness directive. Two airworthiness directives addressed unsafe situations that were identified during accident investigations conducted by the safety investigation authorities of respectively France and the United Kingdom. These two are listed in Table 2 below.

Table 2. Overview of airworthiness directives issued by the French DGAC.

Service bulletin(s) from manufacturer	Airworthiness directive from DGAC	Date	Topic
BS12F0043 (18 Jun 2012) BS20F0010 R1 (2 Nov 2011)	F-2012-002	27 Jun 2012	Replaced F-2011-003 R1 Reinforced flap control system
BS08B0034R2 (21 May 2012)	F-2012-001R1	13 Jun 2012	Replaced F-2012-001 and F-2008-002 Action on the attachment fittings of the elevator/horizontal stabilizer/tailplane

During the investigation of a fatal accident with an MCR Sportster[21] that occurred on 19 July 2010, abnormal wear of the leading screw and carriage of the aileron/flaps (flaperon) system was identified.[22] The airworthiness directive F-2012-002 issued by DGAC stated that such a wear could result in the loss of the aileron control and in the loss of control of the aircraft. Following an emergency airworthiness directive issued in October 2011, Dyn'Aéro designed, tested, and validated a reinforced control flap system. The airworthiness directive issued in 2012 mandated the installation of this reinforced flap control system. Implementation of the manufacturer's mandatory service bulletin on the accident aircraft EC-ZAF could not be confirmed as, apart from the flaps, no parts of the flaperon system were recovered.

20 Now SE Aviation Aircraft, a company based in France.
21 The accident aircraft model MCR01 BAMBI (or MCR VLA) is similar to the Sportster version. The different commercial names are used to indicated that VLA (very light aircraft) version was designed according to European Joint Aviation Requirements (JAR VLA), and the Sportster according to United States of America's Federal Aviation Regulations (FAR 23 amendment 7).
22 Rapport Accident, Rentrée dissymétrique des flaperons après le décollage, demi-tour, perte de contrôle lors de la tentative d'atterrissage, BEA f-de100719, BEA.

On 30 December 2007, an MCR ULC accident occurred in the United Kingdom[23] following a horizontal stabilizer loss caused by a rupture of the stabilizer (tailplane) attachment fitting. To address this unsafe condition, DGAC issued airworthiness directive F-2008-002, later replaced by F-2012-001 and F-2012-001R1, mandating inspection and replacement or reinforcement of the tailplane attachment fittings. The related manufacturer's mandatory service bulletin is applicable to all types of MCR aircraft.

The tailplane of the accident aircraft EC-ZAF was recovered and found separated from the vertical fin (see Section 2.3). The fracture surfaces of tailplane attachment fittings were examined by a laboratory on request of the Dutch Safety Board. The examination concluded that the attachment fittings have failed in overload; no signs of stress corrosion or other failure modes were observed. It was determined that the damage to the tailplane was most probably caused on impact.

The Spanish AESA had not issued a type certificate and airworthiness directives for Dyn'Aéro MCR aircraft. As a result, during an AESA inspection the implementation of the above mentioned manufacturer bulletins is not verified by the inspectors, but is the full responsibility of the aircraft owner.

2.9 Alerting service

In the area where the accident aircraft crashed, the Amsterdam Flight Information Centre (FIC) is LVNL's unit providing alerting service. This section gives an overview of the general regulatory framework for the provision of alerting service and the actual service provided in relation to the accident on 5 June 2022.

2.9.1 Framework for VFR flights

Alerting service is a service provided by an air traffic service provider to notify appropriate organisations regarding aircraft in need of search and rescue aid, and assist such organisations as required.[24] European regulations[25] state that alerting services shall be provided by the responsible air traffic services unit:

1. for all aircraft provided with air traffic control service;
2. in so far as practicable, to all other aircraft having filed a flight plan or otherwise known to the air traffic services; and
3. to any aircraft known or believed to be the subject of unlawful interference.

With respect to alerting service, the main tasks of the air traffic service provider are notification and provision of relevant information to the responsible rescue coordination centre. When an aircraft is considered to be in a state of emergency, the air traffic service provider shall notify rescue coordination centres immediately.[26]

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23 Accident report EW/C2007/12/05, AAIB UK.

24 Regulation (EU) 2017/373 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight.

25 Commission Implementing Regulation (EU) 2020/469, ATS.TR.400 and Regulation (EU) 2016/1185, SERA.10001.

26 Commission Implementing Regulation (EU) 2020/469, ATS.TR.405 Notification to rescue coordination centres. The rescue coordination centre is responsible for the efficient organisation and coordination of search and rescue services.

An international framework for emergency phases has been established consisting of three stages: uncertainty phase, alert phase and distress phase. The applicable phase depends on the severity of the situation; however, the phases are not necessarily sequential. More detail on the three phases is provided in Appendix D. Flight information centres (FICs) or area control centres (ACCs) serve as the central point for collecting all information relevant to a state of emergency of an aircraft operating within the Flight Information Region or control area concerned and for forwarding such information to the appropriate rescue coordination centre.[27]

The Aeronautical Information Publication (AIP) of the Netherlands states that alerting service for VFR flights will be provided to flights for which a flight plan has been submitted.[28]

2.9.2 Responsibility and tasks LVNL

The FIC operations manual details the related responsibilities and tasks of a Flight Information Service Officer (FISO). The manual states that the FISO provides alerting service to a flight in the area of responsibility of Amsterdam FIC, if this flight maintains radio contact with Amsterdam FIC, or if the flight is known or believed to be the subject of unlawful interference. The manual also contains an operating procedure for flights that do not maintain radio contact with Amsterdam FIC. For such a flight, that is only known to Amsterdam FIC because a flight plan was submitted, the FISO provides alerting service to the extent practicable.

The FISO monitors flight progress and maintains a listening watch on the established emergency frequencies, and informs LVNL's Area Control Centre (ACC) supervisor when needed. The ACC supervisor is responsible for the further alerting process, including the notification to the JRCC.

2.9.3 Events on 5 June 2022

At the time of the last radar contact of EC-ZAF, the aircraft was flying in uncontrolled airspace class G[29] without radio contact with air traffic services. At that stage, the identity and intentions of the aircraft were not known by the LVNL operational staff located at Schiphol.

The following information is based on incident logs, e-mails and statements provided by LVNL, JRCC and RPA.

Identification and notification of missing aircraft

Following the disappearance of the aircraft's track from the radar, the on duty FISO at Amsterdam FIC initiated several actions in order to try to locate the aircraft, see Table 3. Approximately 10 minutes after the aircraft's radar track was lost, the FISO informed the ACC supervisor and further actions were initiated.

27 Commission Implementing Regulation (EU) 2020/469, ATS.TR.400 Application (b).
28 AIP the Netherlands, ENR 1.10.
29 Airspace class G is uncontrolled airspace where to VFR flights only flight information service (if requested) is provided by the responsible air traffic service provider. Continuous two-way air-ground voice communication is not required.

When the first wreckage parts were found by a vessel of the RPA at approximately 18.34 hours, the aircraft identity initially remained unclear. Based on the initial wreckage parts found, the finders suspected that it concerned a drone, and in addition, an incorrect aircraft registration was communicated by the staff (EC-6AF instead of EC-ZAF).[30]

The ACC supervisor initiated the procedure on the form 'Luchtverkeersongeval' (Aviation accident) at approximately 18.30 hours. Although the JRCC is mentioned as first organisation on the list, the ACC supervisor did not contact JRCC, as LVNL was in contact with RPA and it was agreed that RPA would contact JRCC regarding the wreckage parts found. The first direct communication between LVNL and JRCC was around 18.55 hours, which was 57 minutes after the last radar contact, when JRCC contacted LVNL to ask for information.

Provision of information from LVNL to JRCC
As part of the alerting service responsibility, LVNL shall collect and forward relevant information about the aircraft concerned to the JRCC, in order to facilitate the search and rescue operation. This includes details from the flight plan, such as number of persons on board and possible dangerous goods, and details of the (last known) position of the aircraft.

There were several communications and information exchanges between LVNL, JRCC and RPA, see Table 3. LVNL extracted the flight plan as soon as the aircraft registration was confirmed to be EC-ZAF, at approximately 19.00 hours.

LVNL extracted the aircraft's radar position information using their Last Known Position (LKP) tool (see Appendix E). LVNL sent the output of this tool – a listing of nine radar responses starting from 17.57:56 hours – by e-mail to the JRCC at 19.07 hours. The staff of the JRCC used the last position on this list as 'last known position' (position listed for 17.58:34 hours), and communicated this position to the emergency services' control room in Rotterdam for further coordination regarding the search and rescue operation.

The extracted flight plan did not include item 19 (number of persons on board), as this item was not submitted by the Norwegian Air Traffic Services Reporting Office[31] (ARO) to the German ARO, and subsequently LVNL.[32] This was due to a limitation in the Norwegian flight processing system. LVNL submitted a request to ARO Germany, who contacted ARO Norway for this information. At 20.12 hours, Norway forwarded the supplementary flight plan that contained the requested information to Germany, which was then forwarded to LVNL.

30 The aircraft's registration mark was indicated on the underside of the left wing. This wreckage part was retrieved.
31 Air Traffic Services Reporting Office (ARO) is an office established for the purpose of receiving reports concerning air traffic services and flight plans submitted before departure. (Source: Commission Implementing Regulation (EU) 2020/469)
32 Both flight plans (Norway-Germany and Germany-France) were submitted by the pilot to the Norwegian Air Traffic Services Reporting Office (ARO) and forwarded by the Norwegian en subsequently German ARO to LVNL.

Table 3: Overview communication.

Time (LT) approx.	From	To	Message/Information
17.58			Last track on radar screen FISO.
18.01	LVNL FISO	Heliport 'Pistoolhaven'	FISO asks if a helicopter has landed or is expected. This is not the case.
18.08	LVNL FISO	LVNL ACC supervisor	FISO informs the ACC supervisor that the aircraft is no longer detected by radar. Because the aircraft identity is unknown, the situation is uncertain. The FISO and ACC supervisor take into consideration that the aircraft has continued its flight at low height or has landed at a location other than an aerodrome. Further attempts are being made to clarify more about the aircraft. This includes coordination with Dutch MIL and contacting nearby aerodromes.
18.29	Vessel	Rotterdam Port Authority	First notification of wreckage parts found in water.
18.30	LVNL ACC supervisor	LVNL Staff, Military supervisor, Dutch Aviation Police	The ACC supervisor initiates the procedure on form 'Luchtverkeersongeval' (*Aviation accident*). Relevant LVNL staff, the Military supervisor and the Dutch Aviation Police are being informed.
18.34	Vessel	Rotterdam Port Authority	Finders on vessel indicate that wreckage part looks like an aircraft wing.
18.38	Rotterdam Port Authority	LVNL Flight Service Centre	Notification that a vessel found wreckage in the water with registration "EC6AF". It is mutually agreed that the Rotterdam Port Authority will inform the JRCC.
18.52	Rotterdam Port Authority	JRCC	First contact between Rotterdam Port Authority and JRCC. Aircraft wreckage was found. Presumably a drone. A part contains the registration "EC-6AF".
18.55	JRCC	LVNL FIC	Request for additional information for an aircraft with registration EC-6AF.
19.00	JRCC	Dutch MIL	JRCC contacts Dutch MIL to ask if situation is known. Dutch MIL was aware of unidentified aircraft.
19.01	JRCC		JRCC identifies from photos that registration is EC-ZAF.
19.07	LVNL FMPC	JRCC	The Flow Management Position Controller (FMPC) sends e-mail with Last Known Position.

Time (LT) approx.	From	To	Message/Information
19.15	LVNL ACC supervisor	JRCC	ACC supervisor informs JRCC, as at this stage it is known by LVNL, following information from RPA, that the registration of the aircraft is EC-ZAF.
19.16	LVNL FMPC	JRCC	FMPC contacts JRCC and provides details from the brief flight plan available.
19.17	LVNL FMPC	JRCC	e-mail with Last Known Position.
19.18	LVNL FMPC	JRCC	FMPC contacts JRCC to indicate that e-mail has been sent with Last Know Position, flight plan and departure message for EC-ZAF.
19.29	LVNL FMPC	JRCC	FMPC informs JRCC that aircraft departed Husum-Schwesing airport with 2 persons on board.
20.03	JRCC	Control centre Rotterdam	JRCC sends Last Known Position (extrapolated data point) to the control centre Rotterdam (Dutch: *Meldkamer Veiligheidsregio Rotterdam-Rijnmond*).

2.10 Requirements for VFR flights in the Netherlands

All flights into, from or over the territory of the Netherlands and landings in the territory shall be carried out in accordance with the valid European and national regulations regarding civil aviation.[33] The Aeronautical Information Publication (AIP) of the Netherlands lists the applicable legislation and contains detailed flight rules and procedures. Most relevant requirements and procedures applicable to the flight of EC-ZAF are presented below.[34]

Visual Meteorological Conditions

The pilot of EC-ZAF was conducting a flight under Visual Flight Rules (VFR). For these type of flights specific rules apply that regulate the operation of aircraft in Visual Meteorological Conditions (VMC). The Standardised European Rules of the Air (SERA) and the national AIP specify minimum criteria for VMC visibility and distance from cloud. A VFR flight may only be carried out when flight visibility and distance of aircraft from clouds are equal to or greater than the values specified in the regulations. For airspace class G at and below 3,000 feet, this means a flight visibility of 5 km and clear of clouds with the surface in sight. For flights operating at speeds of 140 knots indicated airspeed or less, the flight visibility may be reduced to 1,500 metres.

33 AIP the Netherlands, ENR 1.2 Visual Flight Rules.
34 See Standardised European Rules of the Air (SERA) Regulation (EU) 2016/1185, SERA.4001 and SERA.5001, and AIP the Netherlands, GEN 1.5, ENR 1.2, 2.2, 1.10, 5.3 and 5.4.

Flight planning

The pilot of EC-ZAF had planned an international flight, crossing several FIRs. For any flight across the Amsterdam FIR boundary, it is mandatory to submit a flight plan prior to operating. A flight plan for an international VFR flight shall include time estimates for crossing of the FIR boundaries.

VFR flights shall not be operated in airspace class A and are not permitted in the Schiphol TMA. When an aircraft enters controlled airspace unauthorised, so without requesting and obtaining clearance from Air Traffic Control, it is considered an airspace infringement.[35]

Airspace infringements can create a significant safety risk and this safety risk often cannot be controlled by Air Traffic Control.[36] Furthermore, it may cause a disruption to flight operations, potentially increasing air traffic controller and pilot workload. The European Union Aviation Safety Agency (EASA) has published guidance for General Aviation pilots on avoiding airspace infringements.[37] The leaflet highlights aspects as flight planning and preparation to be the best way to prevent airspace infringements. Gathering all necessary flight information and staying in contact with Flight Information Services are mentioned specifically.

Communications

For VFR flights in airspace class E and G, two-way air-ground communications with the air traffic service provider is non-mandatory, but advisable. The AIP states that pilots executing VFR flights are requested to report their position at first radio contact with the military air traffic control centre Schiphol (Dutch MIL Info). At the time of the accident, pilots flying in the vicinity of Schiphol TMA 1 were strongly recommended to maintain a listening watch on the frequency of LVNL's Flight Information Centre (Amsterdam Information).[38]

Mode S transponder

All aircraft operating in the Amsterdam FIR shall be equipped with a Mode S transponder with elementary surveillance functionality. Only motorised VFR flights in class G airspace below 1,200 feet AMSL within the universal daylight period are exempted from the mandatory carriage of a Mode S transponder.

Minimum height over obstacles

There are several wind turbines, chimneys and cranes on the Maasvlakte, the area where EC-ZAF crashed. They are listed in the AIP The Netherlands and depicted in Figure 11. The heights of the obstacles vary: lines of moveable harbour cranes of 358-384 feet

35 Airspace infringements occur when an aircraft enters notified airspace without previously requesting and obtaining clearance from the controlling authority of that airspace or enters the airspace under conditions that were not contained in the clearance. (Source: European Action Plan for Airspace Infringement Risk Reduction (EAPAIRR – Version 2.0)).

36 European Action Plan for Airspace Infringement Risk Reduction (EAPAIRR – Version 2.0), Eurocontrol and CANSO, March 2022.

37 Avoiding Airspace Infringement – Reduce your risk of a mid air collision – Guide for General Aviation Pilots, EASA.

38 As of 13 July 2023, pilots are required to maintain an air-ground voice communication watch on frequency 124.300 (Amsterdam Information) below Schiphol TMA 1. Source: Aeronautical Information Circular Netherlands (AIC-A 04/2023), Implementation of TMZ with monitoring COM channel below Schiphol TMA 1, published 27 July 2023.

AMSL, two chimneys of 577 feet AMSL, two flare stacks of 371 and 550 feet AMSL and several lines of wind turbines (8 of 436 feet AMSL, 5 of 511 feet AMSL, 14 of 577 AMSL, one of 817 feet AMSL).

The AIP contains a warning for the Maasvlakte area regarding a gas venting site and an accompanying advisory measure to avoid flying below 1,000 feet above ground level and in close vicinity of this site.

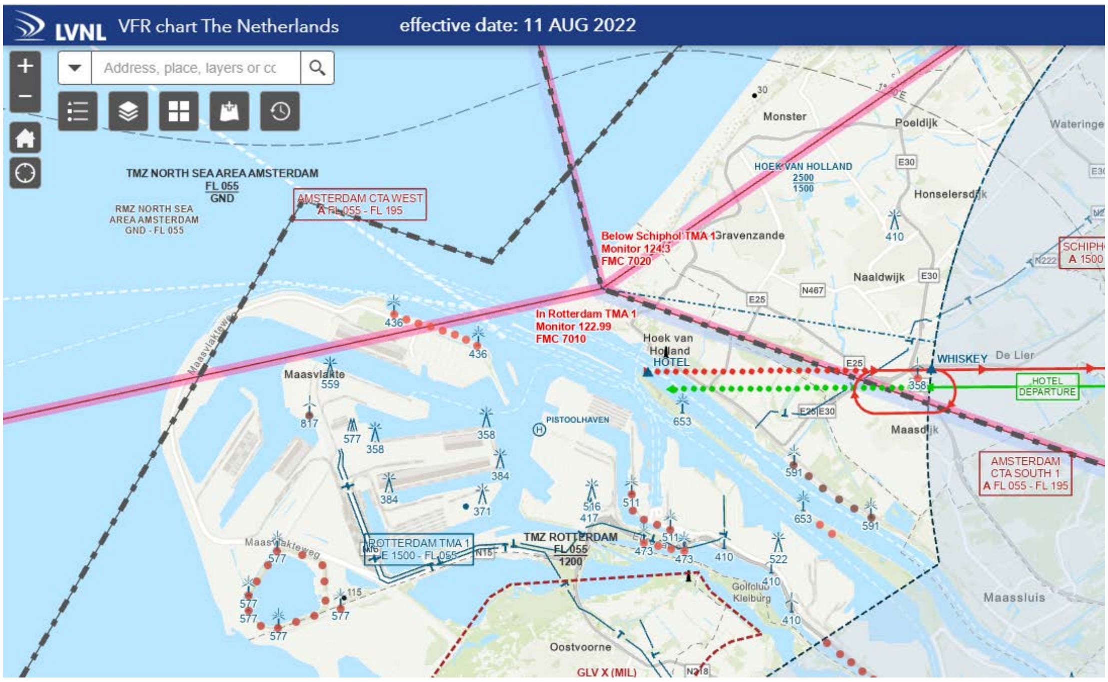


Figure 11: VFR chart with obstacles at Maasvlakte. (Source: VFR chart The Netherlands, LVNL, consulted on 11 August 2022)

2.11 Safety actions taken after the accident

LVNL conducted an investigation following the accident. The results were shared with the LVNL staff through publication of an article in LVNL's safety magazine. The article emphasizes the importance of a working Mode S transponder and radio contact with organisations that provide flight information and alerting service: these are lifelines for pilots. It was only known in hindsight that an accident had taken place. In the operation, there were no indications of an emergency situation, other than that a serious airspace infringement had occurred. The article concludes that it is important for LVNL staff to know that it is always possible to proactively inform the JRCC on doubts regarding the safety of a flight because of abnormal flight operations.

Following the accident on 5 June 2022, the JRCC expressed the desire to be informed earlier in certain situations. In response to this, LVNL has amended its Quick Reference Handbooks (QRH) for, amongst others, ACC supervisor and FIC and the Operations Manual AMS ACC on 10 August 2023. The objective is that the JRCC is already informed if due to circumstances or flight path it is assumed that the general aviation aircraft is in serious difficulty, even though the pilot did not (yet) report an emergency. LVNL also issued related Training Bulletins regarding these amendments on 4 August 2023.

The Dutch Coastguard did not initiate specific actions following this accident.

3 ANALYSIS

3.1 Aircraft crash

3.1.1 Flight track

Because no flight data or other digital information was recovered from the wreckage, the Safety Board used external data sources to analyse the flight path. For the analysis of the last segment of the flight path (up to approximately one minute before the crash), the Board used data from different sources for reconstruction:

- Air Traffic Control (ATC) radar data from LVNL;
- Rotterdam Port Authority (RPA) maritime (primary) radar;
- Rotterdam Port Authority (RPA) maritime heat camera.

For detailed information of these sources, see Appendix F.

ATC radar data

Analysis of the data indicates that at 17.57:46 hours the aircraft was flying west of Hoek van Holland at an altitude of approximately 900 feet above mean sea level (AMSL) and was moving in south-westerly direction (see Figure 12). The aircraft moved steadily along this trajectory and remained at 900 feet until 17.57:56 hours. The next two radar measurements show a drop in altitude, first to 700 feet, and then to 500 feet at 17.58:06 hours. Concurrently, the track shows a change of heading towards the south.

The altitude of the aircraft between 17.58:06 hours and 17.58:16 hours is unclear, since no validated radar data are available. This may be attributed to highly dynamic aircraft behaviour, but this cannot be determined with certainty. The last validated radar response at 17.58:16 hours shows the aircraft at an altitude of 800 feet, just east of the Beereiland in the Beer Canal.

Rotterdam Port Authority (RPA) maritime radar

Analysis of the data indicates that the radar images of the maritime radar show a normal picture in the minutes before the crash, with some ship movement in the area. At 17.58:25 hours, the radar image shows a primary radar reflection east of the Beereiland, halfway of the Beer Canal. This reflection is located north-east of the last valid ATC radar measurement, at a distance of approximately 350 metres and azimuth of 60 degrees. This reflection persists for several seconds and fades away around 17.58:30 hours.

Because of the proximity of this radar reflection to the last ATC radar measurement, the location of the floating wreckage parts found and information obtained from RPA regarding the tidal stream at the Beer Canal[39], there is a high probability that this

39 Data from RPA was obtained regarding the tidal stream at the Beer Canal (stream direction and velocity). Based on this data, the location of the first wreckage parts found may fit to the possible accident location.

reflection can be associated with the crash of the aircraft. At the same time, because the horizontal displacement of the reflection is minimal, it is hypothesized by the Safety Board that the last segment of the flight path (altitude ranging from ground up to approximately 100 feet above ground level) occurred steeply. Based on this data, it is therefore estimated that the accident occurred at approximately 17.58:30 hours.

Maritime heat camera
The Dutch Safety Board obtained heat camera images originating from a camera located on the north bank of the New Waterway. Analysis indicates that the camera images show an object moving towards the ground at high speed and in steep inclination for several seconds, just to the right of a passing ship. Although this trajectory would fit with and confirm the resulting trajectory from combining the ATC and RPA radar information, it cannot be determined with certainty that the object seen in the camera image is the aircraft.

Final trajectory approximation
By combining the information obtained from the ATC radar and maritime radar, an approximation of the flight path of the final stage of the flight was made and is depicted in Figures 12 and 13. Given the validity of the radar responses and taking into consideration the maritime radar reflection, after the last valid ATC measurement at 17.58:16 hours, the aircraft (or parts thereof) changed heading and was traversing in easterly direction.

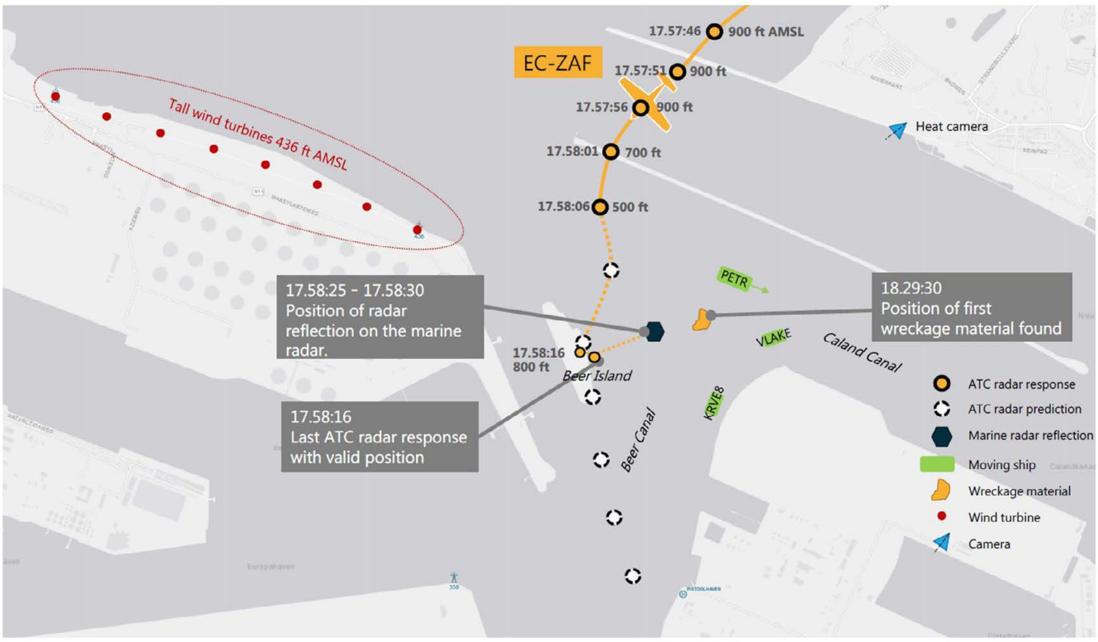


Figure 12: Final stage horizontal flight path. (Source data: LVNL and RPA)

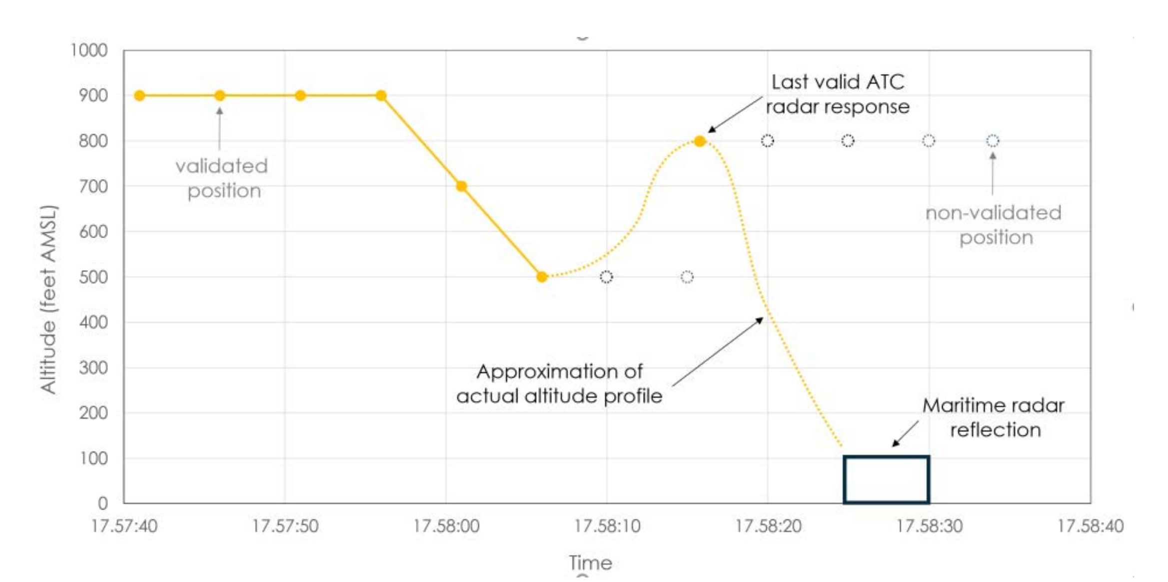


Figure 13: Final stage vertical flight path. (Source data: LVNL and RPA)

Radar data from ATC shows that just before the accident, the aircraft was flying at an altitude of about 900 feet AMSL. In a period of 10 seconds, the aircraft descended over the Nieuwe Waterweg and Caland Canal to an altitude of 500 feet AMSL. What happened the seconds after, remains unclear. The last valid radar measurement, with an altitude determined at 800 feet AMSL, indicates that altitude variations occurred during the latter part of the flight.

The accident is estimated to have occurred at approximately 17.58:30 hours. By combining ATC and RPA radar data, it is hypothesized that the last part of the flight path pointed steeply downwards and followed a change in heading towards the east.

3.1.2 Examination of the wreckage

Only limited wreckage parts were retrieved. Despite an extensive search conducted after the accident, some major parts, including the engine, were not found. It was therefore not possible to conduct a full technical examination of the aircraft. Examination of the recovered wreckage parts did not reveal any pre-existing technical defects. Detailed examination by a laboratory of the fracture surfaces of the tailplane's attachment fittings did not give an indication of pre-existing anomalies. The investigated attachment fittings were slightly curved, which indicates that the damage occurred during impact.

The rod-end on the trim-tab was stuck and unable to move freely due to a not installed spacer, that is required according to the manufacture's drawings. There are no indications that the aircraft with this stuck trim-tab was out of trim, since the aircraft took-off in Norway, made a stopover in Germany and took-off again and the snapchat recording showing that the pilot was flying the aircraft with both hands relaxed.
Overall, the damages observed on the recovered parts seem consistent with forces acting on the aircraft as a result of the impact.

The maintenance records for the aircraft stored on board were not available for examination, so it could not be determined whether all the maintenance requirements had been adhered to. The related mandatory service bulletin to either replace or reinforce the tailplane attachment fittings before 21 March 2013 had not been complied with. It is not known if the pilot, the current owner of the aircraft, was aware of this.

On the parts of the aircraft wreckage that were recovered, no indications of pre-existing defects or anomalies were observed. As only limited aircraft parts were found, a technical cause or technical contribution to the accident sequence cannot fully be excluded.

3.1.3 Weather conditions

An extensive analysis of the available weather information was performed to determine the actual weather conditions at the time of the accident.

When looking at the forecast available at the time of the stopover in Germany, in general Visual Meteorological Conditions (VMC) were expected along the route. However, there was significant weather forecasted for the part of the flight along the coast of The Netherlands in southerly direction. There was a chance to encounter temporary isolated local, occasional showers of rain, thunderstorms with rain, a deteriorating visibility and a lowering cloud base.

The actual weather conditions and the Meteorological Aerodrome Reports (METARs) of Schiphol and Rotterdam The Hague airport were in line with the issued low level forecast and Terminal Area Forecasts (TAFs). Along the route of the aircraft in Dutch airspace, the weather conditions deteriorated. It seems plausible that the descent of the aircraft along the route to Hoek van Holland was necessary in order to remain in VMC.

Analysis also shows that the prevailing weather condition in the vicinity of the accident site can still be considered as meeting VMC criteria. Although meeting the VMC criteria for airspace class G, it cannot be ruled out that in the last trajectory flight visibility was further reduced with few/scattered clouds between 1,000 and 1,500 feet and a visibility of 1,500 to 2,000 metres in light, possibly moderate, rain. No (embedded) cumulonimbus (CBs) were present in the vicinity. It cannot be established with certainty whether there was a discernible horizon, due to the possibility of reduced visibility as a result of light up to moderate rain in the vicinity of the accident site. With a cloud base between 1,000 and 1,500 feet, it is considered unlikely that the pilot lost visual contact with the surface during the last part of the flight.

The Dutch Safety Board notes that the weather observations made by the police helicopter crew and the METARs of Schiphol and Rotterdam The Hague airport were not representative of the weather conditions encountered by the aircraft. Both the flight track of the police helicopter and the location of the two aerodromes is more land inwards. As also visible on the radar images of the precipitation in Figure 9, the weather conditions over land were different from the conditions near the coastline.

Based on analysis of the actual weather data, it was determined that the weather deteriorated along the flight route of the aircraft in Dutch airspace. It seems plausible that the pilot decided to descent during his flight along the coastline in order to remain in VMC. The prevailing weather at the time and location of the accident was in general VMC. It cannot be established with certainty whether there was a discernible horizon. But with a cloud base between 1,000 and 1,500 feet, it is considered unlikely that the pilot had lost visual contact with the surface during the last part of the flight.

3.1.4 Conduct of the flight

The pilot had according to his logbook an irregular flying pattern in recent years. He had conducted an international flight a few months before, when he was flying EC-ZAF from Spain to Norway.

Regarding the preparation of the flight, several aspects are noteworthy. As the aircraft did not have a Mode S transponder, it did not meet the legal requirements for the route flown in the Netherlands. The airspace infringement when the aircraft crossed the Schiphol TMA 1 is highly remarkable. Flying in this airspace unauthorized, without radio communication and no listening watch on the established emergency frequencies, has the potential for creating hazardous situations such as the risk of an airprox with commercial air transport aircraft. It could not be determined in how far and in how much detail the pilot had prepared for the flight.

Though not required for VFR flights when flying in airspace class E and G, maintaining radio contact with air traffic services, at least a listening watch, is recommended. After the established radio contact with Eelde Tower, the pilot's read-back of the frequency of Dutch MIL Info was incorrect. The video recording taken by the passenger shortly before the accident showed that the pilot had still selected Dutch MIL Info as active frequency and had not changed to Amsterdam Information. In addition, incorrect frequencies were selected: 135.355 MHz as the active frequency (note that the correct frequency for Dutch MIL Info is 132.350 MHz) and 124.305 MHz as standby frequency (the correct frequency for Amsterdam Info is 124.300 MHz). It remains unclear why the pilot did not establish contact with Dutch MIL Info or Amsterdam Information. As a result of the incorrect frequency settings, it was impossible for the air traffic service providers to reach the pilot at that time. The video recording also shows that the aircraft was in straight and level flight according to the artificial horizon displayed on the primary flight display.

No weight and balance sheet for this flight was recovered. Therefore, the Dutch Safety Board could not compute the centre of gravity (CG) of the aircraft.

The final twenty minutes of the flight, the aircraft followed the Dutch coastline. As indicated in Section 3.1.3, the weather conditions deteriorated along the route. When approaching the Maasvlakte, the distinct shoreline ends into a land section with different obstacles. Figure 14 presents three screenshots taken from a video recording of a helicopter flight performed by the Dutch Aviation Police one month after the accident.

These screenshots give an impression of the visual environment the pilot encountered. It is to be noted, however, that this specific helicopter flight was performed in far more favourable weather conditions in comparison to the accident flight. Directly on the right of the flight path, there was a line of eight tall wind turbines. Ahead were lines of moveable harbour cranes, chimneys and more wind turbines.

When reaching the Maasvlakte, the flight track shows a change of heading towards the south, but also a drop in altitude, followed by altitude variations. Although it cannot be determined with certainty, the end of the distinct coastline and appearance of the Maasvlakte and obstacles may have triggered a reaction by the pilot to avoid the obstacles by changing direction. As the cloud base was around 1,000 to 1,500 feet, there was only limited opportunity to climb.

Figure 14: View towards Maasvlakte from altitude of 776-772 feet on 13 July 2022. (Source: Dutch Aviation police)

It could not be determined in what manner and to what level of detail the pilot had prepared for this flight.
However, the following aspects are highly remarkable and can be considered as indications of insufficient flight preparation:

- the airspace infringement of the Schiphol TMA 1,
- the use of airspace where Mode S is mandatory without being equipped with a Mode S transponder, and
- the absence of further radio communication with air traffic services and incorrect frequency selection on the radio.

3.2 Alerting service

3.2.1 Identification and notification of missing aircraft

LVNL stated to the investigators that it is not uncommon for VFR flights to 'disappear' from the radar. The minimum height at which aircraft are being detected by the radar depends on the location and circumstances. According to LVNL, in the accident area it is not uncommon for radar targets to disappear at and below approximately 500 feet. After the track of the accident aircraft was lost, the FISO and ACC supervisor took into account at that time that the aircraft continued flight at low height or landed at a destination other than an aerodrome, as happens with helicopters. The type of aircraft was unknown at this stage.

The controllers initiated action after the loss of the radar track: they made a phone call to a nearby helicopter aerodrome, and coordinated with the Dutch MIL a further search by contacting aerodromes. After approximately 30 minutes, the ACC supervisor initiated the procedure on the form 'Luchtverkeersongeval' (Aviation accident). This timing is in line with the reasonable period established for the escalation of an emergency state and the initiation of the uncertainty phase (see Appendix D).

The possibilities of identifying whether the aircraft was in a state of emergency were hampered by the unknown identity of the aircraft – and therefore unknown flight plan and destination – and lack of radio contact.

The absence of the Mode S transponder resulted in the aircraft not being identifiable on the radar screens of the air traffic controllers. The uncertainties that existed regarding this specific flight are not exceptional and can exist for other VFR flights in airspace class E or G as well. It is however not guaranteed that an unknown identity, lack of radio contact and/or loss of radar track trigger the initiation of alerting service by the air traffic service provider for such VFR flights. In the case of the accident aircraft, the airspace infringement of the Schiphol TMA 1 raised the awareness of ATC for this specific flight. LVNL indicated that this – in combination with limited other VFR traffic being present at that moment – has influenced the initiation of the alerting phase.

For the responsibility area of Amsterdam FIC, the LVNL procedure regarding the provision of alerting service is in line with the existing European regulations[40,41]. The overall statement regarding alerting services for VFR flights in the AIP the Netherlands, however, diverges slightly. Where the AIP states that alerting services will be provided to all VFR flights for which a flight plan has been submitted, LVNL's FIC operations manual has limited this to flights that have established radio contact. Alerting service is obviously limited if there is no radio contact.[42] For flights that have not established radio contact with Amsterdam FIC, and only are known because they submitted a flight plan, the FISO provides alerting service as far as practicable. In this respect, the statement in the AIP lacks this nuance that is reflected in the EU regulatory requirements and procedures of LVNL.

With respect to the efforts of identifying the aircraft, the Safety Board notes that efforts made by LVNL included contacting Dutch MIL and the Aviation Police, who sent a helicopter that tried to intercept the aircraft. LVNL Schiphol did not contact LVNL's Eelde Tower. LVNL stated that the history of an unknown flight cannot be displayed on the air traffic controller's workstation. In addition, there was no communication between Dutch MIL and Eelde Tower regarding the unidentified aircraft. Also, during its flight in Dutch MIL airspace, Dutch MIL air traffic controllers did not try to establish contact with the aircraft. In case of an unidentified aircraft, an active inquire at other air traffic services units may yield details regarding the identity of the aircraft.

The Joint Rescue Coordination Centre (JRCC) responds to different emergency messages or transmissions, including notifications from an air traffic service provider, distress calls on the emergency channels, use of the emergency transponder codes and activation of an Emergency Locator Transmitter (ELT). When the FISO raised the missing aircraft to the ACC supervisor, the supervisor informed relevant stakeholders using an established procedure and form. When Rotterdam Port Authority (RPA) called LVNL regarding the

40 Regulation (EU) 2016/1185.
41 Commission Implementing Regulation (EU) 2020/469.
42 This does not mean no action is taken at all if there is a missing aircraft. But this will mostly happen at a later stage and is not necessarily initiated by Amsterdam FIC, but for example by an airport authority.

found wreckage parts, both parties agreed that RPA would contact JRCC. The ACC supervisor did therefore not contact JRCC initially. Although RPA did contact JRCC, it is important, as also reflected in the EU-regulations, that LVNL notifies JRCC directly. This allows collaboration and early coordination on required information for search and rescue purposes.

JRCC indicated in an interview with the Safety Board that it would like to be informed at an even earlier stage about abnormal or suspicious situations, before official alerting phases are initiated. In the investigation report of the Cessna accident at the Maasvlakte[43], it was determined that time gains could be achieved by concurrently carrying out various activities during the uncertainty phase. This would allow decisions and preparations for possible search operations to already be taken and implemented during the uncertainty phase.

At the time of the accident with the EC-ZAF, there was no clear shared framework between LVNL and JRCC when and for which situations to contact and notify the JRCC. There was no specific coordination arrangement in place, even though this was announced in both the LVNL's and Dutch Coastguard responses to the Safety Board's safety recommendation issued in 2013.[44]

The disappearance of a radar target of a VFR flight is not a direct indication of an emergency or crash of the aircraft. Despite the unknown identity and unknown destination, LVNL did take action following the loss of radar track and raised the emergency state after 30 minutes.

At the time of the accident, there was no clear shared framework between LVNL and JRCC when and for which situations to contact the JRCC. There was no specific coordination arrangement in place between the two organisations.

3.2.2 Provision of information

LVNL used their Last Known Position (LKP) Tool to extract the nine last radar responses of the aircraft and sent them by e-mail to JRCC. This e-mail was sent more than an hour after the aircraft disappeared from the radar and 37 minutes after the issue was escalated by LVNL.

The e-mail contained an explanatory text regarding restrictions of the usability of the radar data. These restrictions include the remark that the end of the track does not mean the aircraft crashed at that location. The statement that the last three positions on the list are extrapolated data, indicated with an asterisk. A phone number was mentioned as well, in case the recipient of the e-mail has questions or doubts about the e-mail.

43 Dutch Safety Board, *Aircraft missing, Cessna accident at Maasvlakte* 2, May 2013.
44 https://www.onderzoeksraad.nl/en/page/2006/vliegtuig-vermist---cessna-ongeval-op-tweede-maasvlakte-28-mei-2012

The JRCC received this information and used the last radar response of the list. This last position was an extrapolated radar response, indicated with an asterisk. According to the on duty officer at the JRCC, during a crisis situation, he does not have time to read the explanation and to consider which radar responses should be used for the search and rescue operation.

A correct understanding of the available radar data has proven to be vital in the Cessna accident at the Maasvlakte in 2012. The investigation of this accident concluded that a *predicted* (extrapolated) radar response was used for the search and rescue operation, while the last *validated* radar response was the location where the aircraft had crashed. For that specific situation, this made a huge difference, as the aircraft had crashed on land instead of in the water, where the search operation was focussing on. Following this accident, LVNL has developed the LKP tool to be able to easily extract radar data from their systems.

The LKP tool enables timely and easy extraction of the radar data, in particular when the aircraft registration is known. A thorough understanding of the data that is being presented in the LKP output listing, however, is essential for an effective search and rescue operation. Based on the use of the radar data by JRCC and the selection of a predicted radar response, it became clear in this accident that there is no common framework and understanding of the radar data that is sent by LVNL to JRCC. The explanatory information in the e-mail on actual and extrapolated data points does not meet the objective of creating a better understanding of the data presented. The incompatibility of the two systems at LVNL and JRCC – the JRCC has to enter the radar data manually into their systems – and the lack of visual presentation does not help either. In its task to support the JRCC, LVNL is in the position to assist in the interpretation of the radar data and support the JRCC in using this for search and rescue purposes.

Once the aircraft registration was known, LVNL extracted the flight plan details. International coordination with the German and Norwegian ARO's was necessary in order to obtain official information regarding the number of persons on board (part of item 19 of the flight plan). This was due to the fact that the Norwegian flight processing system did not allow to transfer this data with the German ARO. Although this issue did not delay the search and rescue operation, the number of persons on board is a mandatory item to be included in the flight plan[45] and essential information for the purpose of search and rescue operations.

The LKP tool developed by LVNL after the Cessna accident at the Maasvlakte in 2012, enables extracting the last radar responses of an aircraft track. LVNL used the tool to extract data for the accident aircraft. This data and explanatory information sent by e-mail an hour after radar contact was lost, was not sufficient to create a common framework and understanding of the radar data to be used by the JRCC for the search and rescue operation.

45 See requirements in ICAO Annex 2 and EASA SERA.

4 CONCLUSIONS

4.1 Cause of the accident

The cause of the accident could not be determined. Radar data confirm that altitude variations occurred during the last part of the flight. The final part of the flight path was steep. The aircraft descended from 800 feet above mean sea level (AMSL). After approximately 14 seconds, it impacted the water. Analysis of the actual weather conditions indicate that Visual Meteorological Conditions (VMC) prevailed at the time and location of the accident with a cloud base between 1,000 and 1,500 feet, it is considered unlikely that the pilot lost visual contact with the surface during the last part of the flight. In combination with the artificial horizon displayed on the primary flight display, spatial disorientation due to loss of visual reference seems unlikely, however this can not be ruled out.

Due to the limited wreckage parts recovered, a possible technical cause or contributing factor of a technical nature cannot be fully excluded. Several essential aircraft parts, including the engine, have not been found. Examination of the available wreckage parts did not indicate pre-existing defects or anomalies. The tailplane was available for examination and it was determined that a manufacturer's mandatory service bulletin to either replace or reinforce the tailplane attachment fittings had not been complied with. Detailed examination by a laboratory of the fracture surfaces of the attachment fittings indicated that the damage occurred during impact.

4.2 Alerting service

The disappearance of a radar target of a VFR flight is not a direct indication of an emergency or crash of the aircraft. Despite the unknown identity and unknown destination, LVNL did take action following the loss of radar track. The Last Known Position (LKP) tool, developed by LVNL after the Cessna accident at the Maasvlakte in 2012, was used to extract data for the accident aircraft. This data was shared with the JRCC.

Further analysis of the actions following the loss of radar track of EC-ZAF showed that there are some areas for improvement regarding the coordination between Air Traffic Control the Netherlands (LVNL) and the Joint Rescue Coordination Centre (JRCC).

First, at the time of the accident, there was no clear shared framework between LVNL and JRCC on when and for which situations to contact the JRCC. The JRCC was only involved when the first wreckage parts were found approximately 35 minutes after radar contact with the aircraft was lost. During that time period, LVNL had already initiated several actions in order to try to locate the aircraft. Early notification and contact between LVNL and JRCC about suspicious situations contributes to more efficient and effective search and rescue operations. This was already identified during the investigation of the Cessna accident at the Maasvlakte in 2012. LVNL has updated its procedures and amended Quick Reference Handbooks (QRH) and the Operations Manual AMS ACC on 10 August 2023.

Second, when the emergency status was escalated and around the same time the first wreckage parts were found, LVNL did not notify the JRCC themselves, but agreed with the Rotterdam Port Authority (RPA) that RPA would contact the JRCC. Direct contact and communication between LVNL and JRCC is essential in order to be able to provide relevant information timely for the search and rescue operation, even in cases where the situation is still unclear.

Third, LVNL sent Last Known Position (LKP) Tool output information to JRCC more than an hour after the loss of radar contact and approximately 50 minutes after the FISO informed the ACC supervisor about the loss of radar track. Timely retrieval and provision of the LKP data is important for the search and rescue operation. The JRCC staff did not clearly understand the interpretation of the radar responses listed, although the radar data sent by e-mail was accompanied by an explanation. The LVNL is in the position to better support the JRCC in the interpretation of the radar data.

In 2013, the Safety Board issued recommendations to LVNL and JRCC addressing improvement of practical aspects of cooperation, communication and exchange of information. The LKP tool is in principle a good aid to extract radar data from LVNL's systems. However, to use the information in a good and effective manner, coordination and cooperation between LVNL and JRCC is key. The notification process and the way the information was provided indicate that a clear shared framework did not exist at the time of the accident with EC-ZAF. In this respect, both LVNL and the Dutch Coastguard indicated in 2013 that they would prepare and implement a coordination arrangement. There was no such arrangement in place. The current investigation highlights that communication and coordination between the two organisations still require improvement in order to provide effective search and rescue operations in The Netherlands.

4.3 Lessons for VFR pilots

Although the cause of the accident remains undetermined, the investigation highlighted some lessons that the Dutch Safety Board considers useful to share with the General Aviation community.

When looking at the weather forecast available at the time of the stopover in Germany, in general Visual Meteorological Conditions (VMC) were expected along the route. However, there was significant weather forecasted for the southern part of the Netherlands.

1. In general, it is good practice to include a risk assessment for adverse weather along the route, in your pre-flight preparation. Plan your flight according to weather limits, taking into account the lowest cloud base, minimum visibility and maximum winds aloft. Besides regulatory limits, it is important to take your personal (stricter) limits

into consideration as well. During the flight, the encountered weather conditions might be different than expected and adjusting your initial plan might be necessary. Examples of adjusting your plans such as flying a different route, diverting to an en route aerodrome, or even cancelling or delaying the flight, are options that should be considered.

The pilot of the accident aircraft had submitted a flight plan for his international flight. As the pilot only had a Mode C transponder, the different air traffic services in the Amsterdam FIR could see the track of the aircraft on the radar, but not the identity of the aircraft. Therefore, the track could not be linked to the submitted flight plan.

The unknown identity together with the absence of radio contact impacted the effectiveness of the alerting service. Overall, the circumstances of the accident can also be applicable for VFR flights that remain in airspace class G below 1,200 feet, where there is no Mode S transponder requirement, and that have not submitted a flight plan.

The disappearance of a radar target of a flight under Visual Flight Rules (VFR) is not a direct indication of an emergency or crash of the aircraft. VFR pilots are to be aware of their own responsibilities regarding successful provision of alerting services in case needed. Submitting a flight plan, updating the flight plan when relevant and being identifiable by Air Traffic Control (ATC) are key elements in this. Although not mandatory, maintaining radio contact with air traffic control or flight information services is recommended and considered useful for example in case of unforeseen emergency situations and search and rescue operations.

2. For the effective provision of alerting service to VFR flights, VFR pilots are responsible for making themselves known to the local air traffic service provider, either by means of a filed flight plan, transmission of aircraft identity and/or established radio contact.

The pilot did not establish radio contact with air traffic services, except for communications with Eelde Tower. The reasons for this are unknown. A video recording made by the passenger on the aircraft, shows that the radio frequency was set incorrectly. It can occur that after switching to the next frequency, communication cannot be established. In the worst case, this is caused by a failure of the radio, but in most cases the frequency is not correctly set by the pilot.

3. If communication with air traffic services on your next frequency cannot be established, do not hesitate to do a frequency check at the previous air traffic service provider. Other options to verify the correct frequency are to check the frequencies depicted on navigation charts, information provided in navigation applications on tablet/mobile devices and to refer to your notes made during your flight preparation.

APPENDIX A

RESPONSES TO THE DRAFT REPORT

In accordance with the Dutch Safety Board Act, a draft version of this report was submitted to the parties involved for review. The following parties have been requested to check the report for any factual inaccuracies and ambiguities:

- Agencia Estatal de Seguridad Aérea (AESA)
- Air Traffic Control the Netherlands (LVNL)
- Bundesstelle für Flugunfalluntersuchung (BFU)
- Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA)
- Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC)
- Dutch Coastguard
- Dutch Ministry of Infrastructure and Water management
- European Union Aviation Safety Agency (EASA)
- Rotterdam Port Authority
- SE Aviation
- Statens havarikommisjon (AIBN)
- The relatives of the pilot

The responses received, as well as the way in which they were processed, are set out in a table that can be found on the Dutch Safety Board's website (www.safetyboard.nl).

The responses received can be divided into the following two categories:

- Corrections and factual inaccuracies, additional details and editorial comments that were taken over by the Dutch Safety Board (insofar as correct and relevant). The relevant passages were amended in the final report.
- Responses that were not adopted by the Dutch Safety Board. The reason for this decision is explained in the table.

No responses were received from the Rotterdam Port Authority.

AIRCRAFT MISSING, 28 MAY 2012

On 28 May 2012, a Cessna 172M aircraft with four occupants on board crashed at Maasvlakte 2 near Rotterdam, the Netherlands. No one witnessed the accident due to sea fog that had rolled in that day. The heavily injured occupants had been lying on a desolate piece of land for five hours. Only after the fog had lifted, the aircraft and the occupants were localized. After the emergency services found the aircraft, the occupants were taken to hospital. The pilot died of his injuries two weeks later. Two of the three passengers sustained serious and permanent physical injuries as a result of the accident.

Among others, the investigation established that Air Traffic Control the Netherlands (LVNL) and the Dutch Coastguard Centre did not collaborate effectively and that the search for the aircraft could have been expedited by carrying out procedures concurrently.

Safety Recommendations issued in 2013

The Dutch Safety Board issued in total five recommendations in 2013. These recommendations addressed practical aspects of cooperation, communication and exchange of information between LVNL and the Dutch Coastguard Centre. These five recommendations were:

To the Minister of Infrastructure and the Environment, the Minister of Defence and the Minister of Security and Justice:
The launch and execution of Search and Rescue operations involves a chain of parties who are reliant on one another. They are Air Traffic Control the Netherlands, the Netherlands Coastguard and the security regions.

1. *In consultation with the Chairman of the Executive Board of Air Traffic Control the Netherlands, the Chairman of the Safety Council [Veiligheidsberaad] and the Director of the Netherlands Coastguard, develop and implement standards for cooperation, communication and information-sharing between the partners in the chain. Emphasis should in any case be placed on the following:*
    - *making information accessible to and sharing it unequivocally with the partners in the chain;*
    - *updating the information shown on maps of Dutch territory and the digital versions thereof and ensuring the information continues to be updated;*
    - *improving the mutual understanding of the tasks, responsibilities and information needs of each other's organisation. This could, for instance, be achieved by periodically staging joint exercises and cross-training sessions as well as organizing joint evaluation sessions.*
2. *Ensure that the parties cooperate in accordance with these standards.*

To the Chairman of the Executive Board of Air Traffic Control the Netherlands and the Director of the Netherlands Coastguard:
The current process, which commences with the report of a missing aircraft, involves sequential activities. Time gains can yet be achieved by carrying out the various activities concurrently during the uncertainty phase. The parties could, for instance, simultaneously perform the communication search, locate mobile telephones, read out radar data and alert the Search and Rescue units.

3. *Jointly ensure that the requisite information is made available as swiftly as possible so that decisions on and preparations for a possible search operation can already be taken and implemented during the uncertainty phase.*

To the CEO and Chairman of the Executive Board of Air Traffic Control the Netherlands:

4. *Implement a system which will enable Air Traffic Control the Netherlands to swiftly and accurately determine the latest bearings taken of the geographical positions of aircraft.*

To the Director of the Netherlands Coastguard:

5. *At operational level ensure a critical and open mind, to overcome inward focus or to minimise the risk of inward focus arising. In this context, you may wish to consider:*
   - *Training staff to take a critical look at the information received, irrespective of its origin, and to view it in its entirety;*
   - *organising internal sessions on argumentation to reflect on the strategy chosen for a specific operation. This can be achieved by allowing staff who were not involved in the relevant operation to review decisions on a continuous basis.*

The parties submitted a response to these safety recommendations. Both LVNL and the Dutch Coastguard indicated the intention to arrange mutual visits and joint exercises and establish a coordination arrangement by the end of 2014. In addition, LVNL stated to have amended its systems to be able to quickly and accurately determine the last actual geographical position of aircraft.

The full investigation report in Dutch and an English summary as well as the responses to the safety recommendations are published on the Safety Board's website https://www.onderzoeksraad.nl/en/page/2006/crashed-during-cross-country-flight-cessna-172m-maasvlakte-2-28-mei.

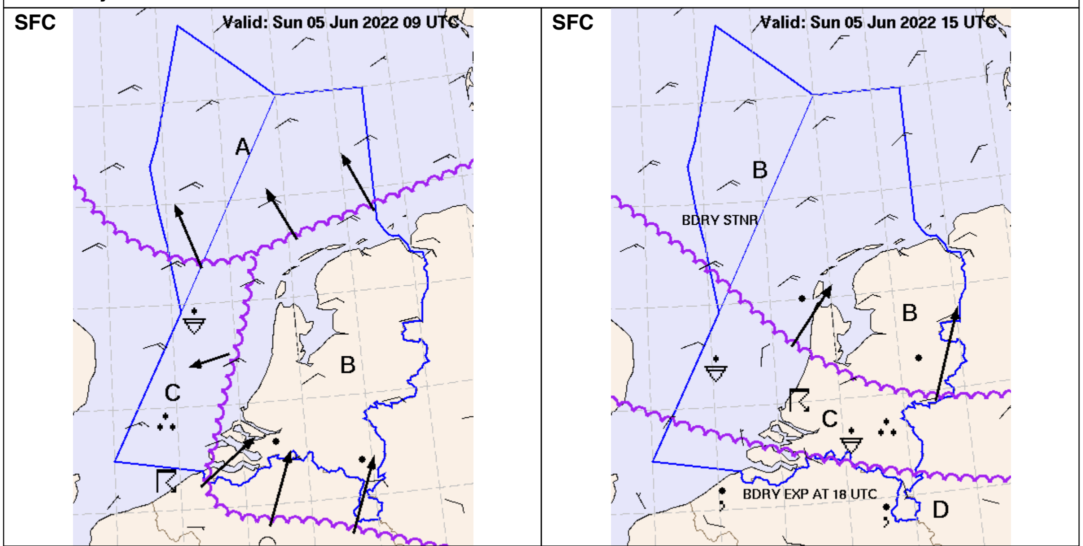
WEATHER INFORMATION 5 JUNE 2022

C.1 Low level forecast

The following low level forecast was issued by the Royal Netherlands Meteorological Institute (KNMI) at 10.36 hours.

Graphic Low Level Forecast, valid 05 Jun 2022, 09-18 UTC.
Issued by MWO-EHDB at 08.36 UTC. **SFC-FL100**

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management



Area A **SIGWX:** NSW.
VIS: 10+ km, in NE lca 5-8 km.
CLD: Bkn ST 500-1000 ft, lca blw 500 ft. Tops 1500-2000 ft.

Area B **SIGWX:** Mainly in S-part lca -RA.
VIS: 10+ km.
CLD: Lca bkn AC 7000 ft or higher. Tops abv FL100.

Area C **SIGWX:** Tempo RA. Also isol, lca ocnl, SHRA/TSRA.
VIS: 10+ km. In precipitation 5-8 km, lca 3-5 km. In TSRA 1500-3000 m, risk less than 1500 m.
CLD: Bkn SC 3000-5000 ft, lca 2000-3000 ft. Mainly in E- and S-LAN increasing risk bkn ST 500-1000 ft. In SH few/sct CB 4000-6000 ft. Tops abv FL100.

Area D **SIGWX:** Lca (-)RADZ.
VIS: 10+ km, in precipitation 5-8 km, risk 3-5 km.
CLD: Lca bkn SC 3000-4000 ft, tops 5000 ft. Fm 15 UTC mainly LAN increasing risk bkn ST 500-1000 ft, tops 1500-2000 ft.

Sea area
FZL: FL090-FL100.
Ice and turb: -
Sign. waveheight: Around 1.5 m, in NE 1.0-1.5 m.
Sign. waveheight >= 6m: Not exp.
Lowest sea water temp: 11 C.
Lowest QNH: 1011 hPa in S.
Outlook 18-24 UTC: Areas mov N. Fm 23 UTC in SW increasing risk isol (-)SHRA.

Land area
FZL: Around FL100.
Ice and turb: -
Thermals: Weak, in NE lca mod. Wkn by cld and mainly in area C disturbed by SH. Dying out around 17 UTC.
Max. temp: Around 20 C, in NE lca 24 C.
Outlook 18-24 UTC: Areas mov N. Increasing risk ST.

Remarks:

Figure C.1. Low level forecast. (Source: KNMI)

Used abbreviations in Figure C.1	
Abv	above
Blw	below
Cld	clouds
FL	flight level
Ft	feet
GR	large hail
Isol	isolated
Lan	land
Lca	local
Lyr	layer
Nsw	no significant weather
RA	rain
Sigwx	significant weather
SH	shower
Tempo	temporary
TS	thunderstorm
Vis	visibility
Wkn	weaken

C.2 Terminal Area Forecast (TAF)

Amsterdam Airport Schiphol (EHAM)

TAF EHAM 051056Z 0512/0618 03004KT CAVOK
TEMPO 0514/0520 6000 SHRA RA BKN045 SCT060CB
PROB30 TEMPO 0515/0519 2500 TSRA BKN030 SCT050CB
BECMG 0518/0521 SCT008 BKN012
TEMPO 0520/0610 4000 RADZ BKN008
BECMG 0600/0603 24010KT
PROB30 TEMPO 0600/0605 2500 DZRA BKN004
BECMG 0609/0612 BKN015
TEMPO 0610/0618 24015G25KT 6000 RA SHRA BKN012 SCT025CB=

Rotterdam The Hague Airport (EHRD)

TAF EHRD 051056Z 0512/0618 30005KT 9999 BKN040
TEMPO 0512/0519 6000 SHRA RA BKN045 SCT050CB
PROB30 TEMPO 0512/0518 2500 TSRA BKN030 SCT050CB
BECMG 0517/0520 SCT008 BKN012
TEMPO 0519/0606 4000 -RADZ BKN008
PROB30 TEMPO 0522/0604 2500 DZRA BKN004
BECMG 0600/0603 24010KT
TEMPO 0609/0618 6000 RA SHRA BKN008=

C.3 METAR

Amsterdam Airport Schiphol (EHAM)

METAR EHAM 051455Z VRB04KT 5000 SHRA SCT048CB 19/16 Q1012 TEMPO 4000=
METAR EHAM 051525Z VRB01KT 6000 SHRA SCT048CB 18/17 Q1012 TEMPO 9999 -RA=
METAR EHAM 051555Z 28007KT 250V320 5000 SHRA FEW008 SCT039CB 18/17 Q1012 TEMPO 4000=

Rotterdam The Hague Airport (EHRD)

METAR EHRD 051455Z AUTO 31005KT 260V360 6000 -SHRA SCT015CB BKN029 OVC032 16/15 Q1012 TEMPO 4000=
METAR EHRD 051525Z AUTO 36004KT 320V040 4700 RA BKN015CB BKN035 OVC044 16/15 Q1012 TEMPO 6000=
METAR EHRD 051555Z AUTO 34006KT 300V030 3800 SHRA FEW013 BKN015CB BKN049 16/15 Q1012 TEMPO 4000=

APPENDIX D

ALERTING SERVICE – EMERGENCY PHASES

Commission Implementing Regulation (EU) 2020/469 of 14 February 2020 defines the three emergency phase (See ATS.TR.405 Notification to rescue coordination centres).

1. Uncertainty phase when either of the following situations applies:
   (i.) no communication has been received from an aircraft within a period of 30 minutes after the time a communication should have been received, or from the time an unsuccessful attempt to establish communication with such aircraft was first made, whichever is the earlier;
   (ii.) an aircraft fails to arrive within 30 minutes of the estimated time of arrival last notified to or estimated by air traffic services units, whichever is the later.

Uncertainty phase does not apply when no doubt exists as to the safety of the aircraft and its occupants.

2. Alert phase when either of the following situations applies:
   (i.) following the uncertainty phase, subsequent attempts to establish communication with the aircraft or inquiries to other relevant sources have failed to reveal any news of the aircraft;
   (ii.) an aircraft has been cleared to land and fails to land within 5 minutes of the estimated time of landing and communication has not been re-established with the aircraft;
   (iii.) at AFIS aerodromes, under circumstances as prescribed by the competent authority;
   (iv.) information has been received which indicates that the operating efficiency of the aircraft has been impaired, but not to the extent that a forced landing is likely;
   (v.) an aircraft is known or believed to be the subject of unlawful interference.

Points (i) to (iv) do not apply when evidence exists that would allay apprehension as to the safety of the aircraft and its occupants.

3. Distress phase when either of the following situations applies:
   (i.) following the alert phase, further unsuccessful attempts to establish communication with the aircraft and more widespread unsuccessful inquiries point to the probability that the aircraft is in distress;
   (ii.) the fuel on board is considered to be exhausted, or to be insufficient to enable the aircraft to reach safety;
   (iii.) information is received which indicates that the operating efficiency of the aircraft has been impaired to the extent that a forced landing is likely;
   (iv.) information is received or it is reasonably certain that the aircraft is about to make or has made a forced landing.

Distress phase does not apply when there is reasonable certainty that the aircraft and its occupants are not threatened by grave and imminent danger and do not require immediate assistance.

APPENDIX E

LVNL'S LAST KNOWN POSITION TOOL

After the accident with a Cessna 172M on the Maasvlakte (see Appendix B), LVNL has developed and implemented a web application to find and retrieve relevant information of an aircraft radar track (aircraft 3D position, ground speed and ground track). The aircraft track information retrieved by the Last Known Position tool is processed radar data: this is the same information as presented to the air traffic controllers on their radar screen. Indicated aircraft positions are either based on actual radar measurements or, for example if the aircraft is no longer detected by radar, based on calculations. The position is extrapolated from previous radar measurement positions. Extrapolated positions are indicated in the tool's output listing with an asterisk (*). If an aircraft is no longer detected by radar, the last three position reports are extrapolated positions based on the last measurement, before the track stops.

Below is the output from LVNL LKP-tool provided as submitted to the JRCC on 5 June. The output consists of a listing of nine positions and an explanation on usability and meaning of the radar data. It lists the following limitations:

- The end of the track does not indicate the location where the aircraft or helicopter crashed;
- The end of the track indicates that the radars at that moment no longer had any sighting. It is possible that the aircraft continued flight below the radar horizon. Extrapolated tracks are marked with an * (asterisk).
- After the end of the track, it is possible that the aircraft flew a different course and changed (descent) speed.
- Radar data is one of the sources that can be used to determine the state of an aircraft or helicopter or to determine the search location for a missing aircraft or helicopter.
- In case of questions or doubt regarding the data, the phone number of the ACC supervisor is indicated.

Last Known Position

Hierbij de coÃ¶rdinaten van de kist waarvan het vermoeden is dat jullie deze hebben gevonden.

-- tracknr: 716

UTC	flight-id	positie		koers	hoogte	snelheid	mode-A	mode-S
15:57:56	________	51°58.99'n	4°05.21'e	224	FL009	63kts	7000	______
15:58:01	________	51°58.85'n	4°05.07'e	220	FL007	63kts	7000	______
15:58:06	________	51°58.69'n	4°05.02'e	193	FL005	61kts	7000	______
15:58:10	________	*51°58.51'n	4°05.07'e	168	FL005	64kts	7000	______
15:58:15	________	51°58.30'n	4°04.94'e	184	FL005	67kts	7000	______
15:58:20	________	51°58.14'n	4°04.99'e	174	FL008	67kts	7000	______
15:58:25	________	*51°57.96'n	4°05.03'e	169	FL008	67kts	7000	______
15:58:30	________	*51°57.79'n	4°05.09'e	165	FL008	67kts	7000	______
15:58:34	________	*51°57.62'n	4°05.18'e	161	FL008	67kts	7000	______

Toelichting bruikbaarheid en betekenis radardata

Een vermiste vlucht wordt telefonisch gemeld; deze email bevat aanvullende informatie. Bij vragen of twijfel over de data: **bel** LVNL ACC-supervisor op [redacted] (GEEN e-mail).

Bruikbaarheid radardata

Houd bij het **gebruik van de radardata** voor bijvoorbeeld search and rescue rekening met de volgende **beperkingen**:

1. **Het einde van de track betekent NIET dat op die plaats een vliegtuig of helikopter is neergestort.**
2. Het **einde van de track** betekent dat de radars **op dat moment geen waarnemingen meer** hebben gedaan. **Het vliegtuig kan verder gevlogen zijn** onder de waarnemingshorizon van de radars. De tracker geeft nog een aantal geëxtrapoleerde track-updates, gemarkeerd met een **'*'** (asterisk).
3. De track geeft betrouwbare informatie over de koers, snelheid en hoogte van de vlucht tot de laatste waarneming. **Het vliegtuig kan na het einde van de track een andere koers zijn gaan vliegen en van (daal)snelheid zijn veranderd.**
4. De radardata kan **één van de bronnen** zijn **om de toestand vast te stellen** van het vliegtuig /helikopter.
5. De radardata kan **één van de bronnen** zijn **om de zoeklocatie te bepalen** voor een vermist vliegtuig / helikopter.
6. Bij vragen of twijfel over de data: **bel** LVNL ACC-supervisor op [redacted] (geen e-mail; een reply op deze email wordt niet gelezen).

Legenda

UTC	=	tijdstip van trackupdate, in uur:min:sec.
		lokale wintertijd = UTC-tijd + 1 uur; lokale zomertijd = UTC-tijd + 2 uur.
flight-id	=	het callsign (bijv. KLM1234) òf de registratie (bijv. PHABC) òf niet beschikbaar.
positie	=	lat-long in WGS84.
***positie**	=	berekende positie zonder radarinput; geëxtrapoleerd door de radar-tracker.
koers	=	bewegingsrichting; deze kan verschillen met de kompasrichting van het vliegtuig, bijv. door zijwind.
hoogte	=	flight-levels; flight-levels zijn honderdtallen voeten (bijv. FL018 = 1800 voet).
		Flight-levels zijn ten opzichte van de isobaar 1013 hPa. Als de luchtdruk op zeeniveau 1013 hPa is, dan komt FL000 overeen met de zeespiegel

APPENDIX F

DATA USED FOR FLIGHT PATH RECONSTRUCTION

Air Traffic Control (ATC) radar data (LVNL)

The Dutch Safety Board obtained radar data from Air Traffic Control the Netherlands (LVNL). These data include measurements from multiple radar sensor locations and ARTAS, which is a system that integrates these measurements and provides a prediction of the flight path by means of extrapolation.

Because the distance of the different radar sensor locations varies with respect to the accident location, the different radar measurements may show small differences in position and altitude of the aircraft. ARTAS provides a best estimate of the actual position and altitude of the aircraft and also gives information relating to its certainty.

Analysis by the Dutch Safety Board and LVNL of the final stage of the flight path shows that not all of the last twelve ARTAS calculated aircraft locations (starting at 17.57:41 hours and onwards) can be considered as certain; in particular the altitude of some measurements could not be validated. Therefore, only measurements traceable back to a (validated) measurement from one or more radar sensors were used for the reconstruction of the flight path.

Rotterdam Port Authority (RPA) maritime radar

In addition to radar information obtained from LVNL, the Dutch Safety Board used primary radar data provided by RPA. The authority has multiple radar installations situated around the port area to track the movement of vessels. A number of radar installations are located around the Maasvlakte. Because these installations are tuned to track maritime traffic, they typically perceive up to a height of approximately 30 metres above ground level.

For the analysis, it is assumed that the (UTC) times of the ATC radar and RPA radar were similar to within a few seconds. It could not be determined what the actual difference was at the time of the accident. It was determined however that the observed primary radar reflection east of the Beereiland is not a false or indirect echo of nearby vessels because of the clear line of sight between the radar location(s) and location of the observation.

The reconstruction of the flight path is presented in Section 3.1.1.

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